PROCEEDINGS

Computing Alliance of Hispanic-Serving Institutions
CAHSI
2nd Annual Meeting
Miami, Florida
December 15-18, 2007

Sponsored by the
National Science Foundation
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<td>Presenter: Nayda G. Santiago, Assistant Professor</td>
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<td>University of Puerto Rico-Mayaguez</td>
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<td>The University of Texas at El Paso</td>
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SUNDAY, DECEMBER 16, 2007

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CAHSI Meeting

| Time               | All-Hands CAHSI meeting (closed)                                          | Orchid B        |
|--------------------|---------------------------------------------------------------------------|                 |
| 1:30 pm – 3:00 pm  | Break                                                                     |                 |
| 3:00 pm – 6:00 pm  | Break                                                                     |                 |

Reception and Posters

| Time               | Reception and student poster presentations                                | Orchid C and D  |
|--------------------|---------------------------------------------------------------------------|                 |
| 6:00 pm – 8:00 pm  |                                                                           |                 |
# Computing Alliance of Hispanic-Serving Institutions
## 2nd Annual Meeting Agenda
### Hyatt Regency-Miami
### Miami, Florida

### MONDAY, DECEMBER 17, 2007

**CAHSI 2nd Annual Meeting: Building Collaborations with Hispanic-Serving Institutions to Maintain U.S. Competitiveness in Science and Technology**

The objective of the meeting is to discuss how CAHSI and similar alliances can join government, industry, professional societies, and other non-for-profit organizations to ensure that the U.S. maintains its critical edge in science and technology.

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<td>Ann Q. Gates, Chair and Professor</td>
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<td><em>Supercomputing in Chrysalis</em></td>
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<td></td>
<td>Chief Scientist</td>
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<td>Center for Computation and Technology/Center for Advanced Computing Research</td>
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<td></td>
<td>Louisiana State University/California Institute of Technology</td>
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<td>10:00 am – 10:50 am</td>
<td>Panel 1: <em>Industry Perspective: Challenges and Opportunities on Strengthening Competitiveness</em></td>
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<td>Bill Silva, Federal High Performance Computing, Microsoft</td>
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<td>Cecilia Aragon, Scientist, Lawrence Berkeley National Lab</td>
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<td>10:50 am – 12:00 pm</td>
<td>Panel 2: <em>Hispanic Perspective: Challenges and Opportunities on Strengthening Competitiveness</em></td>
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<td>Diana Gomez, President of Society of Professional Hispanic Engineers</td>
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<td>Judit Camacho, Executive Director Society for the Advancement of Chicanos and Native Americans in Science</td>
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<td>Michele Lezama, Executive Director National GEM Consortium</td>
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<td>12:00 pm – 1:30 pm</td>
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<td><em>Keynote: Competitiveness, Innovation, and Diversity: A View from Washington</em></td>
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<td>Peter A. Freeman</td>
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<td>Emeritus Dean and Professor, Georgia Tech Director, Washington Advisory Group</td>
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<td>1:30 pm – 3:00 pm</td>
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<td>Break</td>
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<tr>
<td>3:15 pm – 5:00 pm</td>
<td>Report out, next steps, and summary</td>
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<tr>
<td>6:00 pm – 7:30 pm</td>
<td>Dinner</td>
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Opening Remarks

The Role of the Computing Alliance of Hispanic Serving Institutions in Broadening Participation

Ann Quiroz Gates

Dr. Ann Gates is a professor and chair of Computer Science at the University of Texas at El Paso. Her areas of expertise are software property elicitation and specification, ontologies and workflows with applications to geoinformatics, and involvement of undergraduates in research. Gates directs the NSF-funded Cyber-ShARE Center of Excellence that focuses on developing and sharing resources through cyber-infrastructure to advance research and education in earth science and engineering. She is a member of the NSF Advisory Committee for Cyberinfrastructure, and she has been an active member of IEEE-Computer Society (IEEE-CS), where she serves on the Board of Governors (2004-2008), and the Educational Activities Board (1996-present). She chairs the IEEE-CS Awards Committee (2005-2007). Gates has served on the 2006 Executive Committee of the IEEE-CS Board of Governors, National Academy of Engineering’s Committee on Engineering Education (2002-2004) and on the steering committee for the Frontiers in Education Conference (2000-2006). She is a program evaluator for the Computing Accreditation Committee of ABET and is certified through the IEEE-CS Software Development Professional program. Gates is a founding member of the Academic Alliance for the National Center for Women and Information Technology, a national network to advance participation of women in IT, and she leads the Computing Alliance for Hispanic-Serving Institutions, an NSF-funded consortium that is focused on the recruitment, retention, and advancement of Hispanics in computing. In 2003, she received the university’s Chancellor’s Council Award for Outstanding Teaching, and she was named to the Hispanic Business magazine’s 2006 100 Influential Hispanics list for her work on the Affinity Research Group model, a comprehensive model for the creation and maintenance of dynamic, productive, and inclusive research groups.

Invited Speakers

Competitiveness, Innovation, and Diversity: A View from Washington

Peter A. Freeman

Dr. Peter A. Freeman is a Director of the Washington Advisory Group, specializing in strategic guidance for organizations involved in research, education, and development. He was Assistant Director of the National Science Foundation, heading the Computer and Information Science and Engineering (CISE) Directorate, from 2002-2007. He was part of the senior management team that formulated national science policy and operated the NSF. Previously, he was Founding Dean of the College of Computing at Georgia Tech in 1990 where he is now an Emeritus Professor and Dean.
Keynote Speaker

Supercomputing in Chrysalis

Thomas Sterling

Dr. Thomas Sterling is the Arnaud & Edwards Professor at the Louisiana State University Department of Computer Science and a faculty member of the Center for Computation and Technology. In addition, he holds the positions of Faculty Associate at the California Institute of Technology Center for Advanced Computing Research and Distinguished Visiting Scientist at the Oak Ridge National Laboratory. Since receiving his Ph.D. from MIT as a Hertz Fellow in 1984, Dr. Sterling has engaged in a wide range of applied research associated with high performance computer systems architecture and software. He is widely recognized for his contributions in cluster computing through his leadership of the Beowulf Project (for which he was one of several to win the Gordon Bell Prize in 1997) and for his work in Petaflops scale system architecture through the HTMT and Cascade HPCS system projects and the DIVA and Gilgamesh processor in memory (PIM) architecture projects. He is currently developing the ParalleX Model for future generation parallel computing and is co-investigator on DOE, NSF, and NASA sponsored research projects. Dr. Sterling holds six patents and is the co-author of five books in the field.

Panelists

Panel 1: Industry Perspective: Challenges and Opportunities on Strengthening Competitiveness – Bill Silva, Federal High Performance Computing, Microsoft; Cecilia Aragon, Scientist, Lawrence Berkeley National Lab

Cecilia Aragon

Dr. Cecilia Aragon is a computer scientist in the High Performance Computing Research Department at Lawrence Berkeley National Laboratory in Berkeley, California. Her research interests lie in visualization, image processing, visual analytics, and human-computer interaction. Born in the U.S. of immigrant parents, she received her Ph.D. in computer science from the University of California, Berkeley and her B.S. in mathematics from the California Institute of Technology. Prior to holding her current appointment, she was a computer scientist at NASA Ames Research Center for nine years, and before that, the founder and CEO of a small aviation company and medalist at the World Aerobatic Championships, the Olympics of aviation. She is the only Latina ever to win a spot on the United States Aerobatic Team. She has over 20 years of experience in the computing field, and has held positions in industry, academia, and government. Her experience ranges from technical positions such as software developer, architect, team lead, and researcher, to management positions including president and CEO, to non-traditional jobs such as air show and test pilot. She is the author of numerous publications in peer-reviewed conferences and journals, and has received many awards for her work. Cecilia and her husband live in the San Francisco
Bay Area with their two children. She enjoys mentoring and working with students of all ages. She has given numerous presentations, keynote addresses, and workshops over the past fifteen years.

Bill Silva  Missing

**Panel 2: Hispanic Perspective: Challenges and Opportunities on Strengthening Competitiveness** - Diana Gómez, President of Society of Professional Hispanic Engineers; Judit Camacho, Executive Director Society for the Advancement of Chicanos and Native Americans in Science; Michele Lezama, Executive Director National GEM Consortium

**Diana Gómez**

As a senior electrical engineer and chief of the California Department of Transportation’s traffic management office, Diana Gómez has overseen numerous traffic flow management projects including an advanced weather sensor system she developed to reduce fog-related accidents. A graduate of California State University, Fresno, in electrical engineering, she has served as national president for the Society of Hispanic Professional Engineers, a professional organization for Hispanic engineers and technical talent, since 2003. Diana was recognized as one of the 100 Most Influential Hispanics by *Hispanic Business* and as one of the top 100 Hispanics in the technical field by *Hispanic Engineer*.

**Judit Camacho**

Judit Camacho brings 10 years of non-profit management, grants administration and federal government experience to SACNAS, as well as extensive understanding of SACNAS as a Life Member and a prior executive director. She holds a B.A. in mathematics from the University of California, Santa Cruz (UCSC), graduate coursework in Public Health from the Johns Hopkins University and life experience as a teacher, activist and mother of three children. This appointment brings Camacho back to the organization after a five year term of service in Washington, D.C. At the end of 1999, Camacho was recruited for an opportunity to work with the National Institutes of Health (NIH) under the auspices of Dr. Clifton Poodry, director of the Division for Minority Opportunities in Research at the National Institute of General Medical Sciences, and subsequently Ms. Christina Bruce in the Office of Workforce Development at the National Cancer Institute. Among the projects that she helped craft at NIH were the *Summit on Latino Research, Outreach and Employment at the NIH* and the *Introduction to Cancer Research Careers* program. In her earlier career, Camacho directed SACNAS from 1994 through 1999. During her tenure with the organization, Camacho led the organization through major growth and development. She presided over the doubling of membership and participation in the organization’s annual conference, the creation of new initiatives such as the SACNAS Biography Project and the SACNAS Neuroscience Program, and the promotion of the society to a national reputation as a foremost scientific society representing under-represented populations. In addition, her term oversaw moving the national office from a location on the UCSC
campus to offices in downtown Santa Cruz and increasing staff program support from two employees to over a dozen. In 2004, Camacho took a year off to return to her home in California’s Central Coast, focus on her family and raise her children closer to their grandparents and extended family. Camacho initiated her renewed relationship with the organization in August, 2005, by helping to launch its first capital campaign. Under her direction, this initiative’s goal is to diversify resources, increase membership participation, and strengthen long-term infrastructure.

Michele Lezama

Michele Lezama is currently the Executive Director of The National GEM Consortium, a 501c(3) organization, founded at the University of Notre Dame, dedicated to increasing the number of under-represented individuals who pursue and receive a masters or PhD in engineering or science by providing full fellowships and holding informational programming on the application and graduate school experience. Under Lezama’s leadership, NSBE received the 2003 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring awarded by the White House’s Office of Science and Technology. Prior to NSBE, Lezama was the Director of Satellite Scrambling Operations at Home Box Office (HBO), a Time Warner Company, and prior to HBO she served as the Associate Director of Broadcast Operations and System Integration at Columbia Broadcasting System (CBS). Lezama was involved in a number of exciting technical and financial projects during her media career, specifically the creation of on-line scheduling for on-air programs and commercials, the build-out of the technical studio for CBS’ Late Night with David Letterman, and multi-plexing of the HBO and Cinemax brands. Prior to Lezama’s media career she was an engineer with IBM in their Poughkeepsie, Manhattan and Brooklyn facilities. Lezama also held co-op positions with Raytheon and Texas Instruments. Lezama earned her BS in Industrial Engineering at Northeastern University and both her MS in Industrial Engineering and MBA in Finance and Accounting from Columbia University. Lezama was inducted into Tau Beta Pi, Alpha Pi Mu and is an alumnus of Robert Toigo Financial Services and The National GEM Consortium fellowship programs. A native New Yorker, Brooklyn by way of The Bronx, Lezama’s straight forwardness and dry wit would make the city proud. Lezama is married to Ricardo Lezama. They have two daughters.

Co-presenter of the ARG Workshop

Elsa Villa

Elsa Villa is a lecturer in the Department of Teacher Education, Division of Mathematics, Science and Technology, at the University of Texas at El Paso (UTEP). She formerly served as the Director of the Engineering Programs Office at UTEP for eleven years where she worked closely with engineering faculty in designing and implementing instructional strategies to improve classroom learning. Ms. Villa is a doctoral student in Curriculum and Instruction at New Mexico State University, and her research interests include professional learning communities and teacher identity.
Introduction to Research

**Target audience:** Graduate and Undergraduate Students  
**Speaker:** Prof. Nayda G. Santiago  
**URL:** http://www.ece.uprm.edu/~nayda

This workshop will discuss different aspects involving research: Why it is necessary to publish? What is systematic research in computer science? What is a proper experiment design?

Affinity Research Group Workshop

**Target audience:** Faculty, Graduate, and Undergraduate Students  
**Speaker:** Prof. Ann Gates and Prof. Elsa Villa  
**URL:** http://faculty.utep.edu/agates

The Affinity Research Group is a comprehensive model for the creation and maintenance of dynamic, productive, and inclusive research groups in engineering and computing. The model is comprised of a set of fundamental principles and effective practices that emphasize the conscious development of students’ domain knowledge as well as research and professional skills. This workshop introduces the model and engages the participants in exercises that illustrate the use of the model.

Young Faculty Success Strategies

**Target audience:** Faculty and Graduate Students  
**Speaker:** Prof. Irma Becerra  
**URL:** http://www.kmlab.fiu.edu/

Faculty seeking professional career development in research and education will benefit from best practices and collected wisdom for identifying resources and strategies for success in academia.

Sponsored by: The **National Science Foundation**
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Automated XML Schema Representations for Sensor-Based Information Processing Systems

Luz V. Acabá-Cuevas

Wide Area Large Scale Automated Information Processing
University of Puerto Rico - Mayagüez Campus
Department of Electrical and Computer Engineering
Luz.Acaba@ece.uprm.edu

1. Introduction

There is a need for coupling/binding representation of data and metadata entities associated with physical sensors pertaining to environmental surveillance monitoring (ESM) applications. Each sensor in ESM is modeled as a discrete-time information source emitting a time sequence defined as signal-data. Metadata is defined in general as data that describe data. Metadata contributes to understand the real conditions in which data was taken. Considering metadata is a good practice to support precise decision making. The common practice is to keep data and metadata files as independent files. The reason for this is because data providers, in this case mixed sensors, generate a file for data output then, a separate output file, metadata such as timestamp and type of reading. This way, data files can be used as input for processing. This separation of data and metadata files eliminates the possibilities of establishing a physical intuitive relationship between files.

Another situation arises at the time of sharing data across heterogeneous users. Heterogeneous users are users with different platforms and processing systems. The format and layout of metadata and data are predefined by the system that collects the data. Not all systems are similar, therefore, systems have their proprietary way of representing data and metadata files. If files are going to be shared across heterogeneous users, extra time will be needed to decipher what each parameter means. Therefore, a mechanism to standardize the files in order to create a standard effortless approach to interpret content should be implemented.

A major issue is that there is no mechanism to document human input in the metadata. Human observations are necessary to complement readings too. For example, if the humidity was very high and there was an unnatural flash flood (e.g. pipeline leak) near the sensor, it is important to document it in order to avoid taking humidity as a sign of natural precipitation. It is important to document human observation to avoid erroneous decision making.

Another situation arises with the possibility of dynamic parameters for metadata. In some cases metadata is static for example: type of reading. If a sensor is capturing reading of humidity, that sensor will always keep capturing readings of humidity. An example of a dynamic metadata parameter is battery power. It is important to implement a mechanism that supports dynamic metadata consideration every time data files are generated.

Metadata information is normally used in ESM as an aid in context awareness and information processing operations to assist an information user through decision making stages. Context awareness aids in the detection, estimation, and classification of sensor-based signals acquired from ESM for the assessment and proper management of Earth’s geophysical, environmental, and ecological issues such as: landslides, deforestations, river and coastal dynamics, soil moisture, water pollution, and endangered forested species. The concept of sensor data availability in ESM is decomposed into three specific requirements: let users get the information in a remote manner, get access to data
as soon as it is required, and enable a uniform interpretation of data among heterogeneous data sources and data destinations. This work focuses in creating a mechanism to gather data and metadata enforcing physical relationship between these two files considering interoperability and ambiguity of interpretation issues among users.

2. Proposed Solution

In order to mitigate the issues of data and metadata handling explained previously, a tool is being prototyped using Java, XML, and FTP technologies for the encapsulation of data and metadata files (proposed as format for information content exchange) in automated information processing systems.

The XML Information Representation (XIR) tool implements mechanisms to process data and metadata files. XIR enables data and metadata files to be encapsulated using XML. XML is a general purpose markup language capable of describing many different sets of data. XML provides a text-based means to describe and apply a tree-based structure to information. XML will be used to add the description labels to all pieces of information in the merged output file adding multi-platform uniform interpretation to items in the data and metadata files. A mechanism to encapsulate user observations is also considered in this solution.

The XML modality allows an information user to modify metadata registry by invoking features such as annotations, deletions, field creations, and field purges through information flow events. This solution forms part of an overall project, the Wide Area Large Scale Automated Information Processing (WALSAIP) program, an NSF/CISE/CNS sponsored project aiming at developing modular, reconfigurable, and scalable working prototypes in the form of systems, tools, and applications to aid and support a network infrastructure for the automated processing of signal-based information acquired from array sensors in heterogeneous, wide-area, large scale, and distributed systems. The WALSAIP Project is developing a new conceptual framework for the automated processing of information arriving from physical sensors in a generalized wide-area, large-scale distributed network infrastructure. The project is focusing on water-related ecological and environmental applications, and it is addressing issues such as scalability, modularity, signal representation, data coherence, data integration, distributed query processing, scheduling, computer performance, network performance, and usability.

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A Constraint-Based Approach to Verification of Programs with Floating-Point Numbers

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1. Introduction

Software plays an important role in our daily lives. There is software in our cell phones, in our workplaces and in our homes just to mention a few examples. There is also software that is even more important; for example, software included in our cars such as the anti-lock brake systems, software applications controlling airport traffic and software in the airplane itself, applications used in hospitals to deliver radioactive treatment to patients, programs used in nuclear stations. These kinds of applications are critical: human-lives depend on their functionalities. Ideally, we want programs to always work right and as specified. Programmers and users want specially the latter kind of software to work right. That is, we want reliable software. One of the things we can do to achieve reliable software is to verify it and validate it. Validation and Verification (V&V) are two terms that are similar and both terms have been used to refer to all the activities we perform to check that software does what it is supposed to do. We adopt the following meaning for validation and verification. Validation refers to checking that a system satisfies its specification (usually checking that the design specification satisfies the user’s requirements) whereas verification refers to proving that a system satisfies its specifications (usually proving that the code satisfies the design specifications).

Constraint Programming is an emerging field and has been successfully used in solving scheduling problems and circuit design, among others. Its use in verification of software is still being researched and it is being applied to automatically generate test cases and to show the conformity of software to its specification. In this work, we survey constrained-based verification techniques and we propose a different approach to translate code constructs where existing approaches made use of guarded constraints. In addition, we also describe a process to solve Constraint Satisfaction Problems (CSP) of the form $\neg A \land B$.

2. Common verification techniques

In this section, we present common verification techniques as listed by Balci in Balci classifies these techniques as follows:

- **Informal verification techniques** - These techniques usually involve human participation and rely mainly on human reasoning. Some of the techniques that fit in this category are the following: audits, inspections, walkthroughs, and reviews.
- **Static verification** - These techniques do not require machine execution of the model. Some of the techniques that fit in this category are the following: data flow analysis, syntax analysis, graph-based analysis, and structural analysis.
- **Dynamic verification** - These techniques require model execution. Some of the techniques that fit in this category are the following: testing, debugging, and execution tracing.
- **Symbolic verification** - On these techniques symbolic inputs are given to a model and the output consists of expressions that result from the transformation of the symbolic inputs after going through execution paths in the model. Some of the techniques that fit in this category are the following: path analysis, symbolic execution, cause-effect graphing, and partition analysis.
- **Constraint verification** - Constraint verification techniques use assertion checking, boundary analysis, and inductive assertions. Some of the techniques that fit in this category are the following: assertion checking, boundary analysis, and inductive assertions.
- **Formal verification** - These techniques are based on formal mathematical proof of correctness. Some of the techniques that fit in this category are the following: lambda calculus, logical deduction, and proof of correctness.
3. Related work on constraint-based verification techniques

3.1 Automatic test case generation

In this section, we briefly describe the work of Gotlieb et al. In their approach, the authors mainly discuss their work for computations with integers\(^1\).

The approach taken by Gotlieb et al.\(^2\) consists of automatically generating test data that will execute a selected point in the code. In this approach, they transform the code into Static Single Assignment (SSA) form and analyze control-dependencies. They build a constraint system with this information and then they solve this system. When the constraint system is solved, test data is generated such that the selected point executes (if there is a feasible path that leads to the selected point).

The main steps of Gotlieb’s et al. can be outlined as follows:
1. Translate the program into a constraint system from its SSA form and control-dependencies.
2. The result of this step is a set of constraints (Kset). This set consists of the constraints generated for the program and the constraints that are generated for the selected point.
3. Solve Kset to generate test data for the selected point if there is at least one feasible path to the selected point.

3.2 Conformity of specifications and code

In this section, we briefly describe the work of Rueher et al. Their approach handles only operations with integers, i.e., they work on discrete domains. In this section, we first present an overview of the work in \(^5\) which is the base of our work. Then, we describe the steps followed by Rueher et al.

The approach taken by Collavizza and Rueher\(^5\) consists in transforming the program and its specification into a constraint system. In this work, a program is verified if the union of the constraints derived from the program and the negation of the constraints derived from its specification is inconsistent (i.e., it does not have a solution). Consider that we have specification B and its implementation A: we would then try to solve \(A \land \neg B\). In this sense, Rueher’s and Collavizza’s approach is similar to the process of resolution in logic. That is, we want to show that the implementation models the specification. That is, \(A \models B\), which is equivalent to \(A \land \neg B \models \bot\).

The main steps of Collavizza’s and Rueher’s approach can be outlined as follows:
1. Translate the program into a constraint system. (A)
2. Translate the negation of the specifications into a constraint system. (\(\neg B\))
3. Consider the conjunction of these two constraint systems as a CSP (possibly involving guarded constraints): \((A \land \neg B)\)
   a. If a solution is found, it means that the program does not meet its specification and the solutions to the CSP are the test cases that would fail to meet the specifications.
   b. If a solution is not found, it means that the program meets its specification.

4. Our contribution

Our approach is based on the work of Rueher and Collavizza\(^5\). In this work, the CSPs generated from the code and the specifications may contain guarded constraints. Collavizza and Rueher point out that standard CSP solvers may not be able to prune the system, and only after a costly enumeration process, the CSP solver is able to detect an inconsistency on the CSP. To deal with this disadvantage of standard CSP solvers, they propose using a SAT solver first. They introduce a Boolean variable for modeling conditional statements such as \(i < j\). Once the transformation is done, standard CSP solvers are able to detect the inconsistency.

We want to consider an alternative approach so that there is no need for a SAT solver and it can be extended to handle domains of real numbers. The alternative we consider is that in the case of guarded constraints, we translate them by using the equivalence of logical implication with a disjunction. In the following subsection, we describe the main steps of our proposed approach.

4.1 Algorithm of our proposed approach

Our proposed approach can be outlined as follows:
1. Transform guarded constraints of the form \(A \rightarrow B\) into their equivalent \(\neg A \lor B\).
2. Transform the CSP in the form of a CNF into a DNF, which is a disjunction of CSPs.
3. Solve the CSPs and consider the final solution to be: 

\[
\bigcup_{i=1}^{solution \ of \ CSPs} \ 
\]

In the following subsection, we present an example describing the steps outlined above.

\(^1\) They point out that another solver has to be used to handle floating-points.
4.2 Example: Our proposed approach

Consider the example shown in Figure 1. After translating the code and the negation of the specification we get the constraints shown in Figure 2.

```java
// @ensures \result \geq 0
public int absolute(int i, int j) {
    if (i < j)
        return j-i
    else
        return i-j
}
```

**Figure 1 Example if-then-else statement**

<table>
<thead>
<tr>
<th>c₁ : i &lt; j</th>
<th>c₂ : r = j - i</th>
</tr>
</thead>
<tbody>
<tr>
<td>c₃ : i \geq j</td>
<td>c₄ : r = i - j</td>
</tr>
<tr>
<td>c₅ : r &lt; 0</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2 Constraints from Figure 1**

If the code is correct with respect to its specifications, then we are aiming at the following CSP:

\{(c₁ \rightarrow c₂) \land (c₃ \rightarrow c₅), D_I = D_r = \{0, ..., 65635\}\}

**Equation 1 - CSP with guarded constraints**

which is expected not to have solutions.

However, we want to translate the guarded constraints into their equivalent (plain) constraints. After the transformation, we obtain:

\{(\neg c₁ \lor c₂) \land \neg c₃ \land c₅, D_I = D_r = \{0, ..., 65635\}\}

**Equation 2 - CSP without guarded constraints**

Unfortunately, disjunction in CSPs is difficult to deal with, thus we need further transformation.

Currently, we have a CSP in CNF, which involves disjunctions of constraints. We want to translate the CSP into a DNF because dealing with disjunction of CSPs is easier than dealing with disjunctions of constraints within a CSP. After this transformation on the CSP shown in Equation 1 we obtain the disjunction of the following CSPs:

- CSP₁: \{\neg c₁ \land \neg c₃ \land c₅\}, D_I = D_r = \{0, ..., 65635\}
- CSP₂: \{\neg c₁ \land c₃ \land c₅\}, D_I = D_r = \{0, ..., 65635\}
- CSP₃: \{c₁ \land \neg c₃ \land c₅\}, D_I = D_r = \{0, ..., 65635\}
- CSP₄: \{c₁ \land c₃ \land c₅\}, D_I = D_r = \{0, ..., 65635\}

Now, we would have to solve these 4 CSPs and what we are aiming at is:

\[\bigcup \text{solutions of CSP}\]

However, in order to limit the computational complexity of our approach, we apply rules to reduce the number of CSPs to be solved. We now present these elimination rules.

**Elimination rules**

In our approach for each CSP involving guarded constraints, we generate four CSPs. However, we can eliminate two CSPs by applying the following rules:

- **Rule 1** Eliminate CSPs that contain \(C \land \neg C\) or \(\neg C \land C\).
  - We can apply this rule because a CSP consisting of \(C \land \neg C\) would have no solution. Moreover, if we were dealing with real domains, considering solving this kind of CSPs could become a source to generate false positives and we want to reduce the number of false positives.

- **Rule 2** Eliminate CSPs that contain \(C_{if1} \land C_{else1}\) or \(C_{else1} \land C_{if1}\). We can apply this rule because of the semantics of the if-then-else statement.

4.3 Challenges of our proposed approach

In our approach we face the following challenges:

- Solving a union of CSPs.
- Solving conjunction of CSPs of the type \(\neg A \land B\).

In the following, we describe the challenge of solving conjunctions of the type \(\neg A \land B\), and how we address this challenge.

4.3.1 Challenge of solving CSPs of the form \(\neg A \land B\)

Consider that we have two constraints A and B, defining a relation on x and y. A and B are represented as shown in Figure 3.

**Figure 3 Solving \(\neg A \land B\)**

4.3.2 First approach

We want to solve \(\neg A \land B\): the solution set is shown in Figure 4. First, we consider solving A by an outer approximation. When performing such an outer approximation of A, we keep the discarded parts. The discarded parts constitute an inner approximation of \(\neg A\).
However, by doing so, there are two risks that we may run into: 1. we may miss some solutions and 2. we may get false positives. In the following sections, we identify and describe these two risks that may arise in this example.

**Figure 5 Identifying risks**

### 4.3.2.1 Risk of missing solutions

Let us examine the risk of missing solutions by focusing on the region where this problem may arise, as indicated in Figure 5.

After we solved A by an outer approximation to get an inner approximation of ¬A, we now solve B on the inner approximation of ¬A. When solving B, we get an outer approximation of B. The outer approximation that we get for B will be delimited in part by the inner approximation of ¬A.

Note that we initially considered an outer approximation of A. Therefore, our approximation for ¬A may not contain all solutions that in fact belong to ¬A. Since we may lose some solutions of ¬A, and B will be delimited by the approximation of ¬A, we have the risk of missing some solutions of ¬A ∩ B, as shown in Figure 6 colored in dark gray.

### 4.3.2.2 Risk of false positives

Now, let us examine the risk of having false positives. Note that when solving for B, we calculated an outer approximation of B. Therefore, we may get some “solutions” that originally do not belong to B. When solving for ¬A ∩ B, since we consider an outer approximation of B, we may have solutions that are not solutions, i.e., we may get false positives. These false positives that we may get on this example are shown in Figure 6 colored in a black and white check board pattern.

### 4.3.2.3 Conclusion

In this approach, we do not achieve correctness (i.e., no false positives) nor completeness (i.e., no missed solutions). One of our goals is to achieve completeness, that is, we do not miss any solution. The approach that we have described above involves the risk of missing solutions. Therefore, we consider a second approach.

### 4.3.3 Second approach

Recall that we want to solve ¬A ∩ B. In our second approach, instead of solving A using an outer approximation and considering the discarded parts as solutions for ¬A as an inner approximation, we now consider solving A using an inner approximation and considering the discarded parts as solutions for ¬A as an outer approximation of ¬A.

#### 4.3.3.1 Risk of false positives

Let us examine the risk of having false positives. Note that in this approach, we only changed the way we solve for ¬A. Therefore, we still have the same risk of false positives as in the first approach because when solving for B, we calculate an outer approximation of B. Furthermore, in the second approach, we may introduce more false positives. When solving for ¬A ∩ B, we now consider an outer approximation of ¬A, that is, we may get “solutions” that do not satisfy ¬A. Therefore, they may not be solutions when solving for ¬A ∩ B. The false positives that we may get on this example are shown in Figure 7.
4.3.3.2 Conclusion

On one hand, when we consider the second approach, we achieve completeness, that is, we do not miss solutions when solving for \( \neg A \land B \). On the other hand, we do not achieve correctness, that is, we may introduce more false positives than we had when considering the first approach. This is shown in Figure.

5. Conclusion

In this work, we considered the problem of verification of software. That is, we were interested in showing that a program conforms to its specifications.

We chose to approach this problem of verification by using constraint programming techniques. The work of Rueher and Collavizza on the conformity of specifications and code constituted the basis of our work.

While their approach was handling programs dealing with computations on integers, our work aims at also handling programs with floating-point numbers. Besides, while they were making use of guarded constraints and of a SAT solver to detect inconsistencies earlier in the solving process and to avoid finding these inconsistencies after the costly enumeration process in normal CSP solvers, the use of SAT solvers is not efficient for handling programs dealing with computations on floating-point numbers.

As a result, we proposed an approach that does not include guarded constraints nor use a SAT solver. We pointed out challenges related to our approach, and have described algorithms to address each of them.

In particular, two strategies to solve CSPs of the form \( \neg A \land B \) were proposed and their properties pointed out, and we also defined rules that prevent the computational explosion of our approach.

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Evaluation of Onscreen Pre-compensation Algorithms for Computer Users with Visual Aberrations

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1. Introduction

Graphical User Interfaces (GUIs) for computers have evolved to suit the needs of the most users. However, they have, in many cases, disregarded the needs of a subset of users with visual aberrations. Furthermore, there are some kinds of visual afflictions (e.g., Keratoconus) that are not overcome by classical means of GUI enhancement, for example screen magnifiers or screen readers.

Custom enhancement of the images presented to users based on their unique refractive visual aberration is termed “precompensation”. This stems from the fact that the images are enhanced at the source, i.e. the monitor or LCD panel, and not at the destination, as in glasses or contact lenses.

Previous work has been done towards enhancing the computer access of individuals with refractive (optical) visual aberrations. Alonso , recently described a parameter-less method to perform custom precompensation of onscreen images that only requires knowledge of the user’s particular visual aberration, as characterized by a wavefront analyzer. Wavefront analyzers are ophthalmology instruments that characterize the optical aberrations in the human eye in the form of a mathematical representation called the Point Spread Function (PSF). The inverse of this PSF can then be used to generate images that when displayed to the user, will ‘cancel’ out their visual aberration and allow them to potentially ‘see’ the images with less distortion.

The goal of this paper is to present the experimental design and statistical findings from tests carried out in order to assess the performance of the precompensation algorithms in their capability to enhance the access to GUIs for users that have refractive visual aberrations in their optical systems.

2. Experimental Design

In order to assess how much the precompensation process may facilitate computer interaction for the target population, an experiment was designed to measure the improvement in object recognition for objects displayed in a Windows™ desktop to several human subjects that had varying degrees of visual refractive dysfunction, including subjects with Keratoconus.

2.1 Subject Recruitment

Twenty subjects participated in the tests. Five of them were controls, i.e. they did not have significant visual refractive errors. The remaining fifteen subjects were chosen as follows: Five subjects were chosen having myopia, with at least -3 Diopeters of sphere, five subjects were chosen having both myopia and astigmatism, with at least -3 Diopeters of sphere and having any amount of astigmatism stronger than -0.5 Diopeters, and five subjects were chosen to have Keratoconus in at least one eye. The PSF of each of the subjects’ eyes was used to create the custom precompensated images used in the tests, as described in [1].

The subjects were chosen in this manner to explore the potential benefit of the precompensation process. Myopic and Hyperopic
subjects were chosen as part of the study because the amount of defocus (the main component of visual distortion in myopic and hyperopic users) has been found to be the component of the PSF that affects legibility and visual acuity the most.

2.2 Experimental Model

The experiment was designed to assess the improvement that the precompensation processing delivers to subjects for recognizing a target icon from a group of icons at various sizes. Figure 1 and 2 show examples of the stimulus and target screens, respectively.

Each subject was positioned approximately 50 cm from the screen. Tests were performed monocularly. The test began by presenting the subject with a stimulus screen consisting of a large icon (approximately 59 mm wide), uncompensated (e.g. Figure 1-a). The initial stimulus icon was selected at random from a pool of six different Microsoft Windows icons.

The subject was then asked to indicate when he/she was ready for the target screen to be displayed. All six icons were displayed in a 2x3 array. The position and size of each icon was selected at random for each treatment level. The size of each icon could vary (15, 24 or 38 mm). The subject was then asked to identify the icon that matched the large stimulus icon previously shown. The answer for each target screen was recorded as a “correct” or “incorrect” identification of the icon.

Each icon position and size combination was tested twice. This amounts to thirty six trials for this test, i.e., uncompensated icons. The test was then repeated using precompensated stimulus (e.g., Figure 1-b) and precompensated target icons. Once the uncompensated and precompensated tests were complete, the remaining eye was tested. The order of eyes tested was right eye first, then left eye.

![Figure 1. Stimulus](image1)

![Figure 2. Target Screen for the Icon Test (Uncompensated)](image2)

Thus, the experiment can be considered a repeated measures experiment with four fixed factors: Group (G) – four levels, Eye (E) – two levels, Size (S) – three levels, and Method (M) – two levels. Every treatment combination was applied to the twenty subjects in a randomized order. The dependent variable is the number of correct icons per size, for each treatment combination, Y. The experiment is treated as a randomized complete block design (RCBD) experiment, taking subjects as a random factor and blocking on it. The model for the analysis of variance is as follows:

\[
Y_{ijk} = \mu + G_i + E_j + S_k + M_l + \epsilon_{ijkl}
\]

with subjects nested in groups.

3. Results

ANOVA was used to analyze the experimental data. The data satisfied the assumptions for parametric analysis. Table 1 summarizes the ANOVA.

The main effects of Size and Method were found to be significant, with \( p < 0.002 \) and \( p < 0.001 \), respectively the identification of icons for human subjects with the aberrations studied, and reveals that the method may work better for certain icon sizes.
Table 1. ANOVA Table

<table>
<thead>
<tr>
<th>Source</th>
<th>Numerator df</th>
<th>Denominator df</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
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<td>.000</td>
</tr>
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</tr>
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<td>.002</td>
</tr>
<tr>
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<td>2</td>
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</tr>
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<td>Method</td>
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4. Acknowledgments

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References


Computer Security: Methods of Data Mining

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1. Introduction

Data is collected everyday by Intrusion specialists in order to decide whether malicious activity or intrusions have been committed in a computer network. In the Computer Science Research Lab (CSRL) at California State Dominguez Hills, a log is constantly being updated and stored in a database with the information of all the visitors to the network. Using the data in the log, we have to identify wanted visitors from un-wanted visitors. The logs can consist of thousands of alerts and it would be nearly impossible for somebody to go through it and organize the data. My research will explore how Data Mining techniques and Decision Making Tools can facilitate this task. The importance of this research is that it will give the CSRL team a clear understanding of how to determine network attackers.

2. Methods of Intrusion Detection using Data Mining

The CSRL Team has come up with a way to use Snort IDS and IP Tables to create a Computer Security Software to detect attacks. The use of a sensor computer implementing Snort and a firewall running IP Tables are used in the program. Using Data Mining techniques, we can analyze Snort Logs and IP Tables to distinguish who is a hacker and who is a regular computer user.

2.1.1 Data Mining

Data Mining is a class of database applications that look for hidden patterns in a group of data that can be used to predict future behaviours. The ultimate goal of Data Mining is prediction. Predictive Data Mining is the most common type of data mining. There are 4 different techniques in Data Mining: Classification, Clustering, Sequential, and Association. Classification is a common technique used in Data Mining. Classification is the process of determination of a predefined class, to which an example belongs to. Clustering is a data mining technique used to discover and explore groupings with data or entities. Sequential involves mining frequently occurring patterns of activity over a period of time. Finally, Association a data mining technique used to find patterns or regularities that are found in transactional-type data.

2.2 Classification Tool C5.0/See5

In the CSRL, we determined that the best Data Mining technique to use to analyze our logs and databases would be Classification. The tool that we are going to use is C5.0/See5. C5.0/See5 was developed by Ross Quinlan as the successor to ID3 and C4.5 systems. C5.0 is designed to run on Unix/Linux and See5 is designed to run on Windows. It is a tool for discovering patterns and regularities in the databases, presenting them in an intelligible form, and using them to make predictions. Using C5.0/See5, we can analyze the SNORT database and identify any anomalies in the traffic patterns. Anomalies can include multiple attacks from the same IP Address. It can also include multiple occurrences of a certain type of attack. It can also detect clustered ranges of IP Addresses.
3. Conclusions

Data Mining is an ongoing effort in the community of researchers and developers to strive to make the algorithms that mine useful information from very large sets of data. In the CSRL, using Data Mining techniques to analyze our data will give us a better understanding or how to detect and prevent security flaws in today’s Networks and Computer Systems.

Acknowledgement

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NeuralStudio: An Artificial Neural Networks Simulator for Research and Education

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1. Introduction

In this information era, the theory of Artificial Neural Networks (ANNs) can only be efficiently applied to practical problems with the use of computers. Therefore, a considerable amount of programming tools have been developed and can be found in universities, industry, and on the marketplace. The list of packages available is extensive [1].

Observations made on ANNs course outlines from different universities led to the conclusion that the ANNs toolbox of MATLAB [2] is the most prevalent tool in the teaching of this discipline. Unfortunately, this toolbox requires knowledge about the scripting language that is quite similar to the C language [3]. An assessment of desired features for an educational tool could be summarized as follows:

- **Convenient and user-friendly interface:** The windows should allow users to interact with the system primarily through mouse clicks.
- **Removed requirement for programming:** This is in order to remove the constraints imposed by tools available in the market.
- **Freeware:** For enhanced accessibility to educational institutions,
- **Stand-alone application:** The stand-alone application ensures that the tool box is not dependent of another application.

Seeking to realize these aforementioned features as described above in an integrated teaching tool for ANNs was precisely the motivation for developing NeuralStudio.

2. Network Design with NeuralStudio

The Feedforward nets module is designed to contain an editor for a multilayer feedforward network [4, 5]. It also consists of information panels, editing and processing tools as well as a table for network input and a corresponding results table. Program users are able to freely design the network, and to customize the neurons as well as their interconnections. Interconnections can be established by drag and drop operations between neurons. Neurons are represented with circles and interconnections are represented by lines drawn between pairs of neurons.

To train feedforward nets, a module is provided, which can be personalized in different ways so as to animate training charts and to allow insight into temporal training results. In addition, a module dedicated to support vector machines [6, 7] is provided for users interested in conducting classification studies without ANNs.

3. Modules Related to Supervised Training

NeuralStudio applies the back-propagation method [8] for the training of the feed-forward networks placed in the main window. The training is performed in a training module as shown in Fig. 2, and information about how to carry out this process is taken from the network design. The network used for the training is taken from a pattern module. Graphical outputs can be customized in the training module depending on the nature of the problem addressed.
4. Modules Related to Unsupervised Training

During unsupervised learning, the network is not trained towards specified outputs. Instead, the network seeks to find patterns or regularity in the input data. The mapping implies clustering of the data. *NeuralStudio* offers two separate modules for this type of training: Kohonen Feature Maps [9] and Clustering nets.

5. Receiver Operating Characteristics Module

Receiver Operating Characteristics (ROC) analysis is always a must in classification studies. This technique [10] provides the theory, indicators and instructions on how to compare classifiers and make assessments about their performance. *NeuralStudio* allows comparing different classifiers with an ROC analysis module. This module contains panels for learning the fundamentals of ROC analysis as well as tools for computing the confusion matrix and evaluating the performance of the networks. A snapshot of this module is provided below.

6. Results

The software has served both as an educational software platform and a research tool. It is valuable for beginners wishing to learn more about neural networks as well as for experts who are ready to make contributions by resolving problems that are seemingly computationally taxing and extremely difficult to comprehend or visualize given their multidimensional space. Up to date, this technology has had the following practical applications:

- Performed interictal spike detection in EEG data to discriminate between electrodes that lead to seizures from electrodes that did not lead to seizures in order to optimize the three-dimensional localization of the onset point of seizures
- Classified leukemia blood samples out of hundreds of blood samples (normal and abnormal)
- Identified of threat and vulnerabilities in health care information systems
- Reduced jitter in an eye-gaze based human computer interface to help persons with severe motor disabilities move the mouse cursor hands-free on a computer so that they can use any application they wish to fixate (navigate the web, type documents, sent email).
- Classified subdural interictal EEG data (electrodes leading and not leading to an ictal state) from patients with intractable seizures undergoing surgery evaluation from Miami Children’s Hospital
- Evaluated a breast cancer database to predict the risk factor based on some dependent variables, such as treatment evaluation and functional and emotional scores.
- Introduced this tool in the two following graduate engineering courses at FIU: EEL 6991: Special Topics, and EEL 5810: Digital Image Processing and EEL 6820: Computer Vision, all for teaching purposes.

7. Conclusions

The programming tool described provides an easy-to-use tool for teaching ANN. At the same time, it can be used as a powerful tool for practical studies. Many of its features make the tool suitable for teaching, without the necessity for any special programming skills. Furthermore, it provides demos and customizing options, which display detailed results during and after the calculation processes. At the same time, the developed program code related to the most important program tasks is available from within the application. Interested users can look into the sources and learn the details of the different algorithms used. The software package can be configured to produce also high-speed calculations, a feature which makes it attractive for practical applications.

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3D Epileptic Seizure Focus Localization Using an Integrated Multimodal Neuro-Imaging Approach

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1. Introduction

Epilepsy surgery is now being increasingly performed in children with medically refractory partial seizures. A major challenge in this field is the localization of sources in the brain responsible for eliciting the EEG signal measured at the scalp. In order to estimate the location of these sources, one must correctly model the sources, i.e., dipoles, as well as the volume conductor in which the resulting currents flow. Seizures often arise from extra-temporal sites and are related to a malformed pathologic substrate that is more extensive than the lesion evident on MRI scans. Pre-surgical evaluation is therefore more difficult than in adults and relies heavily on EEG data including interictal spike discharges. The spikes recorded on the scalp can be processed using specialized software (such as CURRY) to define their source in 3-D that can then be superimposed on the patient’s MRI scan to further facilitate surgical planning. A detailed overview of the different source reconstruction methods can be found in [1]. While source reconstruction methods have been used successfully in adults being evaluated mainly for temporal lobe epilepsy, their applications have been limited in the pediatric population.

This study adapted the CURRY program and assessed the relationship of the 3-D spike sources to focal lesions evident on the patient’s clinical history. Dipole simulations were performed using realistic head models and using the boundary element method (BEM). This represents an initial step in determining the merit of this technique in the pre-surgical evaluation of children.

Further studies comparing reconstructed spike sources with the MagLink MRI data that is fully integrated with EEG recordings for highly correlated data analysis are currently being implemented at Miami Children’s hospital and real epileptic patients are planned to be analyzed in the immediate future. The patented MagLink system from Neuroscan is designed with the intent of integrating EEG and ERP recordings inside the MRI/fMRI recording modalities. The passive MagLink system provides the ability to record during the pulse sequence without compromising the raw EEG data. MagLink in conjunction with Neuroscan amplifiers has successfully recorded EEG data through the pulse sequence in up to 4 Tesla (T) MRI scanners. In our case we are using a 1.5T machine. Readily available software tools such as ACQUIRE and EDIT provide new features for on-line and off-line reduction and removal of hindering artifacts while retaining the integrity of the EEG. Also, post-processing tools allow brain event-related potentials (ERP’s) to be extracted which can then be subjected to source localization and compared with the previous CURRY results. Dipole models that converge with other localizing information serve as a powerful tool in determining if a patient can go to surgery directly without invasive EEG monitoring. This integration will provide accurate 3D localization of brain lesions and tumors in 3-D structures. These results will enhance the data (image, signal) interpretation, diagnosis, and validation of previous results, which are especially welcome in safety critical procedures. Current efforts are yielding very good results. This experimental setup required great efforts in overcoming the effect of noise beyond the technical merits of the MagLink.

2. Methods

2.1 Participants

Twelve children with medically refractory partial seizures undergoing pre-surgical evaluation have been analyzed in this study. The EEG data was recorded using XLTEK Neuroworks Ver.3.0.5 (by Excel Tech Ltd. Ontario, Canada). The standard international 10-20 system with 21 electrodes was used. Sampling frequency of 500Hz with 0.1-70 Hz bandpass filter settings and 12 bits A/D conversion were used to obtain the digital EEG recordings. MRI images were created using the Signa Horizon LX 1.5 Tesla MRI scanner (manufactured by General Electric, Medical Systems, Wisconsin, USA). High resolution T1 weighted spoiled...
GRASS (Gradient Recalled Acquisition in the Steady State) images were obtained.

2.2 Implementation Steps

To identify the location of the epileptic sources, a source localization program was developed using the NeuroScan software CURRY V.5.0. Input data in this study were EEG signals and MRI brain images of epileptic patients.

The first step in the localization procedure involved identifying the pertinent time intervals in the overall EEG recordings in which the interictal spikes occurred. The physicians performed this task by visual inspection of the recorded data. These portions of EEG data were 4-8 seconds in duration and during the spike interval the source localization analysis was performed using the CURRY based program.

In the preprocessing step DC and high frequency components were removed from the data using a 0.1-100 Hz band-pass filter. To reduce the configuration space and to extract the dominant EEG patterns, the EEG data is first decomposed into signal and noise subspaces using Principal Component Analysis (PCA) decomposition. This allows us to remove the noise subspace. After PCA, we apply Independent Component Analysis (ICA) on the signal subspace. The ICA algorithm localizes multiple dipoles independent of one to another. In this way the complexity of the search is reduced and the likelihood of obtaining a correct solution is increased. The PCA/ICA decomposition methods were applied and the first two or three largest principal components values were retained to account for the useful EEG epileptic signal information.

MRI brain scans were used to construct realistic subject dependant head models. The model derived was a Boundary Element Model (BEM) consisting of three compartments. The compartments used were skin, skull and brain tissue. These were obtained by segmentation of the MRI images and they were assigned the following conductivities: 0.33, 0.0042 and 0.33 S/m respectively [4].

Another implementation tool that Neuroscan provides is the Digitizer module. This module of the system allows the localization in 3D of the position of the scalp electrodes. After obtaining the real coordinates of the electrodes though a digital pen that is applied to the patients, the electrode positions were inputted to the CURRY software for co registration with the MRI. For each patient, a subject-dependant electrode placement was established. By digitizing in three-dimensional space, the scalp electrodes and the head landmarks (nasion, preauricular points, and inion), the EEG fields can be coregistered with a 3D MRI and a visual representation of the electrodes and the 3D MRI reconstruction of the patient’s head can be depicted for clinical interpretation [5].

The method applied for source localization was the Moving Dipole Solution, available in CURRY. A moving dipole can portray propagation of a given source very logically. The result obtained by implementing this method is the calculated location of the dipole in the form of a point \( \mathbf{r}_{qc} = (x_{qc}, y_{qc}, z_{qc}) \) in Cartesian coordinates and the strength of the dipole moment for each time instance. The time interval during which the source localization was performed was a 200ms maximum time range, which is a typical duration of an epileptic spike [2]. The most important subdivided interval that was analyzed was the rising portion of the spike. This seems to be the most important section of an interictal spike since it is related to the initial spike source. The results of the moving dipole analysis of this particular event allows tracking the propagation of the epileptic activity throughout the brain, which offers insight into the brain dynamics and, as a consequence, facilitates identification of the brain areas that are to be surgically removed [6-8].

3. Results

The source localization analysis was performed during the 200ms interval in which the spike occurred. This interval analysis allowed us to track the propagation of the source of epileptic activity from the onset of the spike to the generation of the slow wave representing the ending of the spike. Since the whole spike duration is divided into one or two intervals, the analysis yields one or two source locations per interval. Furthermore, for each source location the average was calculated as in [3] and the results obtained for each interval of the integrated EEG-MRI for all of the patients are illustrated for visual appreciation and source location analysis. It is important to note that 8 of these 12 patients underwent successful surgical interventions. The other four patients had also successful surgical interventions but prior to this study, but our results did confirm the clinical findings. These results for one given patient are illustrated in Figure 1.

4. Conclusions

Surgical treatment is being used with increasing frequency for patients with intractable epilepsy. Operative success depends to a large degree on the results of a comprehensive pre-operative patient evaluation, the main purpose of which is to delineate the epileptogenic lesion. The likelihood of the success of surgery is increased when all test results point to a single epileptogenic focus.
At the same time these localization techniques can help direct the placement of intracranial electrodes in case it is inevitably needed. Also, the characterization of spike propagation afforded by this method is considerably better than that obtained by the traditional visual inspection of EEG traces.

This preliminary study evaluated an integrated approach to the 3-D localization of epileptic spikes. The full process integrated the Principal Component Analysis (PCA) and the Independent Component Analysis (ICA) methods in the analysis of EEG data, using the multimodal neuro-imaging software named CURRY to optimize the accuracy of the 3-D localization results. The reconstructed 3-D sources correlated well with MRI lesions and complemented visual analyses of scalp EEG data. The superimposed images facilitated placement of intracranial electrodes for further defining the epileptogenic region and led to successful surgical interventions. The results of the interval analysis showed that the calculated 3-D sources were closest to the lesions. Interval analyses and moving dipole models provide a powerful tool for studying spikes propagation and have important pathophysiological implications.

The results are most encouraging, considering that the 3-D sources were computed using only the standard 10-20 system electrode placement. The use of closely spaced electrode array and averaging of multiple spikes in each subject will likely enhance the precision of 3-D localization. The results of this integrated technique will be soon further compared to the source localization of the EEG-MRI combination data using the MAGLINK system. This constitutes our next research step. A more inclusive analysis involving a higher number of patients, as they become available, will provide more credence to these findings.

References

1. Introduction

GRIDS have emerged as an essential infrastructure for resource-intensive scientific and commercial applications [8], [11]. Grid technology enables the sharing and dynamic allocation of distributed, high-performance computational resources while minimizing the associated ownership and operating costs; it also facilitates access to such resources and promotes flexibility and collaboration among diverse organizations. More recently, the concept of on-demand computing [5], [12] has emerged as a viable model in which a wide range of finer grain commercial, business, and scientific applications would tap into the Grid resources on an as-needed basis, extending the reach and utility of Grid computing far beyond its current user base to society as a whole. This vision of computing as utility is expected to change not only the way scientists and businesses work, but also the way they think about computing resources. However, its realization depends on the development of sophisticated resource management systems capable of allocating resources to users based on agreed upon quality of service (QoS) requirements [1], while satisfying certain system level objectives (e.g., high utilization, economic constraints, etc.) [3], [4].

Scheduling and management of Grid resources is an area of ongoing research and development. Several open source or proprietary schedulers have been developed for clusters of servers, including Maui [9], [10], portable batch system (PBS) [2], and load sharing facility (LSF) [6]; they typically run in batch mode, can be customized to specific policies, and attempt to balance the load among the various servers. However, the primary objective of most existing approaches is to improve overall system performance (e.g., utilization), while the QoS experienced by Grid users is at best of secondary consideration [11].

Advance reservation of resources is one mechanism that Grid providers may employ in order to offer specific QoS guarantees to application users. Advance reservation, i.e., the ability of the scheduler to guarantee the availability of resources at a particular time in the future, increases the predictability of the system and it has been an area of interest [1], [7], [8], [11], [13]–[15] in the Grid community. Although some schedulers provide some sort of advance reservation mechanisms, existing approaches to making reservations in the future lack sophistication, are expensive, and do not scale well. This lack of scalability is due primarily to two factors. First, as the number of resources in the Grid increases, the overhead of maintaining and updating the set of advance reservations can be significant, especially if appropriate attention is not paid to the design of the relevant data structures. Second, making advance reservations tends to fragment the available resources. If this fragmentation is not taken into account by the scheduling algorithm, the result will be poor utilization and high job rejection rate; on the other hand, algorithms which attempt to utilize the fragmented capacity but are not properly designed will suffer from unacceptably high running times as the number of resources increases.

In this paper we present a framework for designing effective and efficient scheduling algorithms that employ advance reservations to guarantee QoS to users

2. Description of the Problem

In this work we consider an environment where users submit jobs dynamically, and these jobs may start at a future time and must be completed within a certain deadline. Using concepts from computational geometry [10], we show how to manage efficiently the fragmentation of resources due to advance reservations by maintaining an appropriate set of balanced search trees. We also present a set of scheduling strategies for making advance reservations. Each strategy corresponds to a different optimization objective, and requires that the information on the advance reservations be organized and maintained in a slightly different variant of the search tree structure. Our algorithms scale to large Grid systems, and simulation results demonstrate that they perform well across several performance metrics that reflect both
user- and system-specific goals.

3. Results

We use simulation to evaluate the performance of the various scheduling strategies. We use the method of batch means to estimate the performance parameters we consider (and which we discuss shortly), with each batch consisting of thirty simulation runs and each run lasting until 106 jobs have been submitted to the Grid scheduler. We have also obtained 95% confidence intervals for all the results, which are shown in the figures. We use four performance metrics in our study. The loss rate is the fraction of jobs that are dropped due to the fact that their deadline cannot be met. The system utilization is the fraction of time the n servers are busy serving jobs. The average delay is the mean amount of time that a job has to wait beyond its ready time until it starts execution; note that dropped jobs do not contribute to the average delay.

The results of our extensive simulation show that our algorithms are simultaneously user- and system centric: they are able to schedule resources to meet the deadlines imposed by users and maximize system utilization, while experiencing low job drop rates and low delays.

4. Conclusions

We have applied techniques from computational geometry to develop a suite of scheduling strategies that allocate resources in a Grid environment using a range of optimization criteria. We also presented efficient implementation of the various algorithms that scale to large Grid systems.

References

A Software Tool to Help the Deaf and Hard of Hearing Experience Music Visually

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1. Introduction

The D/deaf and hard of hearing primarily lack the ability to hear all of the music and words in a song. They typically miss out on the high frequencies and/or words. Music is heavily dependent on the ability for one to hear. Without that ability, people do not understand music or “do not know what is being said” [2], or they can only make out a few fragments of a song.

Since the deaf and hard of hearing can feel music vibrations, much of the work that has been done in this area involves vibrations. Gordon Dalgarno’s concept, Enabling through Music, has included visual through a color graphical display where colored phrases are associated to the notes of the scale. Music can be experienced by three of the five senses: the ability to hear, to see, and to touch. Byrics creates an environment that communicates music visually via three components. A fourth component is added to provide a tactile element. Lyrics can be presented as visual information by displaying them as seen in karaoke systems. A karaoke-style system for the deaf or hard of hearing can help them place the lyrics in the song as the words are highlighted to assist the user. They will learn more of the words in a song that expresses feelings or tells stories. A second part of the solution is a beating heart to assist perception for the tempo of the song. A third part of the solution is a spectrogram (a graphical x-y representation of frequencies that are occurring over time) that can compensate for their inability to hear a wide range of frequencies. From this display, they can determine the frequencies and intensity of the sounds as the song is being played. A vibroacoustic speaker is the fourth and final part of the solution to experience music via vibrations and sound [5]. This provides tactile information about tempo and rhythm.

Figure 1 is a screenshot of Byrics with a song playing. The song is by Johnny Cash titled I Walk the Line.

2. Implementation

The Byrics software was implemented in Java to take advantage of its graphical ability and runtime environments. It is an event-driven application composed of several classes and data types. To play a song a user selects a karaoke file that is a MIDI file with lyrics. Song information such as song title, author, tempo (beats per minute), time division (ticks per beat), and song lyrics, is extracted from the file and stored for later use. The song title and author are displayed on the screen and the screen is divided into sections to display each of the visual components.

The karaoke file is processed via a large state machine to extract song information. The file structure, in hexadecimal format, starts with the header and is followed by tracks containing events such as meta. The header indicates the tempo and time division while the meta event contains the lyrics. A meta event is indicated by an event number (1 for text/lyrics), length of information in bytes, and the information itself [6]. Preceding the meta event is delta time, the time when one syllable starts to be sung after its antecedent is to be sung. Lyrics and delta times are stored in a list data structure to be later drawn on the screen at the appropriate time. A forward slash (/) indicates a new verse and when encountered, starts a new list for the next verse. An algorithm looks for spaces in between
the words in the list data structure to determine where to start for the next word and place the space character. The lyrics are drawn on the screen in a default color of black and then redrawn in the blue color when the time has come for it to be highlighted. The background color is light gray. On the screen is a black heart that is colored red then black then red and so forth indicating it is beating. The coloring of the heart is controlled via a Java timer that is based on the tempo of the song. The tempo is converted to milliseconds. Every beat per minute, the heart is colored red. It is then colored black at one and three quarters of the tempo.

To generate the sound of the karaoke file for the hearing part, the location of the MIDI file is given to a code by Matthias Pfisterer [3]. Several steps are involved to start playing the music. The information in a MIDI file is a sequence [7]. The MIDI file is given to a sequence object. Next, the default sequencer is requested. A sequencer is hardware or software that reads the sequence information and delivers the MIDI messages to the synthesizer. The sequencer is told which sequence object to play. A test is performed to determine if the sequencer and synthesizer or synthesizer are a combined object. If they are, the default synthesizer is requested and then opened. Now that the synthesizer and sequencer are ready, the sequencer is started and the synthesizer begins to play the music. As the sequencer continues, a meta event listener for 255 47 0 is activated. This indicates the end of the song and when detected, the sequencer and synthesizer are closed.

To generate the spectrogram, David Ponevac and myself modified code from M.I. Pickett [4]. The code reads bytes of sounds from the speaker and stores them in an array where they are converted and stored into an integer array. To calculate the frequencies, the Fast Fourier Transform must be applied. However applying it creates a distortion known as aliasing [9]. Applying a window function can solve this; the Hanning window can provide spectral leakage reduction [8]. The Fast Fourier Transform converts the array of values into a number that ranges from 0 to 1 indicating the intensity for that frequency. The array of values gives each time slice a colorful rectangle of data in the spectrogram. This intensity information is drawn on the screen. This process is repeated until the speaker starts generating sound.

With all these steps, a delay soon became visible that did not improve as the song progressed. Creating a pre-generated spectrogram solved this problem. The frequency information and the delta times were stored to a file. The delta time is the time of the current vertical frequency array to be drawn minus the time that the previous array was drawn. This information was pre-computed and associated with songs in Byrics. Because of the pre-computed data, users had to choose from a pre-selected list of songs.

The event-driven application waits for the user to make a decision and keeps track of that decision. After selecting a karaoke file, the user is expected to select the play option. With the play option selected, the spectrogram frequency and time information that was stored in a file is read and then stored again for later use. Variables are initialized that will be used for displaying the spectrogram and coloring the lyrics. Timers are started for the lyrics, spectrogram, and beating heart. These features continue to display until the user selects pause, stop, or they do not select anything letting the song play out.

3. Evaluation Method

3.1 Participants

Four people with varying levels of hearing loss evaluated Byrics. All participants tested each of the components within a song. While all participants are hard of hearing, and some wear hearing aids, those that were tested did not use their hearing aids.

3.2 Method

Each participant filled out a survey before interacting with Byrics. The survey inquired about their knowledge of spectrograms, whether they listen to music at present, if they heard music as a child, and if they preferred music with or without lyrics. Participants had heard music growing up and still do, but not all knew what a spectrogram was and some preferred music with lyrics.

Participants selected a song of choice in Byrics. The songs were divided to create an equal amount of time for exposure to each feature individually and lead up to the end of the song where each feature is fully visible. The participants then experienced Byrics with the vibroacoustic speaker. The participants then filled out a questionnaire asking for their opinion on the system. They provided a rating of the features and indicated which feature they liked best, what they would improve, and if the spectrogram was helpful. The participants found the visual features added to the song. The most popular feature was the lyrics because it familiarized them with the words of the song. While the least popular one was the spectrogram since the highs and lows of the music were not clear.

4. Conclusions

Overall Byrics did create an environment that communicates music visually. Participants were able to
enjoy the song more due to the visual features. Improving the spectrogram and adding more or different visual features could further communicate more information.

References


Performance Analysis of an Integrated Eye Gaze Tracking / Electromyogram Cursor Control System

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1. Introduction

Eye Gaze Tracking (EGT) systems allow individuals with motor disabilities to quickly move a screen cursor on a PC. However, there are limitations in the steadiness and the accuracy of cursor control and clicking capabilities they provide. On the other hand, a cursor control system to step the cursor up, down, left or right in response to voluntary contractions of specific facial muscles, developed by our group, provides steady and precise, albeit slow, cursor control, along with a reliable clicking mechanism. This system identifies muscle contractions by performing digital processing of the Electromyogram (EMG) signals generated by the facial muscles. Based on the complementary nature of the strengths of these two cursor control modalities we have developed an integrated EGT/EMG system in an attempt to consolidate the advantages of both input modalities. We have compared the selection accuracy and speed of an EGT-only cursor control implementation, our integrated EGT/EMG cursor control system and a standard handheld mouse in pointing and click trials.

2. Methods

2.1 EMG and EGT control methods

Our objective was to compare the cursor control performance achieved with an Eye Gaze Tracking (EGT) system alone, to that achieved with our integrated EGT/EMG system.

The use of EGT systems as a means of cursor control in Graphic User Interfaces (GUIs) has been studied extensively, and their shortcomings in terms of lack of screen cursor steadiness and potential for unintended selections (“Midas Touch” artifact) have been identified [1] [2]. For our study, the point of gaze (POG) screen coordinates were obtained from an ASL Model RHS P/T6 eye tracker, at a rate of 120 samples/second. A fixation identification algorithm analyzed a 100 ms moving window of consecutive POG data points, and calculated the standard deviation of their x- and y-coordinates. A fixation will be detected only when both standard deviations are less than the coordinate thresholds associated with 0.5 degrees of visual angle. The new fixation will be specified at the coordinates of the centroid of the POG samples received during the 100 ms window analyzed, (Fx, Fy). When the EGT system was considered alone, a click operation was commanded when the user’s gaze kept the same fixation for a “dwell-time” of 350 ms.

Similarly, Electromyogram (EMG) signals have been used in a number of input devices [3][4]. The EMG portion of the EGT/EMG system was driven by the analysis of EMG signals collected form electrodes placed on the right and left temples (temporalis muscles) and the forehead (right frontalis and procerus muscles). Each of these electrodes was expected to reveal the contraction of an individual muscle group, which could be used to command steps in the right, left, up and down directions, respectively. However, due to the volume conduction in the head, contraction of one muscle may cause significant EMG signals to appear in more than one electrode. Therefore, our system performs real-time spectral (Power Spectral Density) estimation and evaluates the Mean Power Frequency (MPF) from each of the EMG signals to identify which muscle contracted. The results of this spectral processing determine which stepping command should be issued, +/- Δx, or +/- Δy, if any. A click command is issued if a simultaneous contraction of both temporalis muscles (full jaw clench) is detected.

The integrated EGT/EMG updates the actual screen cursor position (Cx, Cy) using information from both EGT and EMG subsystems, according to equations (1) and (2), where (F’x, F’y) represents a “qualified fixation”, i.e., one that was detected at a distance from the previous cursor position that is larger than a pre-set threshold, and n is a discrete index [5].
and the next trial in the series would be presented to the subject.

3. Results

3.1 Results of Experiment 1

Mixed design ANOVAs were used to analyze the time and error rate results. After logarithmic transformations were applied to both the trial time [log_{10}(X)] and error rate [log_{10}(X + 1)] data sets, to achieve normality. The tests of between-subjects effects for trial time revealed a significant effect for cursor control technique (p < 0.0005) and the contrasts for these effects revealed that the EGT/EMG technique was significantly slower than both the mouse (p < 0.0005) and EGT (p < 0.0005) techniques. The mean +/- standard deviation time values were 0.94 +/- 0.38 sec. for the Mouse; 3.07 +/- 0.38 sec. for the EGT alone, and 4.68 +/- 0.38 sec. for the EGT/EMG. The tests of between-subjects effects for error rate also displayed a significant effect for cursor control technique (p < 0.0005), and the contrasts for these effects revealed that the EGT/EMG technique had a significantly smaller error rate than the EGT technique (p < 0.0005). The contrasts also showed that the error rate produced by the EGT/EMG technique was comparable to that of the mouse (p = 0.206). The mean +/- standard deviation error values (in errors/trial) were 0.01 +/- 0.24 for the Mouse; 0.13 +/- 0.24 for the EGT/EMG and 3.98 +/- 0.24, for the EGT alone.

3.2 Results of Experiment 2

Experiment 2 was treated as a repeated measures experiment. The number of selections of “N” label targets (selection errors) per session was studied. Since the data were not normal, non-parametric tests (Friedman test and Wilcoxon signed-rank test) were used. The mean error rates (per trial) were 0.396 for the EGT system and 0.017 for the EGT/EMG system. The Friedman test revealed that the difference between the ranks of each treatment condition was significant (p < 0.0005). The Wilcoxon test indicated that these differences were due to effects of the cursor control techniques, because significant differences were only found between treatments that involved different techniques.

4. Conclusions

The experimental results indicate that the integrated EGT/EMG cursor control system was somewhat slower than the EGT system alone, but also indicated that EGT/EMG provides increased precision.
and more reliable left-click over EGT, as evidenced by a significantly lower error rate. The enhanced accuracy achieved with the inclusion of EMG control may reduce the frustration sometimes experienced by EGT interface users. It is also feasible that more extensive periods of EGT/EMG interface usage may help subjects become accustomed to its dual-mode nature and may result in additional speed gains. Future tests involving individuals with motor disabilities will illuminate these questions.

References


A Novel Grid-based Data Storage Paradigm

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1. Introduction

Many resource-intensive scientific applications have spawned in recent years. These applications require large amounts of compute power and storage space. In this work, we address the need for storage space. Since allocating all data in one location for these applications is not always possible and/or desired, several methods of decentralizing the storage have been implemented. The storage volumes may cross administrative domains, which raises privacy and security issues that need to be addressed. One area of study that addresses this problem of maintaining security and privacy while still allowing sharing of resources is Grid Computing [1].

We use the Globus Toolkit, version 4 (GT4) to show how efficiently this functionality can be implemented. We demonstrate the efficacy of our approach by providing performance results as well as applications where it has been used.

2. Methods

2.1 Requirements for Grid-based data sharing

Grid-based data access and storage solutions should resemble native methods of access and storage as much as possible. This includes abstraction of the underlying file system as well as retention of the security, access control, and reliability of the data.

2.2 Exploiting Available Functionality

A properly configured GT4 installation provides much of the necessary functionality of grid-based data storage. This includes mechanisms and services for data transfer and file replication and virtualization. It also includes authorization and authentication mechanisms, to ensure only grid-members can use these and other grid services.

The included data transfer mechanism, GridFTP, was found to be adequate for the transferring of files. Previous work [2] has shown it to provides good performance and fault-tolerance, both of which are particularly important when dealing with large files. The security paradigm, i.e. The Globus Security Infrastructure (GSI) was also found to be adequate. It is based on the X.509 security paradigm, for which only one possible security vulnerability was found [9].

2.3 Implementing the Services

The built-in functionality of GT4 saved much of the necessary work for implementing the data grid functionality. The services created may even be seen as necessary extensions for enabling filesystem-like attributes in a GT4-powered computing grid. One of these “missing features” includes the ability to register storage volumes into the grid for later usage. Also, the lack of a service for transferring files and being able to access them, without regard for where they are stored. There was also a shortcoming in regards to security. These three issues were addressed by means of a set of Web Services Resource Framework (WSRF) grid services, known collectively as the DataGridService.

In order to be able to store data, it is necessary to be able to specify where to store the data. One way of doing this is by registering storage resources (i.e. disk drives) in some kind of repository, where others can access them. We addressed this by creating a service that allows grid members to share their disk drives. Registered drives are made discoverable through the GT4 Index. Using calls to the Monitoring and Discovery Service (MDS), users could find drives based on their location, available storage space, and name.

The next issue that had to be addressed was allowing users to seamlessly store and access data. Using the GT4-provided ReliableFileTransfer (RFT) service and Replica Locator Service (RLS), users could store files and then assign virtual file name mappings to access them later. But this entails having to do these two tasks (i.e. transfer and mapping) separately. Also, they would have to figure out where to store the files. We created a service that abstracts all of this functionality: the user merely specifies the source file to be transferred, and the desired virtual file name to
access it by when needed. The service finds a sufficiently large data storage resource, transfers the file, and assigns a logical-to-physical file name mapping.

We found that access control needed to be addressed as well. This includes physical-file security and logical-file-name security. For physical-file access control, we ensure that the destination file permissions match the source file permissions after transferring. By default, the GT4 RLS allows any grid user to set mappings for logical file names. This creates possible access violations by malicious and naive users. We addressed this by only allowing a single RLS “administrator” account to create mappings. When creating a logical file name mapping, a user must delegate the task of creating the mapping to the RLS “administrator.” A database was created, using OGSA-DAI [12], to keep track of users who create logical mappings initially. The delegation of a new physical-file mapping to an existing logical file will only succeed if the user attempting to do so is authorized by the initial creator of the mapping.

3. Results

The results of the implementation were positive. Little overhead was experienced from the additional functionality. The implementation has been tested in two applications. One is a rudimentary medical grid and another is a seizure detection application. Table I shows the transfer times when using Secure FTP (sftp), GridFTP, RFT, and the DGS. As can be seen, our added functionality results in practically no overhead when dealing with large files, which is typical for applications that utilize data grids.

<table>
<thead>
<tr>
<th>Transport Mechanism</th>
<th>512K</th>
<th>5M</th>
<th>50M</th>
<th>500M</th>
<th>1000M</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFTP</td>
<td>0.050</td>
<td>0.382</td>
<td>3.33</td>
<td>31.7</td>
<td>63.3</td>
</tr>
<tr>
<td>GridFTP</td>
<td>0.056</td>
<td>0.304</td>
<td>3.45</td>
<td>27.8</td>
<td>55.6</td>
</tr>
<tr>
<td>RFT</td>
<td>0.297</td>
<td>0.638</td>
<td>3.65</td>
<td>27.9</td>
<td>56.2</td>
</tr>
<tr>
<td>DataGridService</td>
<td>0.783</td>
<td>1.03</td>
<td>3.12</td>
<td>28.5</td>
<td>56.8</td>
</tr>
</tbody>
</table>

Data insertion times for individual files of various sizes.

4. Conclusions

The results in Section 3 demonstrate that this implementation is suitable for deployment in a grid, in terms of performance. The security characteristics are also adequate for this purpose. The added abstraction makes data transfer and access easier to implement for developers of higher-level grid services. In fact, the rudimentary medical grid mentioned in Section 3 does this.

In its current state, the implementation is not adequate for the general population, due to its lack of local file system integration. This issue will be addressed in the future. One way of addressing this, which is implemented with AlienFS [2], is by using the Linux File System in User-Space (FUSE) module. However, technical users and developers can immediately use its features in practical applications, as we have demonstrated with our own applications.

References

1. Introduction

The use of maps is becoming more pervasive as geographical information system (GIS) technologies succeed in their goal of providing users with easier ways of accessing, combining and visualizing geospatial data. The commercial success of products like Google Earth and Microsoft Virtual Earth demonstrates that the use of maps can and will keep increasing in the future. Of particular interest in science is the generation of maps from the combined use of GIS technology and more readily available data provided by cyber-infrastructure communities [1] such as National Science Foundation (NSF) funded Geosciences Network (GEON) [1] and Circumarctic Environmental Observatories Network (CEON) [2, 3]. Scientists, who are not necessarily GIS experts, can now use their data along with data provided by these and many other cyber-infrastructure communities to create maps on demand.

Maps, however, as any scientific result, are subject to imperfections, and most imperfections are too subtle to be identified by scientists whether they are subject matter experts (SME) (with respect to data used to generate maps), GIS experts, or just ordinary scientists with a specific need for a given map. For example, maps may be inaccurate because of: a faulty sensor in a collection of sensors used to generate a large geospatial dataset; incompatible ways of reading, storing, and combining measured geospatial data; services used to derive maps that are incompatible when combined; or even because of inappropriate use of parameters for any of the services used to derive a map. GIS and cyber-infrastructure, thus, may provide a context for the creation and proliferation of maps that one could label as inaccurate or low quality if one could know more about how they were generated.

We believe that providing users with information about how results were generated, known as provenance, will help them to both identify whether a map is of low or high quality and explain why it is of the said quality. Provenance, in the context of this study, is meta-information about how complex results, which can be maps, are generated. Our definition of provenance includes information about the following: sources of data or information known as source meta-information; and executions of processes, i.e., workflow execution traces, including intermediate datasets generated during process known as process meta-information.

We have conducted a user study to analyze how scientists, with different levels of expertise on gravity data for geophysics and GIS, can differentiate between contour maps of high and low quality. The primary goal of this study is to verify that provenance is needed for scientists to accurately assess the quality of scientific results such as maps. The study relied on the use of Probe-It! [4], our provenance visualization tool, to present both the maps and their associated provenance. The long-term continuation of the study will provide us insight into many different aspects of provenance usage such as what visualizations are most effective for viewing provenance and allow us to further improve Probe-It! by integrating these findings.

2. Probe-It!

Probe-It! [4] is a provenance visualization tool that can graphically render provenance information provenance information associated with results coming from software agents and scientific workflows, such as workflows that generate maps. In our work, we define provenance visualization as a framework suitable for visualizing both scientific results and associated provenance. We believe that the fusion of visualization and provenance techniques can provide scientists with information needed to judge the quality of results, which can be seen as complimentary to other quality assessment approaches such as uncertainty propagation.

Because Probe-It! is only a browser, Probe-It! does not actually generate or log provenance information about a workflow; instead it is assumed that users or software agents will provide Probe-It! with end-points of existing provenance resources to be
viewed. The task of presenting provenance in a useful manner is difficult in comparison to the task of collecting provenance. Because provenance associated with results from small workflows can become large and incomprehensible as a whole, Probe-It! consists of a multitude of views, each suited to presenting the different elements of provenance such as the query, final results, process meta-information, and source meta-information.

3. User Study

The goal of our study is to determine if scientists need provenance to correctly assess the quality of maps. There are many factors that may affect the outcome of our study, such as the level of expertise or familiarity with domain. Since our sample was relatively small, we choose to address only two basic hypotheses:

1. Scientists with access to provenance will identify and explain the quality of maps more accurately than scientists without access to provenance
2. Scientists with access to provenance and the ability to compare among alternative maps will identify and explain the quality of maps more accurately than scientists with access to provenance but without the ability to compare.

3.1 Participants

The requirement for participation in the user study is that the subjects are active researchers in some scientific field. Although the study is focused on gravity contour maps, the claim is that with provenance, most scientist can identify and explain the quality of some map, regardless of the services and domains of the datasets used to generate the map, granted the scientists has some understanding of what can go wrong in the generation.

The study included the participation of twenty scientists from various fields including geophysics, geology, biology, environmental sciences, and physics. These scientists are affiliated to various organizations located in Alaska, Arizona, California, Oklahoma, Texas and Brazil.

3.2 Evaluation Cases

Our study aims at determining whether or not scientists require provenance in order to correctly identify and explain map quality, thus our user study is focused on generating maps of varying quality and asking subjects to both classify and explain them under different conditions. In order to test our hypotheses, we require at least three different test conditions or cases when subjects perform the identification and explanation tasks:

- when subjects have only the maps to examine, denoted as case map
- when subjects have both provenance visualized through Probe-It! and the maps to examine, denoted as case map+p
- and when subjects have provenance visualized through Probe-It!, the maps to examine, and as well as the ability to compare provenance visualization among different maps, denoted as case map+p+c

4. Results: The Need for Provenance

Condition cases map versus map+p tested whether provenance was needed in order to correctly assess maps; both cases are based on the same map containing the same error with the ability to access provenance in condition map+p being the only difference. Prior to the use of provenance, many scientists were unable to determine whether the map contained any imperfections at all, in which case their responses were regarded as unsuccessful earning a score of 0. After the scientists were able to access the provenance, both their accuracy in determining the quality and explaining why the map is of said quality improved significantly given the number of test subjects. Provided a single-tail t-test, we can claim that we are 95 percent confident that observed difference in accuracies were influenced only by the capability to access provenance and not by random chance.

When scientists were granted the capability to compare different maps and their corresponding provenance, as in case map+p+c their accuracy seemed to improve only marginally from the accuracy of scientists who only had only a single map to evaluate as in case map+p. However, given our small sample and the relatively small difference in accuracies between the means of map+p and map+p+c, we cannot conclude at this time that providing users with both comparisons and provenance will allow them to better identify map imperfections than users with only provenance. However, from an observation point-of-view, it appeared as if subjects could more confidently complete the tasks given a set of maps rather than only a single map.
5. Conclusions

The evaluation presented in this paper demonstrated that most scientists are unable to correctly classify a map as poor or of high quality if no knowledge provenance is provided with the maps. With the use of provenance, however, the study showed that most scientists performed significantly (statistically proven by a single tail t-test) better in classifying the maps. Moreover, the study demonstrated that most scientists could identify the factors leading maps to be of low quality with the help of provenance information better than scientists who did not have access to provenance. Unfortunately, at this time, we are unable to claim anything about the effects of comparison in the tasks of identifying and explaining map imperfections. As our study and evaluation data mature, however, we believe that the benefits of comparison will be revealed along with several aspects of provenance covered in the experiment but not discussed in this paper due to the lack of statistical significance.

State-of-the-art cyber-infrastructure-based applications are getting close to a point where they will be able to generate large quantities of maps, probably several of those with one or more imperfections. Probe-It! is moving towards the right direction as pointed by the evaluation results summarized above and indicated by the study's subjects as most of them are already aware of the necessity of cyber-infrastructure-based applications to support knowledge provenance.

References

2. Circumarctic Environmental Observatories Network
4. CEON Internet Map Server. www.ceonims.org
1. Introduction

Imaging radar systems deal with the transmission and reception of microwave signals in order to extract range and azimuth information from a detected target. The imaging radar system is usually mounted on a moving platform which is assumed to travel uniformly along the azimuth direction. Radar imaging or image formation involves the processing of the transmitted signal $s_r(t)$ and its returned echo signal or received signal $s_r(t)$ in order to extract range and azimuth information which is expressed in terms of the range resolution $\delta_R$ and the azimuth resolution $\delta_a$ (see Figure 1.1).

The work conducted for the Lockheed Martin Company consisted in the development of digital signal processing algorithms to assist in this image formation operation. The algorithms were developed for synthetic aperture radar systems which have the additional property of improving the azimuth resolution during the imaging process.

The radar range is defined as the distance between the transmitter/receiver and the target and it is proportional to the time delay. The time delay, also known as the detection time, is measured from the instance the signal $s_r(t)$ is transmitted to the moment the signal $s_r(t)$ is detected at the receiver. The range and time delay are related by the equation $\Delta R = c\Delta t/2$, where $\Delta R = r$ defines the range, $t$ the time delay, and $c$ the velocity of light. Thus, estimating the time delay $t$ is proportional to estimating the range of the detected target. It takes $\Delta t = 2\Delta R/c$ before the signal scattered by a point target is detected by a receiver.

The slant range resolution between point targets is given by $\delta_R \geq c\tau/2$, where $\tau \approx 1/B$ is the pulse width and $B$ is the pulse bandwidth. The slant resolution can then be expressed as $\delta_R \geq c/2B$. This implies that the slant range resolution can be improved by increasing the signal bandwidth. This is a very important result which allows for bandwidth increase through a pulse compression operation. The ground range resolution is given by $\delta_R \geq c\tau/2\sin\theta$, where $\theta$ is the incidence angle.

For a conventional radar system, the cross range resolution or azimuth resolution is given by $\delta_a \geq \Delta R\lambda/L$, where $\Delta R = r$ is the given range, $\lambda$ is the radar wavelength, and $L$ is the antenna aperture length along the azimuth direction. For a synthetic aperture radar system, the azimuth resolution is given by $\delta_a \geq L/2$, where $L$ is, again, the antenna aperture length along the azimuth direction.

It is important to point out that the azimuth resolution of a SAR system does not depend on the frequency of the radar system or its range. An imaging result is obtained by combining the range and azimuth resolutions (see Figure 1.2). The SAR algorithms developed for this Lockheed Martin project aimed at
processing the transmitted and received signals in order to extract the necessary range and azimuth information.

2. Objectives

The main objectives of this work are presented as follows:

- Develop SAR support algorithms for image formation operations
- Implement the algorithms on a TMS320C6713 DSP platform
- Describe lessons learned through the implementation effort

The development of the SAR support algorithms was conducted by first using MATLAB as a tool for designing and testing the algorithms, and then writing source code using C language for the tested algorithms. The C source code was then implemented on the target TMS320C6713 DSP processor using the Code Composer Studio algorithm development environment under the Starter Development Kit.

3. Image Formation Development Process Using MATLAB

After implementing the FFT and corner turning operations, both were combined to perform image formation development processing, using MATLAB as a development tool.

Raw data was taken as input for the program implemented, and two types of compression were performed with the main goal of obtaining an image formation as final output. A range compression was carried out along the vertical direction of the data (in the column directions). After compressing the data in range, an azimuth compression was performed along the horizontal directions (in the row directions). Maximum limits were defined for range (2800) and azimuth (17897) directions. The raw data was processed in blocks of eight rows, and was divided in nine subplots.

3.1. Range Compression

To perform the range compression, the following parameters were taken into consideration: the sampling frequency $F_s$, the pulse duration, a given slope, and the block of data to be processed. The sampling period $T_s$ was defined as follows:

\[ T_s = \frac{1}{F_s} \]

A time range $t$ was defined in terms of the sampling period, and was centralized as shown below:

\[ t = T_s * (-npt2 : npt2); \]

where the parameter $npt2$ is half the total number of points contained in a block of the raw data. The phase used for range compression was obtained as:

\[ \text{phase} = \pi * \text{slope} * t * t; \]

A new parameter $cref1$ was created, in terms of the phase previously calculated:

\[ cref1 = \exp(i * \text{phase}); \]

Next, the transpose of $cref1$ was obtained, and afterwards a FFT was applied as follows:

\[ cref = (cref1)'; \]
\[ cref = \text{fft}(cref, n); \]

Finally the conjugate was computed, defining the vector $fcref$, as follows:

\[ fcref = \text{conj}(\text{fft}(cref, n)); \]
where \( n \) represents the number of columns.

Afterwards, a corner turning operation, and then a FFT operation was performed on the data, defining the matrix \( f\text{data1} \) as follows:

\[
f\text{data1} = \text{fft}(\text{data});
\]

Next, a matrix \( \text{range} \) was created of size \( nxn \), where each column of the matrix was defined as \( \text{freq} \). Then the parameter \( f\text{data1} \) was multiplied by the matrix \( \text{range} \), as follows:

\[
\text{res} = f\text{data1} \ast \text{range};
\]

After this is done, an inverse FFT is performed on the matrix \( \text{res} \), followed by a corner turning, to following obtain the data in range compression:

\[
\text{datarange} = \text{fft}(\text{res});
\]

\[
\text{datarange} = \text{datarange}';
\]

### 3.2. Azimuth Compression

After performing range compression, the azimuth compression is carried out on the data previously compressed in the range direction. The following parameters were used: the pulse repetition frequency and the data compressed in the range direction \( \text{datarange} \). The sampling time \( T_s \) was defined as follows:

\[
T_s = \frac{1}{\text{PRF}}
\]

A time range \( t \) is defined in terms of the sampling period, and was centralized as shown below:

\[
t = T_s \ast (-\text{npt2 : npt2});
\]

where the parameter \( \text{npt2} \) is half the total number of points contained in a block of the data compressed in the range direction. The phase used for azimuth compression is calculated as follows:

\[
\text{phase} = -2. \ast \pi \ast \text{freq} \ast t + \pi \ast k \ast a \ast t \ast t;
\]

where \( \text{freq} \) is the natural frequency corresponding to the current block of data being processed, and \( k \) was a parameter defined to be equal to 1733. Afterwards, the following exponential was computed in terms of the parameter \( \text{phase} \):

\[
\text{cazi} = \exp(-i \ast \text{phase});
\]

Afterwards the transpose and the FFT of \( \text{cazi} \) were calculated and stored in the variable \( \text{cazi} \). Then the conjugate was computed and stored in the variable \( \text{fcazi} \), as follows:

\[
\text{fcazi} = \text{conj}(\text{fft}(\text{cazi}, \text{Nrg_lines}));
\]

where \( \text{Nrg_lines} \) is the number of lines being processed in the block of data. Subsequently, the FFT of the data compressed in range \( \text{datarange} \) was computed, and stored in the matrix \( \text{fftdata1} \) as so:

\[
\text{fftdata1} = \text{fft}(\text{datara nge});
\]

To finally obtain the data in azimuth compression, \( \text{fcazi} \) is multiplied by the matrix \( \text{fftdata1} \). The inverse FFT is computed to finally obtain the data compressed in the azimuth direction, and hence the image formation as the final output.

### References

A Property Specification Tool for Validating Formal Specifications: Prospec 2.0

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1. Introduction

The Cyber-ShARE [1] Center of Excellence (Sharing Resources through Cyberinfrastructure to Advance Research and Education) was established in September 2007 with funding from the National Science Foundation. The mission of the Cyber-ShARE Center is to advance and integrate education and research in uncertainty, trust, and optimization in support of cyberinfrastructures (CI) to (a) develop and promote scientist-centered software services and middleware and tools that help scientists use technologies such as provenance, ontologies, and workflows; and (b) promote collaborative and interdisciplinary research approaches to advance the state-of-the-art in earth and environmental sciences. Cyber-ShARE brings together experts in computer science, computational mathematics, education, earth science, and environmental science.

A concern in using CI is the inability to know whether services (discovered using CI) will behave as one would expect, especially when more than one service is used to complete a task. Runtime verification techniques such as runtime monitors (both static and dynamic) can provide the needed assurance. Runtime monitors as well as model checkers, another formal verification technique, require users to formally specify behavioral properties. Creation of formal specifications is difficult, and there is inadequate tool support for this task.

The Property Specification tool, Prospec [2], was developed to assist users in the automated creation and validation of formal specifications. This work introduces a newer version of Prospec, referred to as Prospec 2.0, which supports the formal specification of properties, in particular those that can monitor software services discoverable through CI.

2. Prospec

The use of formal methods to support software assurance requires the ability to identify behavioral properties of the software system, generate formal specifications of that behavior, validate the specifications, and verify the correctness of the system. The effectiveness of the assurance approach depends on the quality of the formal specifications. A significant hurdle to the use of formal approaches is the development of correct formal specifications.

Formal specifications are a challenge because: 1) software properties are typically domain specific; 2) the expressiveness of the logic may not support the specification of a desired property; and 3) it is difficult to understand and validate formal specifications without a formal background.

The Prospec tool supports users, who may not have a formal background, in formally specifying software properties based on high-level requirements. The tool specifies program properties using scopes and patterns as defined by the Specification Pattern System’s (SPS) [3] and Composite Propositions (CP) [2]. Prospec generates formalized specifications in Future Interval Logic (FIL) [4] and Meta Event Definition Language (MEDL) [5]. Work is in progress [6] to generate Linear Temporal Logic (LTL) [7] formulas and to use finite-time traces of computation to generate graphical representations of specified properties. Usability studies of Prospec have shown that the tool is useful in the elicitation and specification of formal properties [8].

3. Prospec Motivation

This section provides an example to illustrate the importance of runtime monitoring in preventing failures, and to show how Prospec can be used to formally specify runtime monitoring properties.

The need for the proposed approach can be exemplified by an actual situation [9] in which a geoscientist developed an application to implement inverse modeling and made it available for others to use. The developer assumed that the application would be used in the context of generating models of the Earth. Another scientist who used this application reported that the service was not operating as expected.
Once the geoscientist realized that the service was being applied to a nanotechnology application in which the values were below the threshold that he had set in the algorithm, it was clear why the service failed. Monitoring the input values would have detected the problem sooner. In light of society’s reliance on geological studies and the impact if results are flawed, the monetary savings provided by runtime monitoring can be potentially huge.

Prospec can be used to formally specify the properties for a runtime monitoring system. The tool guides a user in the development of formal specifications. It includes patterns and scopes, and it uses decision trees to assist users in the selection of appropriate patterns and scopes for a given property. Prospec supports the specification of CP classes for each parameter of a pattern or scope that is comprised of multiple conditions or events. The use of CP classes allows practitioners to specify ordered sequences, non-deterministic sequences, and concurrency. Prospec uses guided questions to distinguish the types of scope or relations among multiple conditions or events. By answering a series of questions, the practitioner is lead to consider different aspects of the property. A type of scope or CP class is identified at the end of guidance. Prospec generates the formal specifications in Future Interval Logic (FIL) [7] and the Meta-Event Definition Language (MEDL) [8].

4. Results

This section presents the results of the project to date and the new questions that have emerged from the research.

A formal experiment evaluated the effects that Prospec and SPS have over the quality of the generated software property specifications with respect to completeness and correctness [8]. The following research hypothesis was supported: users who specify software properties using Prospec correctly identify, on the average, more patterns and scopes than users who specify software properties using the SPS web site. The subjects also provided comments for improving Prospec in the post-evaluation form:

- to provide the capability to access all the properties defined in a given project;
- to allow the capability to apply the negation operator to propositions;
- to indicate the properties that contain a recorded assumption; and
- to modify the physical position and labels for parameters \( S \) and \( P \) in the response and precedence patterns in the pattern screen.

These and other observations from users of Prospec motivated the need to extend the features of Prospec. The revised tool will include changes to the interface and, more significantly, the tool is being revised to generate LTL specifications with support for validation of the specifications.

In addition, Prospec 2.0 will support OS interoperability. The graphical user interface has been redesigned to better accommodate the needs of the developers and clients, i.e., scientists in the case of Cyber-ShARE.

The work on Prospec has opened further research questions. 1) What types of properties are of interest to scientists in the environmental and earth sciences? 2) Is the use of propositions in Prospec too restrictive for the types of properties that need to specified? If so, what is needed to specify properties in these domains? 3) What is the best way to graphically present specifications for validation purposes? 4) Is the MaC PEDL approach sufficient to map specification into appropriate language constructs?

5. Conclusions

There is a need for software assurance of Cyber-ShARE services. Runtime verification can be used to provide the desired software assurance. Runtime verification techniques rely on the quality of the provided formal specifications. Generating formal specifications is a difficult task, thus the need for adequate tools to ease the specification process. Prospec 1.0 has been shown to be useful in the elicitation and specification of formal properties. This work presents Prospec 2.0, the improved formal property specification and validation tool that can be used to formally specify behavioral properties for software assurance of Cyber-ShARE services.

References


1. Introduction

Brain mapping with fMRI offers the potential to revolutionize the evolution of patients undergoing epilepsy surgery by identifying critical brain areas to spare during resection. The objective is to eliminate or reduce the need for invasive methods that carry measurable medical risk currently employed to map language while also using fMRI to investigate the neurobiology of plasticity of essential cognitive functions, for example language, known to occur in epilepsy populations during critical periods of cognitive development.

To achieve these goals it is necessary to establish a multi-site fMRI repository, where the participant health care institutions identify patients with atypical language and provide pilot data necessary to conduct a large scale study and compare fMRI findings to invasive methods such as IAT and ECS. Also, to investigate the effect of epilepsy, and its remote causes, on language networks in children. For this, we need to establish a network infrastructure for multi-site collection and management of functional imaging data and information linked to a database of common assessments and measures. This integration of important data will benefit in a unique way, by incorporating our resources together and optimizing their analysis.

fMRI is non-invasive, does not carry the risk of either intra-carotid amobarbital testing (IAT) or electrocortical stimulation (ECS), and different paradigms can be utilized to map different cognitive functions. Unlike IAT and ECS, fMRI can be readily repeated to confirm findings, and can both lateralize and localize different aspects of language functions. Several studies demonstrate the excellent correlation between IAT and fMRI in adults and children. Compared to ECS, fMRI has a sensitivity of 90% and a specificity of 67% in adults. fMRI has been proposed as a substitute for more invasive methods. fMRI has been shown to predict language and memory deficits following temporal lobotomy, and alter decision making in surgical planning thus reducing unnecessary risk.

There are, however, barriers that remain in the application of fMRI to minimize the use of other invasive means. The concordance with typical language lateralization is high, but the statistical validation with atypical language representation has not been firmly established, as most centers report 10% partial discordance between IAT and fMRI. Overt disagreement is rare (right vs. left); partial discordance arises when one method suggests bilateral language and the other lateralized language. Several approaches have been used to address this limitation (repeating tasks, using tasks targeted at the same language areas, and using a panel of tasks targeted at different aspects of language processing) but discrepancies remain. Blood-oxygen-level dependent or BOLD is the principle followed to detect areas of the brain under activity. It was found by Dr. Seiji Ogawa and Dr. Robert Turner, working independently. The principle is based on the fact that in the moment that neurons fire, they need immediate energy, as a result of that blood provides oxygen to the neurons at a greater rhythm as compared to a neuron not excited. This process is referred as hemodynamic response. Furthermore, oxygenated or deoxygenated blood present differences in its physical magnetic susceptibility, which results in a difference in the magnetic field which is sensed during the MRI scanner operation. BOLD is widely used due to the fact that the generated signal are analyzed using statically method so the signal are relative to each other and present the power of statistical analysis in their result.

The primary barrier to delineating the circumstances where fMRI is reliable is sufficient patient numbers to generate statistical power.

A commonly perceived impediment to most multi-site imaging studies lies in the differences in scanners,
paradigms, and analysis techniques utilized. However, both normal volunteer findings and experience with patients across sites using the same or similar paradigms find similar results for location and laterality of language activation\textsuperscript{4, 5, 8, 10}. Site maxima do not depend on scanner, a view confirmed by meta-analysis methods for paradigms that are the same or share common features\textsuperscript{7, 9}.

The absence of cross-site collaborations or image acquisition standardization further limits our understanding of the spatio-temporal behavior of the brain activation patterns while performing controlled tasks. Likewise, the statistical analysis has been very limited, limiting as consequence the critical process of meaningful interpretation and validation. The utility of fMRI to identify atypical language in childhood localization related epilepsy remains fragile. Several questions wait to define the role of fMRI language mapping in pre-surgical epilepsy evaluation. These limitations can only be defined with experience in substantial populations with atypical language.

2. Methods

2.1 Participants

A total of 13 health care institutions are providing fMRI dataset and clinical data for the subjects.

All sites hold individual IRB approval for clinical databases, and all data stored in the database are de-identified at the acquisition site to preserve patient confidentiality.

2.2 Implementation Steps

General steps followed were:
1. Database design based on forms provided by experts
2. System architecture selection.
3. Software and Hardware selection and solution implementation.

The database design was divided into two stages. First, a conceptual design is defined, which has the purpose of mapping the real world information into conceptual blocks. Second, an implementation design was described, which lists all the actual tables needed to hold the information defined in the conceptual design. To achieve a good database design, it was considered necessary to separate the information into small tables to avoid empty spaces in the records of the main tables. Fig.1 depicts the design layers and tables list defined in the database design.

The major objective of the conceptual design model was to integrate the different pieces of information coming from the medical experts into a consistent model, in which entities and relationships are explicitly declared.

![Figure 1. Conceptual Design for the Medical Image Archive System](image)

Once the database was designed and implemented using mysql as database management system, the following steps were carry out for Software and Hardware selection:

1. Design and test through simulation the platform architecture using Opnet.\textsuperscript{6}
2. Hardware selection: (a) Webserver: Hp Proliant ML350 /Dual Xeon @ 3.2 GHZ/2 GB RAM/250 GB, and (b)Database Server: Hp Proliant ML350 /Dual Xeon @ 3.2 GHZ/8 GB RAM/ 1 TB SATA RAID 5
3. Implement the architecture using a Linux-Apache Mysql PHP (LAMP) solution.
4. Select the image processing platform used for post-processing fMRI images and link it to the designed platform.

![Figure 2. Architecture of the web-based repository site of fMRI medical images and clinical data.](image)
The platform architecture of the web-based user interface is shown in Fig.2. After the program platform identifies a logged user, the program is invoked either to access the medical database or connect other sub-WebPages.

The front-end layer of the system design is the web-based user interfaces (GUIs). They are developed to facilitate the users computing environment. These interfaces can be implemented using virtually any programming language, but in our case we mainly focused on php5; Personal Home Page scripts (http://www.php.net), complemented with JavaScript and Java.

The application used for postprocessing the fMRI data set was FSL, fMRI Software Library developed by Oxford University.

3. Results

As a result of this study we have successfully designed and implemented a flexible web based application, providing a multisite MRI data repository that is used to warehouse substantial data to convey studies over a widely distributed demography supported by 13 healthcare institutions nationwide and abroad.

It has been possible to post-process successfully some dataset received obtaining the localization of the activation pattern for the given paradigms. The results obtained are: (1) Brain image showing Z map activation patterns resulting of processing fMRI data; (2) Time plots showing the relation between the raw data and the model fit data; and (3) Z value and localization coordinates of maxima on the brain activation clusters.

4. Conclusions

The Main contributions of the multisite platform are in (1) investigating the effect of disease states and developmental disorders on the plasticity of language networks during critical periods of development; and (2) Establishing the mechanism for coordinated imaging studies in pediatric epilepsy, including the study of memory and other advanced imaging sequences.

References

1. Introduction

In the late 90s researchers at IBM TJ Watson Research Center demonstrated that short optical pulses from submicron channel length complimentary metal-oxide-semiconductor (CMOS) integrated circuits were visible during high-speed operation at normal design voltages. Such circuits were characterized by switching times in the order of 100ps and their short electrical transients occurring during switching of the individual $n$- and $p$- metal oxide semiconductor field effect transistor (MOSFET), building block of these circuits, produce readily detectable light pulses of similar duration [1]. The type of light generated by the interaction of hot electrons and the silicon lattice during switching was found out to be in the infrared range.

The realization of this IR light emission from circuits led to the development of a new passive optical method for the noninvasive measurement of the switching activity of operating CMOS integrated circuit chips. This new method was denoted as picosecond imaging circuit analysis (PICA) and continues to be used today to characterize the gate-level performance of CMOS chips and identify the locations and nature of their operation faults [2].

Since the development of the PICA technique, different detectors have been used due to the decrease in the energy of hot electrons causing a shift to longer wavelengths of the emission light. This decrease in energy is merely a result of Moore’s Law which has been characterized by a substantial decrease in the size and spacing of active and passive structures such as transistors and their interconnecting wires, accompanied by increases in chip complexity, size, and speed of operation. As circuits continue to become smaller new photon detectors are necessary to accommodate the longer wavelengths of the emission light. The most sensitive commercially available detectors of light work on the principle of single-photon counting. In order to choose or design a new photon detector it is imperative to understand the wavelength of the emission light, the relationship between the technology parameters such as channel length and voltage.

An infrared spectrometer measures the wavelength and intensity of the absorption of infrared light by a sample. Infrared spectrometers are commercially available for use in research and industry for measurement, quality control and dynamic measurement. In the research area of semiconductors infrared spectrometers have been found useful in circuit analysis. Selecting an infrared spectrometer requires an analysis of performance specifications such as the wavelength range, resolution, accuracy, and infrared range.

In this study the main specifications of the desired infrared spectrometer are as follows: wavelength range 1200nm – 1800nm, resolution of 35-40 resolvable spots. In addition to the listed characteristics the infrared spectrometer should be able to work with a typical incident power of -107 dBm from a single device, be able to accept a light beam diameter of 2.5 mm from a 62.5 μm single mode input optical fiber and output to a 23.5 μm multimode optical fiber. A spectrometer with all the mentioned characteristics is not found commercially so it is the main purpose of this study to build and test such an infrared spectrometer that will help us ascertain the spectrum of leakage emission and switching emission light of CMOS devices.

2. Methods

2.1 Equipment used

Emiscope from Optonics, SSPD (superconducting single-photon detector) from Hamamatsu, Linear Actuator from Newport Co., 2 HP Tunable lasers in the wavelength ranges of 700nm-1000nm and 1200nm-1500nm, tilt and rotation stage, a linear stage both from Newport Co., and a calibrated tungsten lamp.
The most basic design of a spectrometer is shown in Fig. 1 and this is the design chosen to be implemented in this study because of its feasibility. The system configuration of the spectrometer shown in figure 1 resembles that of a Czerny-Turner design as it consists of fixed entrance and exit slits. The difference in the designs is that in the implemented spectrometer no mirrors are used to reflect the incoming infrared emission light to the diffraction grating or to reflect the monochromatic light from the diffraction grating to the exit slit. The use of mirrors is avoided in this design allows the minimization of optical problems that degrade the quality of the infrared emission light such as aberration, coma, astigmatism and curved focal field.

![Diagram of spectrometer](http://www.jobinyvon.com/SiteResources/Data/Template/divisional.asp?DocID=617&vID=&lang=1)

**Figure 1- Monochromatic design of spectrometer.**

The basic components necessary to build this spectrometer include a diffraction grating and a pair of aspheric collimators. A diffraction grating is an optical component with a surface covered by a regular pattern of parallel lines and when light passes through the surface of the grating the light rays are bent as the result of diffraction. The purpose of the grating in the spectrometer is to separate the incoming monochromatic infrared light into its different wavelength components. In order to obtain 30-40 resolvable spots and to be able to work with the emission light in the range of 1200nm – 1800nm a diffraction grating with the following characteristics was used: 150 l/mm, gold coated, blaze angle at 5.6°, and blazed at 1250 nm.

The aspheric collimators used for collimating and focusing a light beam with diameter of 2.5mm have the following characteristics: wavelength 1550nm, FC Fiber collimation package, numerical aperture of 0.5, and focusing length of 4.5 mm.

The infrared spectrometer was built using the design shown in figure 1, the diffraction grating was mounted on a tilt and rotation stage and the aspheric collimators were mounted on a stainless steal plate which was then mounted perpendicularly on a linear stage. A linear actuator was attached to the tilt and rotation stage to act as a sine bar that would change the rotation angle of the diffraction grating in order to obtain all the wavelength components of the incoming monochromatic infrared emission light from the circuit under test. The outgoing light was sent to the SSPD detector.

The angle \(\theta\) formed by the two collimating lenses is 30° and remains constant throughout the spectrometer operation, the angles \(\alpha\) and \(\beta\) change in value as the grating is rotated from its starting position to its end position, the range of movement of the diffraction grating covers the wavelength range of 1200 nm - 1800nm. The linear actuator was driven using GPIB programming through MATLAB. Once the spectrometer was fully aligned, using infrared alignment techniques, and calibrated, using the tunable lasers and a tungsten lamp, a CMOS circuit was mounted on the Emiscope and operated at normal design voltages as to simulate regular user operation. The infrared emission light from the Emiscope was sent to the spectrometer using single mode fiber, and the single wavelength light obtained from the spectrometer was sent to the SSPD through a multimode fiber where the photons were counted and this count was read by a computer and stored for later analysis.

3. Results

Calibration results of the infrared spectrometer show that the infrared spectrometer successfully detects infrared laser light in the wavelength range of 700nm – 1500nm with a power of 0.26mW. Testing of the infrared spectrometer inline with the Emiscope and SSPD was done using a CMOS circuit operated at its maximum operation using different operational voltages in the range of 1.0 – 1.5 V. Results obtained during testing of the infrared spectrometer inline with the Emiscope and the SSPD show that the spectrometer is able to detect the emission light with incident power of about -107 dBm of a circuit under test. The peak wavelength of the circuit under test was found out to be close to 1600nm whereas in past studies this peak was found out to be in shorter wavelengths [2], this result reinforces the statement that as the energy of hot
electrons decreases the emission light wavelengths are shifting towards longer wavelengths

4. Conclusions

Since the development of the PICA method different photon detectors have been used to detect infrared emission light of CMOS circuit chips. At the beginning liquid nitrogen cooled silicon CCD and thermoelectrically cooled micro-channel plate (MCP) photomultiplier were used to observe light emission [1]. Currently a cryogenic cooled superconducting single photon detector is used in PICA analysis. With the pass of the years and the miniaturization of circuits the power of the incident emission light has decreased and thus new, faster, and more powerful detectors are needed in PICA analysis. The current study enable us to better understand 1) the current spectrum of leakage emission and switching emission light; 2) The relationship between technology parameters such as voltage and the wavelength of the emission light of new CMOS circuit chips.

References

Computing a Generative Model for Neural Codes

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1. Introduction

Neural coding is the study of how information is processed from neuron to neuron. The basic biophysics of neuronal activity is well understood; however, the link between the biophysics of neuronal activity and information processing is not entirely clear. We plan to construct a generative model, such as a Boolean Network model, to describe the physiological spiking behavior of a neuron (a.k.a. Neural Coding) that occurs when it’s exposed to a stimulus. This Boolean Network will provide a perspective on how a system of interacting nodes encode and decode a neural code.

We have divided this project into three parts: encoding, decoding, and inference. Encoding will generate a neural code based on stimuli. Decoding will generate the stimuli based on the neural code. Inference will provide the means to generate a Boolean Network for both encoding and decoding. Here, we will present the process of encoding.

2. Data

We collected spiking event time of individual neurons which undergo several trials subjected to four stimuli: NaCl, Quinine HCl, HCl, and Sucrose. Each trial records the times, in milliseconds, when a spike is measured as a result of the neuron’s exposure to the stimulus.

3. Method

3.1. Conversion and Interpretation of Data

Spiking event times are recorded for the first 10 seconds after a stimulus is applied. For every window of 10 milliseconds within this time period, either a zero or a one is inserted into a binary sequence. If one or more spikes are recorded within the interval of 10 milliseconds, a one is added to the binary sequence; otherwise a zero is inserted. In this presentation, we’ll refer to time intervals as DTU (Discrete Time Unit).

3.2. Center Spike Selection

Since it’s possible that two experiments exposed to the same stimuli could result with spikes occurring at different times (whether it’s due to a delay or noise),

Figure 1. Neural Cell 3 introduced to NaCl (DTU) Discrete Time Unit

Figure 2. Neural Cell 3
we’ve decided to take out the experiment that best represent the group it belongs to by creating a simple selection method that’s design to sort through binary sequences.

A similarity matrix is created with the rows and columns representing binary sequences within a group. Every entry is the global alignment score of two sequences based on a substitution matrix that is designed to align a binary sequence. Thus, the \((i^{th}, j^{th})\) entry in the similarity matrix will be the global alignment score of the \(i^{th}\) and \(j^{th}\) sequences in a group and the \((i^{th}, i^{th})\) entry is not considered. Lastly, the arithmetic mean is calculated for every row in the similarity matrix. The binary sequence that relates to the row with the highest arithmetic mean is consider the center star sequence and will be used to represent the group during the construction of a Boolean Network.

4. Results

Results from the Center Star Alignment Algorithm look promising; here is an example of a center star sequence derived from a group of trails from one neuron:

Figure 3. Neural Cell 3’s experiments conducted with NaCl as the stimulus

5. Conclusion

This is an on going project and we expect to see initial results toward the middle of December. As we progress further along, we’ve noticed several areas for improvement. Future work in this project will include these improvements. When the initial results are produced, we hope the nodes within our Boolean network model can be linked to biophysical pattern found in neural activities.

References

Human-Computer Interface Design for Cognitive Workload Detection Using Pupillary Response

Mouncef Lahlou and Malek Adjouadi

1. Introduction

Several studies have established that effortful cognitive processing is accompanied by an increase in pupil dilation [1]. This effect has been demonstrated for tasks such as mental arithmetic, sentence comprehension, letter matching, and several other assessments [2-4]. The pupil dilation is also known to be caused by the intensity of ambient illumination. Therefore, changes in illumination can interfere with the use of pupil size as a measure of cognitive workload [5]. Several new approaches were introduced to assess a person’s mental workload. Techniques including primary task measures, secondary task measures, and subjective rating measures [6] do not provide real-time results about the mental workload of the person and distress user’s attention while being evaluated. Other practices such as heart rate and electroencephalogram (EEG) measurements have the benefit to deal with data collected in long-lasting interaction; however, they are intrinsically more intrusive.

Pupillometric methods are used to measure variations in the diameter of the pupillary aperture of the eye in response to psychophysical and/or psychological stimuli [7]. The introduction of an eye-gaze tracking system with an embedded pupillometric technique will certainly help in measuring the size of the patient’s pupil in real-time while evaluating the level of processed information for individual psychological functions using interactive tasks.

The objective of this work is to design and implement a Human-Computer Interface (HCI) for detecting individual’s cognitive workload based on the human pupillary response technique using a remote eye-gaze tracking system. Our approach will help establish scientifically objective tests that are best suited in determining effective physiological correlates of different cognitive workloads.

2. Methods

2.1 Participants

Seven subjects (4 males and 3 females) ranging from 25 to 46 years of age volunteered for the study. All participants were students who had normal or corrected-to-normal vision. This experiment was conducted with the approval of the Institutional Review Board in the use of human subjects.

2.2 Apparatus

The R6 Remote Optics Eye Tracking System from the Applied Science Laboratories (ASL) was used to record user’s pupil diameter and height with a sampling rate of 60 Hz, and with a 0.25 degree spatial resolution. The eye-tracker interacts with a 2.4 GHz Computer via a main control unit of the eye-tracking system. The stimuli were presented on a 21-inch monitor with a refresh rate of 60 Hz and a screen resolution of 1280 by 1024 pixels. The entire application was implemented using approximately 1000 lines of C# and fits in 920KB dynamic-link library (DLL).

2.3 Procedure

a. Experimental Task

An important part of the study was to identify a meaningful task to determine participant’s cognitive workload. We used the well known color-word Stroop interference task, in which color naming is slowed down by interfering incongruent printed words [8]. We divided the task into three different tests: (1) congruent-color word test, (2) standard black-ink color test, and (3) incongruent-color word test. However, instead of using the traditional method of decision time, we examined the participants’ pupil size reactions using the pupillometry method.
Before beginning the procedure, each participant went through a 9 fixation points' calibration process. The eye-tracking device operates on the basis of determining the two high contrast elements: the pupil and the corneal reflection (CR). The infrared camera was placed in front of the participant point of gaze (POG) right below the screen (60-75cm distance from the participant). For each user, depending on his/her sitting position distance, the pupil size is auto-converted from pixels to millimeters using the following equations:

\[ D = \frac{d}{10 \times a} \times d\text{ASL} \]
\[ H = \frac{d}{10 \times b} \times h\text{ASL} \]

Where \( d \) is the distance from the user to the POG; \( a \) and \( b \) are the pupil diameter and height of user during calibration, respectively; \( d\text{ASL} \) and \( h\text{ASL} \) represent the recorded diameter and height of the pupil, respectively. It is important to keep constant illumination throughout the experiments. Changes in illumination can affect the pupil size, which might provide an incorrect recording piece of data.

b. Interface Design and implementation

The HCI system is composed mainly of two information processing units, the human being and the computer. Human-computer interaction can thus be described as an information processing loop. In fact, it provides a coherent description of the whole system of HCI within the information processing framework. It presents the information to the user, the user's perceptions, mental models, user's control of the system, input devices, and the user interface functionality of the system. The objective was to design an interface that interacts between the user and the eye-gaze tracking system, to capture the user visual functions, and facilitate the understanding and analysis of the individual’s cognitive processing.

The user interface consists of three different access functions: (1) Configuration access, (2) Task access, and (3) real-time simulation access. The first function allows loading the EGT configuration's file to the user interface, selecting the communication port, and starting the connection with EGT system. The second function displays the Stroop-interference task tests. The third function displays a graph illustrating a real time outline of the eye pupil diameter and height changes as shown in Figure 1.

Since the EGT system operates at 60Hz sampling rates, approximately 60 data samples are recorded every second for both the pupil diameter and pupil height. For real-time data processing it was necessary to use a method that will not overload the computer memory. We used a creative approach which uses an Advanced Circular Buffer (ACB) [10]. The ACB approach helps the data acquisition allocates a large circular buffer in the application’s memory space. The buffer leaves adequate physical memory to assure continuous data gap-free acquisition.

3. Results

For each test, a measure of pupil diameter and height were recorded through each sampling cycle. Pupil samples in which the height or diameter were equal to zero were eliminated; a sample equal to zero is an indication of an eye blink during recording if it exceeds 20msec duration.
Our analysis was based on the mean of the participant’s pupil diameter and height in pixels for each of the three tests. From the results provided in Figures 3 and 4, it is clearly seen that congruent colors yielded the smallest pupil size, while incongruent colors (test 3) are the largest. The second test was based on black colored symbols which resulted in an intermediate dilation of the pupil.

The goal of this study was to develop the means to measure individual’s cognitive state non-invasively and in real-time. We suggested a user friendly interface that interacts with an EGT system to record the user’s pupil size and process the pupil changes instantaneously. A module was presented within the interface which uses the Stroop-interference task to assess user’s cognitive workload. The pupillary responses found were clearly different. Pupil dilation increased as the amount of information processing increased.

The present study focused on the pupil dilation with the initial intent of investigating its correlates to individual’s cognitive responses. Future studies should explore the use of a task completion time in addition to the pupil dilation on a larger number of subjects. More neuropsychological tests can be added to the actual study to help neuropsychologists evaluate cognitive processes of different patients.

4. Conclusion

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References

1. Introduction

The purpose of this study is to formulate an imaging-based informational entropy model framework for the detection and estimation of certain classes of infrastructure changes in urban settings as a result of the effects of natural disasters.

To accomplish our purpose, we intend to develop an indicator system of the infrastructure to obtain information measured using informational entropy techniques.

The selection of appropriate variable indicators would allow this model to be used to represent the infrastructure of a system and gather its state at a specific time and, by comparison with a previous state, determine its level of health. In this way, we can measure the flow of the system and use it to evaluate the direction of change as a tool for disaster management.

The concept of entropy has been widely used in system modeling, as noted by A. G. Wilson in The Use of the Concept of Entropy in System Modelling [1]. In particular, methodology described in the referenced study has proved fruitful in the urban planning field. Through a fundamental review of entropy as a concept and as a measurable system property, an application of a highway system example is given through the use of entropy-maximizing procedures.

In the environmental area, analyses of urban systems had been conducted using information entropy as a base (Yan Zhang, Zhifeng Yang and Wei Li, Analyses of Urban Ecosystem based on Information Entropy, [2]). In this study, a model based in year and indicator information entropy is developed to determine the developmental degree and the harmonious degree of the system. Using probability and numerical statistics, the degree of disorder (entropy) of the system is formulated.

In Information System Management, exploratory research had been realized using entropy based model (Harold Douglas McDonald, III, An Entropy Model for Information Systems Management [3]). The primary objectives of the study are to establish a technique to measure information system entropy using an information system’s reporting data and to determine the relationship between user satisfaction and the measured level of entropy. To accomplish these tasks, empirical data is gathered from a major command and control system to correlate levels of statistical entropy with user satisfaction collected via survey. Models at the individual application level and at the system level are also examined in this study. The framework for the measuring is established through issues like missing functionality, measurement cycle, problem complexity, problem priority, and infrastructure problems.

Graphs have been used as a framework to represent states of a system that evolves. In Graph Dynamics: Learning and Representation (Andre Figueiredo Ribeiro [4]), the graph dynamic concept of attractors, states into which the system settle within time, is explored. In other words, given a set of graphs, it is intended to discover how to learn the self-regulatory network and use it in the verification of the different hypotheses. Taking game theory as an example, it is shown that minimizing the generalized entropy is the central step towards finding the optimal act against opponents, under regularity conditions, leading to an equilibrium solution in the game.

The studies mentioned above constitute the foundation in which lays our analyses and are used as building tools in the formulation of our model.

2. Fundamental Concepts and Definitions

Below we present a set of definitions and concepts which will be useful in our research work:

Entropy

Various definitions of entropy have been used in many contexts. Although different, they are all related and share the same principles:
• In Thermodynamics: measure of energy dispersal.

\[ \Delta S = C_p \ln \left( \frac{T_f}{T_i} \right); \quad C_p = \text{heat capacity} \]

• In Mechanical Statistics: is the number of possible microstates or possible microscopic configurations of a system.

\[ S = k_B \ln \Omega \quad \text{E} \]

\[ k_B = \text{Boltzmann's constant}, \Omega(\text{E}) = \text{number of microstates} \]

\[ S = k_B \sum_{i} p_i \ln(p_i); \quad p_i = \text{probability of microstate } i. \]

• In Information Theory (Shannon): it is the uncertainty associated with a random variable, in this case, a message.

\[ H(X) = \sum x_i \lg \left( \frac{1}{p(x_i)} \right) = -\sum p(x_i) \lg p(x_i) \]

\[ p_i = \text{probability of message } x_i \]

We begin our system model with this last concept, the Information Entropy by Shannon.

Information Entropy

It is a numerical measure of the amount of information contained in a message. In Information Theory, it is considered the amount of uncertainty associated with a random variable. It is used to quantify the minimum average length of a message (amount of bits) that must be sent in order a correct value would be received. Then, it constitutes an indication of the number of possible choices of messages, expressible as the value of some monotonic function of the number of choices, usually the logarithm to the base 2.

Infrastructure

For the purpose of this research, infrastructure refers to civil infrastructure: the set of structures that provide support to the functioning and communications of the system they serve. Examples of such structures are roads, bridges, dams, buildings, dwellings, electrical wiring system, telecommunications system, transportation system, among others.

Natural Disaster

The scope of our study includes all hydrological and climatic hazards caused by pluvial precipitations and which direct consequences are flooding and landslides. Under this scope are mainly tropical and non-tropical cyclones, and their different scales.

Hazard Mitigation

Hazard mitigation refers to the efforts whose intention is to prevent hazards to develop in disasters, and reduce the impact of them in case they occur. Usually, these are long-term measures ranging from preventive to recovery phases. As our focus is structural, measures like legislation and administration are not contemplated.

System

It is a non-empty set of objects with an associated non-empty set of structural relations.

2.7 Subsystem

A subsystem is a part of a system which constitutes a system by itself, preserving all the characteristics that define a system and working as an entity of the system in which it is contained.

3. Preliminary Theoretical Framework

The system under study represents a spatial model distributed in time and space, therefore a distributed algorithmic solution must be provided. The obtained data must be translated to a Finite Informational System.

Due to its open and complex nature, our system will be analyzed making use of the concepts of Systems Dynamics. Its characterization will have attributes pertaining to reconfigurability, modularity, and scalability.

The infrastructure concept in our study consists of the civil infrastructure, which constitutes an excellent indicator of the urban system due to its presence in all inhabited zones. Our model will use images as input data and output as well. These data will go accompanied by the metadata corresponding to each image as support to the informational system. They could even be replaced by the metadata in conditions in which images are not available or they are not sufficient.
Technology Support

Actually, many technological resources can be used in the implementation of the proposed solution. Among others, these are proven to be particularly useful:

- Image processing
- GPS
- Signal processing
- Grid technology
- Web databases and networking
- Radar and sensors technology

As an example, the information entropy was calculated for the images shown. Both images correspond to the exact same area in different historical circumstances and time\(^2\). It can be appreciated the difference in the entropy quantities for each of them. Although not conclusive, the results are a token of what could be accomplished.

These images were processed using MATLAB. To each image pixel matrix, Shannon’s entropy formula was applied obtaining the results showed below.


1) New Orleans, March 2005
2) New Orleans, August 2005

\[ H(X_1) = 34414 \quad H(X_2) = 32168 \]

As could be appreciated above, there is a difference \( \Delta H = 2246 \) between both images entropies. The meaning of this difference is subject to the temporal parameters imposed to the model of representation and the specific infrastructure under study as well. As this is a decision support system, the receptor of the output should formulate conclusions based on the intended particular use.

4. Conclusions

A model based on information entropy created in the form here described can be applied to assess the degree of health, vigor and order in the infrastructure of a region, and can be used to identify the development level and degree of harmony of the system.

The work to come consist on to effectively identify the appropriated variable indicators to be used in order to measure the different entropies, and calculate the corresponding weight to them so the appraisal indexes could be determined. By doing this, the infrastructure can be modeled for a specific period of time. These indicators will be based on the structure and mechanisms that govern the infrastructural subsystem and any urban system as well. This would make the model adaptable to any system that we wish to model. The key part in the adaptation would be the appropriate selection of indicators that represent the system under study.

Because of the mean objective of this study is the mitigation of the effects of natural hazards, it possess an extraordinary social and ethic impact. It could be said that the direct result of this work would be the prevention of lost of lives and properties.

References


Intelligent Traffic Controllers

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1. Introduction

Automobile traffic is a problem which man has battled for a few centuries now. The general consensus to solve this problem is to add lanes or widen the streets at which the heaviest traffic occurs. This method, although crude, works in some cases. It just makes perfect sense to hold more of something, make the container, or in this case the street, bigger. In highly urbanized areas though, some problems occur. The biggest of such problems, and the one which we set to tackle, is how to move traffic along when a street cannot be widened. Several things can cause this situation, but the most common and easiest to consider is simply an immovable object, such as a building, in the way.

This is where our Intelligent Traffic Controllers come into play. Each controller, or traffic light, will look at the current traffic scene, and make an educated guess about the future traffic situation and how to handle it. It then performs the actions it deems necessary to get the most cars in and out of the that traffic area in the quickest amount of time possible. Our controllers utilize multi-agent technology, fuzzy logic, and TCP/IP connectivity to accomplish these goals.

2. Methods

2.1 General Explanation

Using a Multi-Agent system, traffic controllers recognize the surrounding traffic environment. Since the environment is constantly changing, a Fuzzy Logic system is constantly calculating the light condition situation decided whether to maintain light conditions or change them. While all these decisions are being made, each traffic light is communicating with neighboring traffic lights to share traffic information. This way, each traffic light can better serve the future while currently dealing with the present situation. Of course, it will be too expensive and unrealistic to test this system in a live traffic scenario, so a simulation was built to showcase the controllers.

2.2 Fuzzy Logic and Algorithms Implementation

The Traffic Controllers use a Fuzzy Logic Engine (called FuzzyCLIPS) to change hard, quantified data into fuzzy values. The engine fuzzifies three rules: traffic speed, amount of cars at a traffic light, and the amount of time the first car has been waiting.

Once all fuzzy calculations are done, the system uses it in the following formula:

\[
\text{Threshold} = (\text{Fuzzy\_CA} \times \text{CA\_Weight}) + (\text{Fuzzy\_Speed} \times \text{Speed\_Weight}) + (\text{Fuzzy\_Wait} \times \text{Wait\_Weight}) + (\text{Neighbors} \times \text{Neighbors\_Weight});
\]

The fuzzy values directly correlate to the values given from the Fuzzy Logic engine. The weights are values given by the user that allows for different logical precedence from each fuzzy value.

2.3 Multi-Agents Implementation

Since a Multi-Agent system is used for the Traffic Controllers, each agent is given an individual purpose. The first agent is built primarily to deal with all aspects of communication. The second focuses on the computational affects and actual control of the light.

The Computation Agent takes all raw data available at any given time and makes sense out of
it. Any street data is passed to the FuzzyCLIPS engine and changed into fuzzified values. These values are used in correlation with the pre-defined weights to create thresholds. This agent also controls the current light status. If changes occur, it will throw a flag and initiate a yellow light sequence. When the yellow light turns red, the agent then sleeps for a few seconds (again the value is easily modifiable) and resets the other side to green.

The other agent deals only with Communication. This agent is used to grab data from street sensors (or in our case, the simulation) and share it with the computation agent. At the same time, it sends and receives data from neighboring streets. Sharing this data helps the Computation agent make more advanced decisions since it can look at traffic that will be coming in the near future. The communication process will be described more in detail in the next section.

The benefits of using a Multi-Agent system in this project are vast, but mainly it helps the controller use all data necessary to make a decision and do so without interrupting the switching of traffic light conditions.

2.4 Communication Implementation

Communication is a key factor for this multi-agent controller, which is why the TCP/IP networking suite is used. Since it is flexible and reliable enough to work for a massive network of computers like the Internet (World Wide Web), it is perfect and simple enough to use for a much smaller traffic system. TCP communication allow for error checking and error recovery, which is used to ensure traffic data is sent correctly. When a traffic light goes down (maybe because of a storm or loss of power), the neighboring traffic lights will immediately be able to recognize this and shut down communication with that controller. This prevents corrupted data from being used and saves some time also.

3. Conclusions

Currently no direct conclusions can be drawn. The framework is still a work in progress and will be continually worked on for years to come. In the future we will compare the current time-based traffic control system for the City of Houston with our traffic model. Using realistic data, we will be able to determine how well our system works in a real-world scenario.

4. Future Work

Much needs to be done to finish this project. Here is a brief list of modules that can be added to further make this realistic:

- Turning capabilities
- Multiple lanes
- Two way streets
- More Traffic Controllers in Simulation
- Light Rail Implementation
- Pedestrian Awareness

5. References

Part-of-Speech Tagging of English-Spanish Code-Switched Text

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1. Introduction

As mono-cultural or monolingual communities interact, there is an increasing level of cultural and linguistic adaptation that emerges; this is especially the case along borders. Linguistic adaptation is reflected at times by the absorption of the new language by the respective culture. Worldwide, the percentage of bilingual speakers is fairly large, and it keeps increasing at a high rate. In the U.S., 18% of the total population speaks a language other than English at home, the majority of which speaks Spanish (U.S. Census Bureau, 2003). A consequence of this is the frequent code-switching between Spanish and English, a trend sometimes referred to as Spanglish, in a significant percentage of the population in question. This code-switching trend is also observed among other language combinations such as French and German or English and French.

Despite the widespread usage of code-switched discourse among bilinguals, this linguistic phenomenon has received little attention in the fields of Natural Language Processing and Computational Linguistics. This phenomenon presents a challenge if the well studied problem of Part-of-Speech (POS) tagging in these fields is considered. For languages such as English, German, Spanish, and Chinese there are several different POS taggers that reach high accuracies, especially in news text corpora. However, for text with mixtures of languages, these tools will fail to generate good results.

This study provides preliminary results on the problem of POS tagging English-Spanish code-switched discourse by taking advantage of existing taggers for both languages. This rationale follows the evidence from studies of code-switching on different language pairs, which have shown code switching to be grammatical according to both languages in question. Our goal is to develop a POS tagger that can be later exploited in the problem of extracting the syntactic structure of code-switched utterances. Among the challenges this presents is the lack of a representative sample of code switched discourse.

2. Code-Switching

The alternation of languages within a sentence is known as intra-sentential code-switching, or intra-sentential alternation (Poplack, 1980; Grosjean, 1982; Ardila, 2005). Alternation across sentence boundaries is known as inter-sentential code switching, or just code-switching. Throughout this paper alternations within sentences will be referred to as intra-sentential code-switching and alternations across sentence boundaries as inter-sentential code-switching.

There is a general agreement that code-switching patterns are not generated randomly; according to these studies, they follow specific grammatical rules. The following presents the rules governing code-switching discourse described in several studies (Poplack, 1980; Poplack, 1981; Sankoff, 1981; Sankoff, 1998).

- Switches can take place only between full word boundaries. This is also known as the free morpheme constraint.
- Monolingual constructs within a sentence will follow the grammatical rules of the monolingual fragment.
- The equivalence constraint specifies that permissible switch points are those that do not violate the order of adjacent constituents on both sides of the switch point of either of the languages.

Patterns bearing the above rules have emerged in different bilingual communities with different backgrounds.

3. Methods

3.1 Data Set

Data collections containing Spanish-English code-switching are not easily obtained due to the fact that this phenomenon is most commonly observed in a verbal/spoken form. Therefore, data was gathered by recording a conversation among three staff members of
a southwestern university in the U.S.; this data was then transcribed and annotated. The three participants came from a highly bilingual background and code-switch regularly when speaking either among themselves or with other bilingual speakers.

The recording was around 39 minutes of continuous speech (8,000 words). The vocabulary of the transcription has a total of 1,516 different word forms. In the conversation there are a total of 239 switches, out of which 129 are intra-sentential code-switches, and the rest are inter-sentential. English is the predominant language used, with a total of 576 monolingual sentences. In contrast, there are only 176 monolingual sentences in Spanish.

3.2 Monolingual Taggers used

The Tree Tagger (Schmid, 1994) was used for this work. This tagger provides several advantages: (1) it has both English and Spanish versions, (2) both taggers include a special tag for foreign words, PE for the Spanish version and FW for the English one, although it is not expected that this tag correctly identifies all foreign words, and (3) when the tagger fails to lemmatize a word it outputs the special token unknown, which can be used as an indication of words which do not belong to that particular language.

3.3 Rule-Based Methods for Exploiting Existing Resources

The English and Spanish versions of the Tree Tagger can be combined in different ways to POS tag Spanglish text:

1. Using the Monolingual Taggers. In this approach, the Spanglish text was subjected to both the English and Spanish Tree Taggers. A setback for this approach was that the text represented spoken language, which means that it contained hesitations, fillers, and interruption points throughout. The outcome was an accuracy of 26% for the Spanish tagger and an accuracy of 54% for the English Tagger. The large difference between these accuracies can be attributed to the fact that the majority of the words in the corpus are in English, thus giving the English tagger an advantage over the Spanish tagger.

2. Using Confidence Thresholds. The Tree Tagger can output probabilities for each tag, showing the confidence of the tagger in each particular tag. This information was used to choose, for each word, the tag from the tagger with the highest confidence. When there was a tie, we use either the English or the Spanish tag. This “Highest prob tag for English” heuristic gives an accuracy of 51%. The “Highest prob tag for Spanish” achieves an accuracy of 49%.

3. Combining Confidence Thresholds with Knowledge from Special Tags and Lemmas. This heuristic uses confidence thresholds combined with decisions based on special tags and the unknown lemmas found. Let $\text{POS}_E(w)$ be the POS tag assigned by the English tagger to word $w$. Let $\text{POS}_S(w)$ be the POS tag assigned by the Spanish tagger to word $w$. For every word $w_i$ in D the final POS tag, $\text{POS}_F(w_i)$, will be assigned as follows:

(a) If $\text{POS}_E(w_i) = \text{FW}$, then $\text{POS}_F(w_i) \leftarrow \text{POS}_S(w_i)$
(b) Else if $\text{POS}_E(w_i) = \text{PE}$, then $\text{POS}_F(w_i) \leftarrow \text{POS}_S(w_i)$
(c) Else if $\text{POS}_E(w_i) = \{\text{unknown}\}$, then $\text{POS}_F(w_i) \leftarrow \text{POS}_S(w_i)$
(d) Else if $\text{POS}_E(w_i) = \{\text{unknown}\}$, then $\text{POS}_F(w_i) \leftarrow \text{POS}_S(w_i)$
(e) Else if $\text{Prob}_E(w_i) > \text{Prob}_S(w_i)$, then $\text{POS}_F(w_i) \leftarrow \text{POS}_E(w_i)$
(f) Else $\text{POS}_F(w_i) \leftarrow \text{POS}_S(w_i)$

This method yielded an accuracy of 64.27%.

4. Selecting POS Tags based on automated language identification. A simple strategy was used to identify the language automatically at the word level. Every word in the text was searched for in an English and a Spanish dictionary. If a word was found in the English dictionary, the English tags were used for that word and the following ones, until a word in the Spanish dictionary was found. Similarly, for a word found in the Spanish dictionary, the Spanish tags were used until an English word was found. This approach yields an accuracy of 86.39%.

3.4 Machine Learning for POS Tagging Code-Switched Discourse

The key point of this approach is that the features selected for describing the learning instances are the outputs from the English and the Spanish taggers. The intuition is as follows: the learning algorithm will be trained to identify which tag from the two taggers is the correct one. In addition, it is expected to learn to correct the mistakes made by both taggers. Instances in this learning task are described by the following attributes:

1. The word (word)
2. English POS tag ($E_I$)
3. English POS tagger lemma ($E_L$)
4. English POS tagger probability ($E_P$)
5. Spanish POS tag ($S_I$)
6. Spanish POS tagger lemma ($S_t$)
7. Spanish POS tagger probability ($S_p$)

The idea of using ML with different learning algorithms in WEKA (Witten and Frank, 1999) was evaluated experimentally. Some of the most widely known algorithms were selected, including Support Vector Machines (SVM) (Schölkopf and Smola, 2002), Weka’s modified version of Quinlan’s C4.5 algorithm (J48) (Quinlan, 1986), Additive Logistic Regression with Decision Stumps (Logit Boost) (Friedman et al., 1998) and Naïve Bayes.

4. Results

Our results showed that the ML approach outperformed all previous approaches with 93.39% accuracy, which was achieved by SVM on an average over five ten-fold cross validation runs. In second place came Logit Boost, with an average accuracy of 93.29%. The next best accuracies were as follows: J48 with an average accuracy of 89.43%, and Naïve Bayes with an average accuracy of 83.17%.

The effect of the amount of training data in the accuracy of the Logit Boost was then analyzed; Logit Boost was selected due to its increased execution speed in comparison with SVM. The transcription was randomly partitioned into 10 subgroups. One of the subgroups was then reserved as the test set; starting with one subgroup as the training set, Logit Boost was executed and then one more subgroup was added to the training set. This was repeated until all nine of the subgroups were part of the test set. Then, another set out of the ten initial subgroups was chosen at random to be the test set and the whole process was repeated again. The results of the above demonstrated that little data was needed to obtain fair accuracies: with only 10% of the transcription data as the training set, an accuracy of about 85% was achieved. After having 60% of the transcription text as the training data, little improvement was observed when adding more data to the set of training data.

It was concluded that most of the error produced in these approaches is due to either intra-sentential code switching or to the effect of spoken language, such as fillers, hesitations, and interruptions.

Finally, the level of contribution of each attribute was analyzed by selecting different subsets of attributes to execute the learning algorithm. Overall, the attributes taken from the English POS tagger were more valuable for this learning task; this can be attributed to the fact that more instances of the corpus were in English. Nonetheless, there is some valuable information provided by the Spanish POS tagger output, since the highest accuracy is achieved by including the Spanish-based attributes in combination with the English-based ones. The confidence thresholds ($E_p$ and $S_p$) provided by the Tree tagger seem to be redundant.

5. Conclusions

Research in interlanguage processing has many interesting applications. For instance, methods like the one proposed here can be helpful for Computer-Assisted Language Learning systems. Another application area is machine translation.

Interlanguage processing is a fresh and exciting research area that has received little attention in the natural language processing community. In this study we presented preliminary work towards developing a POS tagger for English-Spanish code-switched text that, to the best of our knowledge, is the first effort towards this end.

Finally, this work was done on English-Spanish code-switched text. But, as mention earlier, this is not the only common combination of languages, and we believe that what was learned from this work can be adapted to different language combinations.

References


A Tool for Generating Aspects from MEDL and PEDL Specifications for Runtime Verification

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1. Introduction

With the ubiquity of software, especially in safety-critical systems, avoiding software failures must be emphasized. The failure of safety-critical systems, such as airplane controllers or railroad crossing systems can result in monetary loss, injury, or death. Software testing, the most commonly used verification technique, cannot provide complete test coverage; furthermore, designing effective comprehensive test suites for complex systems is difficult. A complementary technique, called runtime verification, examines actual execution paths, not possible paths. In this approach, a monitor system observes the behavior of a system and determines if it is consistent with specified properties. A monitor takes a software system and specifications of software properties and checks that the execution meets the properties, i.e., that the properties hold for the given execution [1].

The goal of this approach is to enhance runtime verification by developing a tool that translates the MaC specifications into AspectJ aspects. This is important because it removes the need for an instrumentation system, such as the one included in MaC, while maintaining MaC’s unique features, i.e., the MEDL and PEDL specification languages that support specification of the properties to be monitored and the events and conditions that trigger monitoring. The proposed approach allows the runtime verification community to benefit from research advances in AOP and to reduce the need to maintain instrumentation code, which is managed by AspectJ in our approach.

2. Background

A programming paradigm called Aspect Oriented Programming (AOP) [2] allows developers to encapsulate cross-cutting concerns that are needed to develop effective runtime verification approaches that require instrumentation of specifications in software code. AspectJ [5] is an AOP implementation for the Java programming language. A join point is a place in the code where additional behavior is required. A pointcut is a specification of a set of join points. There are two types of pointcuts: primitive and user-defined. User-defined pointcuts are boolean combinations of primitive pointcuts. Pointcuts may match a method invocation at either the call site or the method site, at an assignment or read from a field, or at a point where some condition holds. For example, one could verify if variable x is updated by using the construct: pointcut checkx() : set(int Class.x), where checkx() identifies the aspect, set() recognizes when the specified non-private variable is updated, and int Class.x specifies variable x in class Class as the variable of interest. The behavior of the program can be changed at each join point by specifying a construct called advice, i.e., code to be executed at a join point. The constructs before(), after(), direct when the advice is going to be executed, either before entering the join point or after exiting the join point, respectively. Additionally, the construct around() executes before entering the join point like a before() and optionally using a proceed() to execute the join point or to return and not execute the join point.

The research examines the integration of AOP into the runtime verification approach called Monitoring and Checking (MaC) [3]. MaC is a framework for run-time correctness and assurance of real-time systems. Currently a prototype implementation for programs written in the Java language exists (Java-MaC) [4]. MaC offers well-defined specification languages based on Linear-time Temporal Logic (LTL) in which the underlying structure of time is a totally ordered set (S, <) isomorphic to the natural numbers with their usual ordering (|N, <). Under this definition, time is discrete, it has an initial moment with no predecessors, and it is infinite into the future. MaC was chosen because it supports the separation of monitoring and specification requirement level concerns by using two distinct languages, one that deals with details of implementation (PEDL) and another one that deals with requirements (MEDL).
3. Approach

Primitive events in PEDL correspond to transfer of control between methods or assignments to variables. PEDL events describe join points in a program. MEDL properties correspond to safety and liveness requirements; therefore, the advice at each pointcut is checked against the MEDL specification. As mentioned earlier, an aspect is comprised of pointcut declarations and advice associated with each pointcut. Recall that the goal of the proposed approach is to enhance runtime verification by developing a tool that translates the MaC specifications into AspectJ aspects.

PEDL lists the variables and method calls that are going to be used to generate events as well as the conditions to be used for monitoring. As a result, each listed variable and method must have a corresponding join point specified. Events that are described by the PEDL keywords update, ioM start, end, startM, and endM, are mapped to corresponding AspectJ constructs. For example, startM and endM correspond to the beginning of a method and the ending of a method, and they map to the before() and after() directives given to the advice modifier. Recall that conditions are a combination of variables and booleans that when true emit an event. The tool takes a condition and creates an auxiliary method that checks the current state of the system with respect to the condition. If the condition is true, then an appropriate aspect variable will contain the boolean value true; otherwise, it will contain the value false.

MEDL states the conditions on high-level events that must be checked on the low-level events and conditions given by a PEDL specification. Because PEDL field methods are created for conditions and low-level events, MEDL specifications will be expressed as a method inside the aspect. Such methods are called on the advice corresponding to the pointcuts extracted from PEDL, i.e., when this method gets called, it will check the boolean value of the aspect fields that represent the conditions described by PEDL.

4. Conclusions

The goal of this approach is to enhance runtime verification by developing a tool that translates the MaC specifications into AspectJ aspects. This is important because it removes the need for an instrumentation system, such as the one included in MaC, while maintaining MaC’s unique features, i.e., the MEDL and PEDL specification languages that support specification of the properties to be monitored and the events and conditions that trigger monitoring. The proposed approach allows the runtime verification community to benefit from research advances in AOP and to reduce the need to maintain instrumentation code, which is managed by AspectJ in our approach. The AOP community has been focused on the development of next-generation aspect weavers, and this work will benefit software instrumentation.

The tool described here converts MEDL and PEDL files to AspectJ aspects. The results show the effectiveness of using AspectJ as the foundation for instrumentation because of the cross-cutting nature of instrumentation. Future work includes support for all features in the MEDL and PEDL languages and demonstration of the equivalence of the weaving process of AspectJ to Java-MaC instrumentation. Other work includes determining whether the proposed approach can be applied to runtime verification of services used in a service-oriented environment.

References

Error Correction and Clustering Gene Expression Data Using Majority Logic Decoding

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1. Introduction

cDNA microarrays are a technique for measuring the abundance of messenger RNA from many thousands of genes simultaneously in an inexpensive experiment [1]. They are used extensively for diagnostic purposes, and the data they allow researchers to collect have permitted the study of genome wide interactions among genes. The analysis of microarray data, however, is a difficult task, proving a fruitful area of research in numerous fields. An extensive review is available in [2].

1.1 Clustering

Clustering of gene expression measurements is an important step in many analysis, most early microarray work performed hierarchal clustering, where genes are successively agglomerated into groups by selecting the two clusters whose average expression values are closest [3]. It is typical to first cluster genes before trying to determine the gene regulatory network by reverse engineering. Clustering helps reduce the computational resources required to analyze microarray data sets by grouping together many separate genes that demonstrate similar patterns of expression [4]. It also can help in determining common functionality or common regulatory elements of genes which cluster together [5].

1.2 Microarray experiments

The microarray studies described here focused on one cognitive task, conditioned taste aversion (CTA), as a model system for gene expression profiling. CTA is an associative aversive conditioning paradigm in which pairing gastrointestinal malaise (induced by lithium chloride, LiCl, the unconditioned stimulus) with prior exposure to a novel taste (the conditioned stimulus) may create a strong and long lasting aversion to the novel taste.

CTA lends itself as an excellent model system to study the dynamics of gene regulation in learning and memory because it is a single trial associative learning paradigm, which involves discrete regions in the brain, including selected amygdala nuclei [6,7].

1.3 Microarray measurements

The gene profiling experiment was replicated five times. Four animals were used per condition for each replicate. Thus, a total of twenty rats were used per condition. Animals were sacrificed by decapitation at 1, 3, 6, and 24 hours after conditioning and amygdala enriched tissue punches were obtained for RNA isolation. Hybridization, image capture and analysis was similar to the procedures described in [8]. The data set thus obtained (CTA data set) is described in [9]. In summary, the data has two controls, the pre-treatment group and the one hour saline group, and four time points, 1, 3, 6, and 24 hours after conditioning. Each array has 1185 genes, and we have 5 biological replicates of each array.

2. Methods

The methods describe here were developed for the purpose of analyzing the CTA data set, but are sufficiently general to analyze any equivalent data set.

2.1 Error Correction and Clustering

We have devised a scheme for detecting and correcting errors using discretized data. Here we apply our technique to data from gene A01a in the CTA data set described in Section 1 to illustrate the method.
Each row is a repetition of the microarray experiment. Columns represent the measurements of the genes. Pre and Sal are the pretreatment (time 0) and injection with saline solution controls.

### 2.2 Averaging

The first step in the analysis is to average the expression across repetitions.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
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</thead>
<tbody>
<tr>
<td>cons</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
</tbody>
</table>

We also average our control columns to obtain a control value of 0.115.

We compute an epsilon value, such that either the 1 h or 24 h columns are within the range of control +/- epsilon. In this case, the epsilon is 0.022.

### 2.3 Discretization

We proceed to discretize each repetition by comparing each column to the control +/- epsilon. We illustrate for repetition 1:

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>calls</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The control for this repetition is (0.172 + 0.099) / 2 = 0.1355, epsilon is fixed for all our tests at 0.022. We now call a column `"+"` if its value is greater than the control + epsilon, `"-"` if it is less than control - epsilon, and `"0"` otherwise.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>calls</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2.4 Majority logic decoding

We now obtain a consensus for each column by majority logic decoding. 3 or more occurrences of the same symbol in a column indicate that symbol is the consensus. If no consensus is obtained, we indicate `"?"`.

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

### 2.5 Discretizing against averaged controls

The above procedure is very sensitive to the value of the controls. Errors in the controls can skew the entire set of calls. We devised an alternate method of discretization that replaces the control value for each row by the average of the control value for all the rows. In our case this average control is 0.113. The discretization of the repetitions using this average control yields the following values, which we summarize with this consensus versus average control (cvac):

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>cvac</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
</tbody>
</table>

### 2.6 Discretizing the average

We also compute the discretization of the average values of each column, using the control 0.113 and the epsilon 0.022:

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Sal</th>
<th>1 h</th>
<th>3 h</th>
<th>6 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>calls</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2.7 Error correction

We now enter an error correction phase, we seek out outliers in the data of the columns and remove them, and recompute the average, controls, and epsilon. With these outliers deleted from our data we now compute a new set of calls using majority logic decoding as above.

### 2.8 Consistent calls

We are now ready to produce a consistent set of calls for the gene. A set of calls is consistent if the following conditions are met:

1. at least two of the above set of calls agrees in the last 4 columns of data (1 h, 3 h, 6 h, and 24h)
2. either the 1 h or the 24 h columns is a `"0"`
3. across the last 4 columns of data, the column exhibits the consecutive zeros property (i.e., values do not oscillate between `"0"` and `"+"` or `"-"`)

As an example, the set of calls for A01a are:
discretization of the average expression of A05l yields genes on the arrays, the gene most associated with nucleotide database to this entry. Of the two CREB Clontech’s assignment of a gene in the Genbank spot on the Clontech arrays, the accession number is The coordinate column is a uniq

and A05l, these genes with a co

paralleling CREB’s expression. CREB binds to a DNA expression in order to detect changes in gene expression of both CREB and other genes with similar patterns of memory formation [10]. We focused on the expression protein), which is known to play important roles in

A particular focus of interest in our studies was the identification of genes regulated by the transcription factor CREB (cAMP Responsive Element Binding protein), which is known to play important roles in memory formation [10]. We focused on the expression of both CREB and other genes with similar patterns of expression in order to detect changes in gene expression paralleling CREB's expression. CREB binds to a DNA element called cAMP-response element (CRE) in the promoter region of its target genes, and in conjunction with a co-activator promotes the initiation of their transcription[ 11].

There are two genes in our dataset that bind CRE, A05h and A05l, these genes are described below:

<table>
<thead>
<tr>
<th>Coord.</th>
<th>Accession</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A05h</td>
<td>U38938</td>
<td>activating transcription factor 2 (ATF2); cAMP response element DNA-binding protein 1 (CREBP1)</td>
</tr>
<tr>
<td>A05l</td>
<td>X14788</td>
<td>cAMP-responsive element-binding protein 1 (CREB1)</td>
</tr>
</tbody>
</table>

These calls are not consistent, and this gene is removed from further examination. Together, the procedures we developed and the consistency criteria try to capture biologist's intuitions on the nature of gene expression changes.

3. Results

We have performed the analysis described above on the CTA data set described in Section 1. In this data set, there are 127 consistent genes, which we divide into clusters by grouping together the genes that have the same set of calls in the 1 hour through 24 hour timepoints. This results in 23 clusters.

A particular focus of interest in our studies was the identification of genes regulated by the transcription factor CREB (cAMP Responsive Element Binding protein), which is known to play important roles in memory formation [10]. We focused on the expression of both CREB and other genes with similar patterns of expression in order to detect changes in gene expression paralleling CREB's expression. CREB binds to a DNA element called cAMP-response element (CRE) in the promoter region of its target genes, and in conjunction with a co-activator promotes the initiation of their transcription[ 11].

<table>
<thead>
<tr>
<th>Coord.</th>
<th>Accession</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A07i</td>
<td>L24388</td>
<td>galactosyltransferase-associated protein kinase (GTA); CDC2-related protein kinase (CDC2L1)</td>
</tr>
<tr>
<td>B09h</td>
<td>L10362</td>
<td>synapic vesicle protein 2B</td>
</tr>
<tr>
<td>C10c</td>
<td>L33869</td>
<td>ceruloplasmin (CERP; CP); ferroxidase</td>
</tr>
<tr>
<td>D08n</td>
<td>X63255</td>
<td>N-methyl-D-aspartate receptor subtype 1 (NMDAR1; NR1); glutamate receptor subunit zeta 1 (GRIN1)</td>
</tr>
<tr>
<td>E03m</td>
<td>M29712</td>
<td>guanine nucleotide-binding protein G(K) alpha 3 subunit (G(I) alpha 3 (GNAI3)</td>
</tr>
<tr>
<td>E04i</td>
<td>V01228</td>
<td>calcitonin</td>
</tr>
<tr>
<td>E13h</td>
<td>M20713</td>
<td>guanine nucleotide-binding protein G(K) alpha 3 subunit (G(I) alpha 3 (GNAI3)</td>
</tr>
<tr>
<td>E14f</td>
<td>X06890</td>
<td>ras-related protein RAB4A</td>
</tr>
</tbody>
</table>

From Ensembl we obtained genomic sequence for each of these genes, 1020 base pairs starting 800 base pairs upstream of the transcription start site. These sequences were then submitted to TESS [13] to search for transcription factor binding sites. We look for the CRE element, a DNA sequence that is the target site for CREB. Genes that have CRE in their upstream region are potential targets of regulation by CREB.

Based on our findings we focused on two specific genes: E03m or Pmch (pro-melanin-concentrating hormone) and E04i or Calca (calcitonin/calcitonin-related polypeptide, alpha). Both genes have CRE elements in their upstream regions. According to the Rat Genome Database [14], Pmch is a cyclic neuropeptide that induces hippocampal synaptic transmission. Pmch also seems to have an effect on appetite or metabolism [15] and anxiety [16], and promotes synaptic transmission in the hippocampus [17]. Calca is principally a vasodilator, but seems to have a role in axonal regeneration or synaptogenesis [18]. Thus, these genes exhibit a pattern of expression
consistent with the expression of Creb1, have CRE elements upstream of their transcription start site, and seem to have a role in strengthening or creating new synapses.

4. Discussion

We have developed a method for error correction of microarray experiments. The technique produces a clustering of genes and describes each gene as unchanged, upregulated, or downregulated, in accordance to biologists natural description of expression levels. We applied these techniques to a microarray data set derived from a CTA experiment in rats, looking for genes that may be important in learning and memory processes. We found two genes, Pmch and Calca, that share an expression pattern with CREB, contain CRE in their upstream regions, and have demonstrated function related to synaptic plasticity. Pmch and Calca are strongly implicated as important genes for the formation of memories. We are now actively seeking confirmation of these genes role in CTA and of their regulation by CREB as a result of CTA training.

5. Acknowledgments

The authors received partial support from a SCORE grant (S06GM08102), an INBRE grant (P20RR16470) and an IDEA Program grant (P20RR15565), from the National Institutes of Health.

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Research on 3D Biped Motion through the Use of LEGO Mindstorms NXT

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1. Introduction

Biped motion is one of nature’s finest achievements. It can be “a walking motion can be considered as a repetition of one-step motion” (Ha 2) Perfected through millions of years, it has achieved a state-of-the-art status, especially with us. Thanks to this complex walking system we are able to have our hands free and use them to produce tools, make fire, and hunt, among performing many other tasks. The biped motion has indeed been a breakthrough for our species and has proven to be the best motion system for us, allowing us to be efficient in the work we do. Even though it is easy to learn how to walk, the underlying processes of walking is far more complex than imaginable. For example, whenever a step is taken, thousands of sensorial inputs are sent to our brain so it can maintain our stability, apply the right force, and not crash against an object. Then, when all the information is processed, the brain sends thousands of impulses to the muscles in the body, all in perfect coordination, so we can take a simple step. Current technology can hardly perform functions like the human brain does; it would be hard for a computer even just to process hundreds on sensorial inputs in order to calculate a step. For now, we can only expect to copy what nature has already designed, and hope to improve it in the future.

Biped motion is considered one of the most challenging engineering problems. The model - us - is also the judge, and satisfaction will not be reached until a machine can truly approach human grace. Biped motion is a very promising area of research, with lots of benefits and applications.

For example, if a truly compact and powerful array of robotic legs is produced, thousands of people unable to walk could walk normally again, using robotic legs as a replacement for wheelchairs. For this and many other future uses, research on biped motion is imperative and will have a direct impact on people’s lives, just as the computer has.

2. Methods

Many approaches have been investigated during this research. The models used were humans themselves. By analyzing our own walking, My primary design should be based on changing our center of gravity (COG). In humans, changing the COG is achieved by moving the upper part of the body and displacing most of the weight under one leg. This displacement allows the other leg to assume its position for the next step, and walking is achieved by repeating this process.

Starting from this initial point, I used other methods to work around the COG implementation. The first design model used static legs, and the entire body was moved to change the COG “That is, the position of CoG must be in the area above the feet when the biped is standing on leveled ground with no external force to cure” (Satoshi 241). The second design model incorporated a method based on independently-controlled legs joined by a single axle to allow steering. These methods resulted in successful walks; however, they needed to be adapted to work in more robust environments, which is what was done in the third design. Here both COG and independent leg control were implemented on a single robot. The
method was to divide the legs into two parts, namely, upper and lower. The upper part of both legs was controlled by a motor located in the torso resembling the quadriceps in humans, while the lower part of each leg was controlled by a single motor. Finally, the fourth current design incorporates all methods used in previous models. The current design has a very robust structure, allows steering, independent leg control, parallel feet-body stabilization system, feet based COG, and higher weight placement. All these methods depend on the mechanical distribution of the motor force in order to make the machine walk. That is because the micro-controller used could only control a maximum of three motors; therefore, the number of degrees of freedom that could be assigned to the legs was limited and was dependent on the tuned components to make it all work. Before building a serious model, various sketches were made to test design ideas. Four separate models were created. The first two merely tested the design hypotheses, and the last two implemented previous knowledge and solved problems in the previous two designs. The process of improvement of features for the first three preliminary designs is summarized below: Design 1: Implements the basic COG change and steering.
Design 2: Implements the independent leg system, and steering.
Design 3: Implements the COG change, independent legs, robust design, and stabilization bars. This is the first successful design to perform walking.

3. Results

Overall, the robot implemented as the fourth design can stand on one leg and walk some steps. Due to the motor and control limitations, its not very stable, and will only walk on flat surfaces. While walking, it has no resemblance to humans in its grace. Motors suffer while performing steps, making the movement far from smooth. Pneumatics would probably be a better choice for moving parts for future work.

4. Conclusions

In conclusion, it is better to increase the number of motors and give more degrees of freedom to the legs instead of distributing the power of one single motor, tune the robot, and expect all the mechanical parts to work in harmony. Precision from the motors is as vital as the structural strength of the robot. It is better to have a micro-controller that can control at least eight motors than the currently available, which controls three. A more capable micro-controller will allow more degrees of freedom, and can diminish the need of structural robustness.

Acknowledgement

This project has been funded by the NSF- grant (pass thru UTEP) “BPC: A Computing Alliance for HSI’s”. I would like to thank my faculty advisor and mentor, Dr. Mehrube Mehrubeoglu, for her help in this project. I would also like to thank Dr. John Fernandez, the project coordinator, for the opportunity to be an undergraduate researcher at freshman level.

6. References


A Formal Approach for Specifying Access Control Contracts for Java Modules

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1. Introduction

Computer security has become a very important issue in recent years. Nowadays, the computer security community is quite concerned about the problems involving access to sensitive resources [1] [2]. Examples of sensitive resources include database and system files, network ports, CPU processing time and memory space. Proper access to such resources is to be enforced by both designers and developers of software products. Designers are entitled to identify, classify, integrate, and specify which resources within a system are to be protected by means of access control constraints. Developers are expected to enforce the access control constraints either in the source code or by making use of an external monitor [3]. Implementation of the constraints has been traditionally deployed as an independent issue when it comes to system design, separating behavioral from security-related functioning; this methodology is often referred as separation of concerns [4]. Separation is done in order to facilitate both design and implementation of the system as a whole. However, when it comes to component-based system design, this separation may create a potential source for security-related vulnerabilities because it is often difficult to derive and extract security-related and behavioral-related descriptions for independent software components. Furthermore, since security is sometimes seen as a post-implementation event that is to be exercised once the overall system has been developed, chances are that the interaction between components is not completely tested, thereby many potential security issues may not be addressed.

We believe developers and clients can benefit from a formal specification of software products that makes use of both behavioral and security related concerns. The main idea is to develop a declarative mechanism tailored for the specification of access control policies as well as the behavior of a software module such as a Java class or method. We call this specification access control contract. In the application design process, developers can focus on extracting the important access control policies required for their code to work safely, integrating functional behavior with access control behavior. In our approach, the detailed policies are to be described by means of a behavioral interface specification language (BISL), such as the Java Modeling Language (JML) [5]. Such specification can be later processed by a tool in order to produce the necessary Java bytecode to provide access control checks when the code is executed, using an approach similar to the one used by the JML runtime assertion checker [6].

2. Approach

2.1 Java Modeling Language

The Java Modeling Language (JML) [7] [8] is a behavioral interface specification language (BISL) based on Design by Contract [9], and is tailored to describe the behavior of Java modules, that is, what a software module is expected to do. In JML, a contract between a client of a module and its implementer is specified by using pre-conditions, post-conditions and frame conditions, among other things. Before the execution of a method \( m \), if \( m \)'s precondition holds, that is, if it has been completely satisfied by \( m \)'s client, then \( m \)'s post-condition can be assumed once \( m \)'s execution is completed. The contract is commonly added to the Java source code as a special annotation comment.

2.2 Permission-based Approach

The Java Virtual Machine (JVM) provides a mechanism for checking access control constraints whose main functionality is embedded in the so-called Security Manager [10]. The security manager checks for access control permissions granted to a set of principals, such as Java classes, in order to allow or deny access to a requested resource, i.e. a text file in the current file system. Our first approach is to introduce a new JML expression called \( \text{permission()} \) to express the required permission a Java module needs to be granted to behave accordingly.
The permission expression takes as a parameter the permission to be evaluated, which is represented by a valid constructor signature for a class derived from the abstract class Permission. The expression evaluates to true if the permission checking process grants the desired permission. Otherwise, it evaluates to false. Thus, the expected behavior of a Java class or method can be constrained to different specification cases if the checking process grants or denies a certain permission.

2.3 Visibility-based Approach

The second approach is closely related to the visibility specifiers of the Java programming language, also known as access mode specifiers. In Java, a module can be declared to be either public, private, protected or package visible. The public specifier allows every other class to either create an object, in the case of classes, or to call a certain method declared to be public. We propose a new JML expression, \texttt{\textbackslash \textit{called by}()} to restrict the clients that can call the module. The client’s modules can be identified by class name, method signature, interface name or method return type. By means of this expression, the specified callee module can thereby provide different specification cases according to the nature of the caller, varying from different expected behavior to a complete authorization or denial of the method’s execution. The formal specification of both caller and callee can be used together to reason about the use of a protected resource with respect to a certain use defined by a security policy.

```java
package corporation.office;
public class Employee {

  protected String /*@spec_public@*/ name;
  protected String /*@spec_public@*/ SSN;

  @requires
  @ @ 'permission(EmployeePermission(this.name,"read"))
  @ @ "called_by(corporation.office.Manager),"
  @ @ ensures 'result.equals(this.SSN);
  @@*/
  public String getSSN(){...}
}
```

Figure 1: JML and purposed extensions example

Figure 1 shows a short example of JML and the purposed extensions. The first precondition for method \texttt{getSSN()} requires the permission \texttt{EmployeePermission} to be granted by the access control mechanism implemented by the JVM. The second precondition restricts the public visibility of this method by preventing any module named \texttt{corporation.office.Manager} from calling it. If both preconditions succeed, the postcondition of the method, stated by the keyword \texttt{ensures}, guarantees that the result of the method is equal to the SSN of the employee represented by the class \texttt{Employee}.

3. Implementation

Tool support for the purposed approaches has been implemented by using Polyglot [11], an extensible compiler framework. The framework facilitates the implementation of an extension to the Java language by defining a new grammar based on the original Java grammar rules. JML annotations are checked for correctness against the Java language rules and they are later translated into Java source code. The tool takes a Java source file annotated with JML specifications and produces legal Java source code that enforces the access control constraints formally specified by means of the newly introduced JML annotations. The newly produced Java source code can be then compiled with a standard Java compiler, such as \texttt{javac}. Enforcement of the access control constraints is done at runtime, when the program in executed. If the access control constraints are successfully solved, which means access to sensitive resources is granted, the modified Java program behaves exactly as the original one, without any other side effect than a minimal detriment in execution time, caused indeed by the time required by the program to perform such access control enforcement. If the access is not granted by the enforcement code, an exception is thrown indicating a violation of the access control contract.

4. Conclusions

In order to allow a formal specification of access control and behavioral constraints in Java modules, we have introduced two new extensions to the Java Modeling Language (JML). The first one, called \textit{permission-based} approach, is based on the permission system currently used by the Java Virtual Machine. The second approach, named \textit{visibility-based} approach, relies on an extension to the access modifiers of the Java programming language in order to restrict the modules that are granted access to a protected resource, which has been encapsulated into a Java method. Future research topics may be explored based on the ideas we have introduced in this document.

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Advancing Earth and Environmental Sciences through Workflow-Driven Ontologies

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1. Introduction

Cyber-Infrastructures (CIs) and portals such as GEON [1] and CEON [2] provide services and access to data in support of scientific efforts. With the increasing availability of CI resources, there is also an increasing need for mechanisms to integrate data that have varying accuracy and sensitivity and that come from distributed sources. Workflow-Driven Ontology (WDO) is an approach that allows scientists to capture discipline knowledge in the form of ontologies. Such discipline knowledge is then leveraged towards automatically extracting process knowledge about the operational procedures that scientists carry out to create models and other scientific artifacts. As a result, this process knowledge represents recipes that can be shared among a scientific community and that describe how CI resources can be integrated to create models and scientific artifacts.

The development of the WDO approach is currently housed at the CyberShARE Center of Excellence [3]. CyberShARE is an NSF CREST research center that provides a collaboration atmosphere among earth, environmental, math, and computer scientists, making it an ideal test bed for this work. The mission of the CyberShARE Center is to advance and integrate education and research in uncertainty, trust, and optimization in support of CIs to (a) develop and promote scientist-centered software services, middleware, and tools that help scientists use technologies such as provenance management, ontologies, and workflows; and (b) promote collaborative and interdisciplinary research approaches to advance the state-of-the-art in earth and environmental sciences. The WDO approach represents an enabling technology that is in alignment with the goals of the CyberShARE Center.

2. Workflow-Driven Ontology Approach

The WDO approach is divided into two phases, the first phase consists of capturing discipline knowledge in the form of a machine-interpretable ontology, and the second phase consists of using the ontology as input for a reasoner algorithm that automatically extracts process knowledge in the form of abstract workflow specifications referred to as Model-Based Workflows (MBWs). These two phases are described next.

2.1 Capturing discipline knowledge

Use cases typically drive the specification of domain-based ontologies [4]. In the WDO approach, abstract workflow specifications drive the elicitation and specification of concepts and the relationships among those concepts [5]. For example, discipline experts begin the knowledge capture process by identifying a product concept and from that product identifying method concepts (e.g., services) that can be used to generate it. Furthermore, discipline experts can identify data concepts that are required as input for the identified methods. The methodology for creating WDOs is supported by the WDO-It! software tool that scientists can use to produce WDOs in the form of Ontology Web Language (OWL), the standard language to represent ontologies proposed by the W3C [6].

2.2 Extracting process knowledge

Once discipline knowledge is captured in a WDO, scientists can extract process knowledge from the WDO by utilizing a reasoner algorithm to interpret the WDO. The WDO-It! tool allows a user to identify a product concept of interest (as described in a WDO) and to use a reasoner to extract process knowledge from the WDO that describes how to create the selected product concept. Process knowledge obtained from the WDO-It! tool is expressed as an abstract workflow specification referred to as a Model-Based Workflow (MBW) [7]. The workflow specification is called model-based because it is described in terms defined by the target discipline (i.e., the discipline captured by the WDO). Since MBWs are described in terms to which
discipline experts can relate to, discipline experts are motivated to evaluate the process knowledge generated from a WDO, hence allowing discipline experts to contribute in a more systematic manner to the knowledge captured by the WDO. For example, after analyzing a workflow to produce a contour map of gravity data, a geophysicist may detect that the workflow specification is missing a filtering step. The geophysicist can then refine the WDO to introduce a new filtering method concept, as well as to specify the appropriate relationships among existing concepts in the WDO in order to generate a new version of the workflow.

3. Preliminary Results

A preliminary usability study was conducted to evaluate the WDO approach and the WDO-It! tool in particular. The study was conducted through the Summer Southwest Regional Cyberinfrastructure Workshop held in August 10, 2007 at the University of Texas at El Paso. The workshop invited a group of scientists that included students, faculty, and professionals. The main objective of the workshop was to promote awareness of the role of CI as it relates to scientific research. Workshop participants were presented with a series of tutorials, including a WDO-It! tutorial with hands-on exercises. Participants were subsequently asked to assess the tool through a questionnaire and through their contribution in a focus-group meeting.

Overall, attitudes toward the WDO-It! tool were extremely positive. The most appraised features of the tool included the graphical representation of process knowledge generated by the tool, its ease of use, and its potential for cross-disciplinary use. The main problem reported included the expressivity limitations of MBWs; the process knowledge generated by the tool does not support process iteration and process abstraction, i.e., the ability to expand and contract particular steps in the process knowledge to show or hide details.

Next steps include the refinement of the MBW specification to address the limitations reported. To guide such efforts, additional use cases will be gathered in the areas of earth and environmental sciences as they relate to the research projects undertaken by the CyberSHARE center.

4. Conclusions

CI efforts have advanced dissemination of information and tools, resulting in new ways to exploit technology to conduct scientific research. In order to maximize the impact of CI in the performance of scientific research, there is a need to provide scientists with capabilities and methods necessary to take control of how to employ the resources available over CI and to allow scientists to drive future development efforts of CI resources. The WDO-It! tool builds upon previous work on Semantic Web technologies and leverages the cross-discipline research environment provided by the CyberSHARE center as a test bed.

The benefits of capturing process knowledge of scientific disciplines is two-fold: 1) it provides a mechanism by which domain experts can document operational knowledge that can be used as an educational tool to train the next generation of scientists, capturing knowledge that may be not widely known, and 2) it provides a machine-interpretable specification of process knowledge that can be leveraged to harness distributed resources such as those provided by CI.

CyberSHARE also supports other work related to provenance data and trust that is intended to complement WDO [8]. By annotating results obtained from the process knowledge described in WDO with provenance information, scientists can obtain an explanation of how results are constructed, and what resources are used in the construction process along with the intended results. Automating explanations of how scientific products are constructed over CI will become critical as CI grows in complexity. This feature provides a mechanism for promoting the use of CI, and as a result, will support advancement of scientific efforts over CI.

References


Human-Computer Interface for Person with Severe Motor Disability

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1. Introduction

Computer interface research has known respectable growth in the last decade, and the deployed assistive technology tools have been developed to enable persons with disabilities to harness the power of computers and access the variety of resources that are available to all [1–3]. A number of human-computer interfaces (HCI) have relied on the integration of eye gaze tracking (EGT) systems as one possibility to provide for user interaction with the computer through eye movement [4–6]. A typical modality of such assistive systems consists on the use of EGT to determine the direction of gaze, which is then normalized into screen coordinates and used to reproduce any of the mouse pointer actions.

Unfortunately, the use of EGT systems as the primary mechanism for controlling the mouse pointer has been complicated by inaccuracies arising from saccadic eye movement. Some attempts of increasing the accuracy of mouse cursor control through eye gazing activity involve the integration of a complementary technology such as Electromyogram [7–9]. However, these approaches result in the users having to wear some device such as electrodes which may be uncomfortable for the user.

To make matters worse, the jitter effect generally varies in degree and other characteristics between different users. The jitter effect across multiple users may be so varied that a single control scheme to address every user’s jitter effects would likely require significant, complex processing. As a result, the system would then be unable to control the mouse pointer position in real time. But without real time control and processing, users would experience undesirably noticeable delays in the movement and positioning of the pointer.

The objective of this research endeavor is to develop an eye gaze-based HCI system that accommodates and adapts to different users through design customization and configuration. Generally speaking, the methodology relies on a user profile that customizes eye gaze tracking using artificial neural networks (ANN). The user profiling aspects facilitate universal access to computing resources and, in particular, enable an adaptable interface for a wide range of individuals having severe motor disabilities, such as those arising from amyotrophic lateral sclerosis (ALS), muscular dystrophy, spinal cord injury, and other disabilities characterized by lack of muscle control or body movement.

2. Methods

2.1 Overview of the EGT System

The HCI system as proposed is based on a benchtop eye gaze setup. It consists of a CPU for raw eye movement data acquisition, a CPU for user interaction, an eye monitor, a scene monitor, an eye imaging camera, and an infrared light source. The EGT system used is the ISCAN® ETL-500 [10].

2.2 Participants

The study involved twelve subjects, 7 males and 5 females, ranging from 25 to 46 years of age in Test 1. Nine of the initial participants, 5 males and 4 females, were involved in a second experiment. One of the subjects had Spinal Cord Injury and was involved in both tests. The rest of the participants used a head rest to prevent abrupt head movement.

2.3 Implementation Steps

To develop a neural network to effectively reduce the jitter of the mouse due to eye movement, the following steps were implemented: (1) analysis of the mouse cursor trajectory without ANN intervention, (2) define a suitable configuration of the ANN, (3) acquisition of data and extraction of training patterns for training the ANN, and (4) training of the ANN and saving the results from the training (i.e. weights and biases) as a user profile. In step (1), the mouse cursor trajectory was analyzed by subdividing it into smaller sections, which allow the trajectory of the mouse to be described linearly. Each subset contains 6 (x,y) points
generated during a time interval \( t \) of 1/10 of a second and is used as input to the ANN. Therefore, the ANN contains 12 (6 x-ordinates + 6 y-ordinates) neurons in the input layer. Based on step (1), the ANN configuration was defined as: 12-24-2. The ANN is trained using the backpropagation algorithm and default activation functions as follows: (1) Linear for the input layer, (2) Logsig for the hidden layer, and (3) Linear for the output layer.

The data collection process (step (3)) involves a moving target, such as a button, rendered on the display device of the stimulus computer, which the user must follow throughout the entire session which last 2 minutes. As the user looks at the button, the mouse pointer coordinates are taken as the input training set, while the actual average display coordinates of the moving button \((\bar{x}_b, \bar{y}_b)\) are taken as the ANN target set. The training set is then divided into sample frames of 1/10 of a second or 6 separate coordinate pairs for a total of 12 input data values for each training pattern. A non overlapping scrolling window is used for data collection, which simplifies the programming code and reduces the training set size. This process is repeated for each user in order to tailor the ANN data and create user profiles.

The individual training patterns are then applied for training the ANN in step (5) and the results from the training (i.e. weights and biases) are then saved as a user profile, which basically defines EGT behavior of each particular user from a prior experience. The customized ANN based on these users profiles will in time provide the capability for all users in the database (i.e., users with existing profiles) to interact with a computer in real time with minimized jitter effects. Furthermore, besides creating a new profile, users may also edit an existing profile. By retraining an existing ANN, the system adapts in time to the user as subtle differences are learned with each recorded experience. Thus, users may update an existing user profile to accommodate additional changes in jitter characteristics.

3. Results

Test 1 reflects a 35.1% reduction in jittering error when the EGT is supported with ANN intervention, which represents a substantial improvement in the use of eye gaze to control the mouse pointer.

The results of a second experiment reveal an averaged jitter reduction of 53% when the EGT is supported with ANN intervention. Since the participants had already used the system, they were familiarized with the system and some of them had retrained the ANN to further adapt the interface to their jittering characteristics. This is reflected in the results for the degree of jitter since it has been reduced even more in comparison with the results obtained from Test 1.

Mouse cursor trajectory plots reflect a substantial improvement on the control of the mouse pointer through eye gazing when computing the mouse cursor coordinates based on the user’s profile. With the intervention of the ANN, the pointer trajectory is now smoother, and more impressive is that when there were substantial offsets, they were still corrected by the ANN.

Figure 1. Visualization of the jitter reduction under different tests

4. Conclusions

This study focused on the implementation of an algorithm to smooth out abrupt and unwanted jerky behavior of the mouse cursor due to the saccadic nature of the eye movement via the configuration of an artificial neural network that minimizes the jitter effect based on user characteristics. These characteristics were extracted via the creation of user profiles through an embedded graphical interface. The smoothing algorithm resulted in an average jitter reduction of 35% when using the system for the first time and a 53% averaged jittering reduction after using the system several times. Consequently, the trajectory of the mouse cursor was found to be significantly smoother, and could reach the target with an improved degree of accuracy.

The separate, dedicated management of each user profile allows the ANN to be trained, and re-trained, for
each user, respectively. Re-training of the ANN involves updating the weights and bias, thereby building upon prior customization and configuration efforts. More generally, a user profile-based approach to reducing jitter effects addresses the user-specific, or user-dependent, nature of jitter. Conducted experiments proved that after retraining the ANN 3 or 4 times, the system learns even further the gazing behavior for that particular user, which yield an 80% averaged reduction of the jittering behavior of the mouse cursor.

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A Unified Approach to Seizure Detection on Subdural Recordings Using Non-linear Decision Functions

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1. Introduction

The Epilepsy Foundation of America estimates that 2.3 million people in the United States suffer from seizure disorders, which are grouped under the common name of epilepsy.

In the study of epilepsy, seizure detection is an important step towards accurate 3-D localization of epileptic foci, while seizure prediction remains an ultimate goal in order to prevent unforeseen events some with potentially dire consequences. With such critical research aims, many mathematical parameters over the years have been put into practice by various research groups with different measures of success. This outcome is quite understandable given the challenge imposed by such a challenging research endeavor. In the context of this study, many of the methods currently available in the specialized literature have been tested yielding different results.

It is extremely important to detect a seizure. Up to date, different methods are known for seizure detection. Based on our experience, we have denoted that each patient has a different behavior of its EEG signal. Having a method that adapts to every patient would be very helpful for the precise location of an epileptic focus. Thus, a more targeted treatment could be addressed base on its particular characteristics.

In the past, researchers have considered different approaches using a diversity of linear and nonlinear parameters in order to automate seizure detection and prediction [1]. Some of these parameters implemented in this study are briefly described based on the general themes they are set to exploit.

This study provides a performance evaluation of several important features, many of which are commonly used in the literature for seizure detection as well as for seizure prediction [2, 3, and 4]. This is in order to form a retrospective on the functional attributes of such features in their accuracy focusing initially on their prospects to detect seizures. As a corollary of this retrospective is the appreciation of the complexity of the general behavior of these features, and in understanding the difficulties engendered in the different attempts by researchers to generalize their use (intra or inter patients) for seizure detection, and more so for seizure prediction. A simplified architecture is proposed to carry out inter-patient analyses and provide a performance evaluation of 12 standard features commonly used in the literature.

2. Methods

2.1 Participants

Subdural EEG recordings of eight epileptic children were considered in this study. A total of twenty six different seizures were studied. Recordings were performed during pre-surgical monitoring at the Miami’s Children Hospital (MCH) using XLTEK Neuroworks Ver.3.0.5, equipment manufactured by Excel Tech Ltd. Ontario, Canada. This data was collected at 500 Hz sampling frequency and filtered to remove DC and high frequency components using a 0.1-70 Hz band-pass filter.

2.2 Data Analysis

Due to the high volume of information contained in the pre-filtered EEG data files, size reduction was necessary. Data files were segmented in one second time windows and features were extracted for all windows and for each electrode. The size of the set was thus reduced to a small number of features that are representative of the EEG. This set of features was then used for the study. A comparison of all of them was conducted in order to analyze and determine among all these features which one were the most suitable for use in seizure detection. Confusion matrices were generated and the ROC analysis was performed such as to elicit a better understanding of the performance attributes of each of the following 12 features:
F1: activity
F2: mobility
F3: complexity
F4: mean of auto-correlation
F5: standard deviation of auto-correlation
F6: spectral power in the delta band (less than 4 Hz)
F7: spectral power in the theta band (4-8 Hz)
F8: spectral power in the alpha band (8-13 Hz)
F9: spectral power in the beta I band (13-20 Hz)
F10: spectral power in the beta II band (20-36 Hz)
F11: spectral power in the gamma band (36-44 Hz)
F12: correlation integral

Some of the most studied features such as mobility and complexity are known as Hjorth parameters [5]. Other interesting features are used in EEG processing in seizure studies, such as the Lyapunov exponent which is a complex mathematical quantity in which the amount of chaos in the brain is measured [6 and 7]. This exponent is somehow computationally intensive, however, it contains in its formula a quantity called correlation integral, which also deals with the signal chaos.

After extracting the features for each electrode and patient, further data reduction was necessary for the following reasons:

- There were too many electrodes per patient,
- not all patients had the same amount of electrodes, and
- Not all electrodes were placed at the same position from patient to patient.

This situation lead to a large database that would also make impossible to create a model for seizure detection that would work regardless of the number of electrodes and their position. A solution to contend with both the large data base and the different number and locations of electrodes was to compute the average of all features across all electrodes for each time window.

In this study, the procedure was performed to an inter-patient analysis, and therefore, some patient files were used as reference files as baseline to extract the thresholds. The remaining files were kept for testing.

The classification results obtained were then compiled in order to perform an ROC-based analysis.

Throughout this paper, classifier names will be simplified by numbers according to the feature that they are based on. For example, the classifier based on F1 will be named “classifier 1”, and so on.

Performance evaluation of the classifiers was conducted based on the Receiver Operating Characteristics (ROC) terminology [9]. An ROC analysis is started with a confusion matrix [10] which contains information about actual and predicted classifications done by a classification system. The entries of the confusion matrix for a two class classifier are:

- TP (true positive) is the number of correct predictions that an instance is positive
- FN (false negative) is the number of incorrect predictions that an instance is negative
- FP (false positive) is the number of incorrect predictions that an instance is positive, and
- TN (true negative) is the number of correct predictions that an instance is negative.

Sensitivity and accuracy were extracted from the confusion matrices. Sensitivity is the proportion of the number of TP to the total number of positive instance and accuracy is the proportion of the number of correct detections to the total number of detections.

3. Results

Results reveal that the classifier that performed best across all patients was the correlation integral and complexity with a sensitivity value of 100% and an accuracy value of 97%. From the list of twelve, both of them are the most appropriate to be used for seizure detection purposes. An optimum classifier would be one whose sensitivity is 100% and accuracy is near 100%. Sensitivity is very important to account for because it takes into consideration all the FN values. Obviously, 100% sensitivity is what we are looking for in order to avoid false negative instance solutions in our algorithm.

The gamma power, activity, theta power and alpha power had a sensitivity value of 91% with accuracy values of 95%, 72%, 59% and 53% respectively. Mobility had a sensitivity value of 83% with accuracy values of 94%; and the other features obtained low values for both sensitivity and accuracy.

The results obtained through the measures of sensitivity and accuracy reveal interesting findings: (1) Two features have detected seizures across all the patients; (2) accuracy and sensitivity varied across features except for correlation integral and complexity. The merits of the algorithm consist of providing an analysis of the features in term of their compliance to detect a seizure based on ROC.

The results obtained using this unified approach based on nonlinear decision functions are illustrated in Figure 1.
knowledge about the seizure detection endeavor and data. This achievement makes the method suitable for systems [10]. The clinical success of this study relies on which the claim of chaotic dynamics has been made in biological systems [10]. The clinical success of this study relies on detecting seizures from long duration subdural EEG data. This achievement makes the method suitable for real-time detection applications. It is the hope of the authors that this research advances the extensive knowledge about the seizure detection endeavor and helps to disguise the seizure prediction problem. As this research will involve a higher number of epileptic patients as they become available, additional results will provide more weight to our findings.

4. Conclusions

For this study we formulated and evaluated characterizing features of subdural EEG signals. We translated each of the observable characteristics into mathematical expressions such that each and every one of the characteristics is implemented in the development of our algorithm. The uniqueness of this algorithm is in the establishment of a mathematical foundation capable of detecting an epileptic seizure with nominal computational requirements.

A new technique was presented for seizure detection from different EEG datasets. In order to accentuate the influence of the different features, an inter-patient analysis was performed. As a result, it has been found that the correlation integral and complexity are the best features to detect a seizure; the sensitivity was 100% and accuracy was 97%. Correlation integral is currently the most common basis on which the claim of chaotic dynamics has been made in biological systems [10]. The clinical success of this study relies in detecting seizures from long duration subdural EEG data. This achievement makes the method suitable for real-time detection applications. It is the hope of the authors that this research advances the extensive knowledge about the seizure detection endeavor and helps to disguise the seizure prediction problem. As this research will involve a higher number of epileptic patients as they become available, additional results will provide more weight to our findings.

References

Computer Security: Methods of Intrusion Detection and Prevention

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1. Introduction

There are over 15,000 reported attacks according to the Sans Internet Storms, a center for keeping watch of malicious activity. The attacks can pose serious problems for many computer users and non computer users. In the Computer Security Research Lab (CSRL) our goal is to design a better computer security system.

Computer Security Research Lab members have been working hard to research various ways to handle the task. The CSRL project is supported by a grant from the National Geospatial-Intelligence Agency (NGA) under the project title “Information Fusion in Sensor-based Intrusion Detection Systems”. The project steps, which include a setup of a network for actual attacks and testing, a setup of sensor systems to detect attacks, and more, have proven there are ways to accomplish the task. First, CSRL team has setup two production networks that implement a web server and work stations in hope of attracting attackers. Second, a sensor has been set in place running Snort IDS to detect attacks. The first parts of the project have been running and collecting large amounts of data, which include various attacks and activities. The next step is to find a way to incorporate all the learned information throughout the project into a Computer Security Software.

In total, the research projects of CSRL have been exploring ways to create a system that will detect and prevent attacks.

2. Methods of Intrusion Detection and Prevention

The CSRL Team has come up with a way to use Snort IDS and IP Tables to create a Computer Security Software to detect and prevent attacks. The use of a sensor computer implementing Snort and a firewall running IP Tables are used in the program

2.1.1 Sensor Computer

The sensor computer running Snort has proven an excellent tool in detecting attacks. From the data currently collect show various attacks that occurred and attacks also marked unknown. The difficulties in research snort are finding out how Snort data has been stored. Snort Alerts are being stored in a MySQL database and finding out how to use it was a crucial part in creating the software.

2.1.2 Firewall

The firewall running IP Tables has shown to be a very easy yet complex firewall to use. IP Tables with its ability to be controlled to console commands has the capabilities of filtering data, transferring connection, and hiding information in the connection. With these capabilities we hope to create a powerful security system.

In the initial stage after learning how to use IP Tables, CSRL Team has created a small web application for modifying, looking up, and keeping track of IP Tables rules. The software, we call IPTable_LookUp have proven a powerful interface for the software we plan to develop.
2.2 JACED_IPTables

JACED_IPTables Version 1 is the Computer Security algorithm/software and is the result of researching Snort IDS and IP Tables. It will take alerts from Snort database and transform them into IP Tables rules to block out the connection. It runs in live time.

The problem with the first version is the mass amounts of false-positive and the numerous connections that are dropped completely and never recorded. The current stage at CSRL is finding ways to fix the problems in version 1. The propose plans are using data mining techniques and improve the overall flow of the program. The data mining technique propose in version to is classification, which involves checking numerous types of attacks for an IP Address to determine the IP Address is an attacker.

3. Results

The results of the JACED_IPTables Version 1 have proven that it can block out attackers, but proves that it cannot determine if the attacker is a real attacker. Version 2 has great improvement over Version 1 with the implementation of data mining technique classification. The future of the program is to improve the classification and use other data mining techniques.

4. Conclusions

The CSRL members are working hard in finding ways to improve security. JACED_IPTables is one step closer. The future improvements include fusion of sensors and shared collection of data among sensors and firewalls.

Acknowledgement

Supported by a grant from the National Geospatial-Intelligence Agency

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Computer Security: Data Mining Tools

Damien Hsu

Data Mining Tools

Key Data Mining Tools

1. Association Rules
2. Classification
3. Clustering
4. Regression
5. Anomaly Detection

Data Mining Applications

- Classification
- Clustering
- Regression
- Anomaly Detection

Communication: Tool and Software

Data Mining Software

- Weka
- RapidMiner
- KNIME
- Hadoop
- Spark

Conclusion

- Data Mining is a powerful tool for analyzing large datasets.
- It helps in discovering patterns and relationships that are not immediately apparent.
- It is widely used in fields such as healthcare, finance, and e-commerce.

Acknowledgments

- Thanks to all the participants and sponsors for making this possible.

References


CAHSI Annual Meeting Poster Session 2007
3D Epileptic Seizure Focus Localization Using an Integrated Multimodal Neuro-Imaging

FIU

Abstract:

The purpose of this study was to develop a new method for estimating the location of epileptic foci using an integrated multimodal neuro-imaging approach. The study was conducted on a group of patients with epilepsy and interictal spikes using a combination of structural and functional imaging techniques. The multimodal approach was designed to improve the accuracy of localization by integrating information from different imaging modalities.

Methods:

The multimodal approach included MRI, PET, and fMRI scans. The multimodal data were analyzed using advanced image processing techniques and machine learning algorithms. The fMRI data were used to identify the areas of the brain that are involved in the generation of seizures, while the PET data were used to identify the areas of the brain that are hypermetabolic, indicating the epileptic foci.

Results:

The multimodal approach was able to accurately localize the epileptic foci in all patients. The average error in localization was less than 1 cm, indicating a high level of accuracy.

Conclusion:

The multimodal approach for estimating the location of epileptic foci using integrated neuro-imaging techniques is a promising method for improving the accuracy of localization. Further research is needed to validate the method in a larger population of patients with epilepsy.
Efficient QoS Resource Management for Grids
C. Castillo, G. Reinoso, K. Harbouah
NC State University

Advance Reservations
✓ QoS guarantee
✓ Co-allocation
✓ Predictability
Drawbacks
- Low Utilization
- Rigidity

A Half Approach

Geometric Representation

Geometric Analysis of the Problem

Efficient Algorithm

Simulation Results

Conclusions
- Advance reservations can be provided without hurting system performance.
- Our work provides new insight and allows for efficient organization of reservations.
- Scheduling algorithm that have good performance that can scale up to large systems thanks to the logarithmic bound of the algorithm.

Future Work
- Co-Allocation of resources

Complexity
Due to the use of binary search trees the algorithm runs at O(log n) where n is the number of servers.
A Novel Grid-based Data Storage Paradigm

Findings:

1. Improved data availability and reliability through distributed storage.
2. Enhanced performance with parallel processing capabilities.
3. Reduced latency and increased scalability.

Implementation:

- System architecture, networking protocols, and data management strategies.
- Integration with existing grid infrastructure.
- Case studies demonstrating real-world applications.

Conclusion:

The proposed grid-based data storage paradigm offers significant advantages in terms of data availability, performance, and scalability. Further research is needed to optimize system parameters and adapt to diverse application environments.

References:

Abstract

This work presents the design of SAR support algorithms for synthetic aperture radar (SAR) image formation. The SAR image formation algorithms are presented in order to highlight the various FFT's, imagery image formation operations and the estimation processes based on FFT's. Comparison implementation of estimated and received SAR signals are also presented in this work.

Introduction

Synthetic aperture radar (SAR) image formation is a technique for obtaining images of the Earth’s surface through passive microwave transmitted and received signals. This system transmits a series of pulses at a fixed frequency using a moving platform, and collects the backscattered signals.

Through signal processing techniques, the transmitted and received signals are processed by a SAR image formation system to produce an image that is visually seamless and the aircraft discretely chosen with standard and non-synthetic image locations. The core concept of using a SAR signal is that the length of the aperture is significantly reduced in order to form detailed images.

Methodology

The following procedure was used for the implementation of the algorithms in a Matlab environment. The SAR image was obtained as a development platform, the SAR data was configured to test the various FFT algorithms. These FFT algorithms were used to process the radar correlation process. The correlation algorithms introduced and scenes varying implementation, a Convolution model that was obtained in terms of number of radar and resolution times. Image and output correlation algorithms were developed using Matlab.

Conclusion

This work presents the results for implementation efforts at ISIT and of various imaging algorithms on the SAR raw data. For these algorithms, the evaluation times obtained on the SAR with early steps using Matlab software, it also validates correlation algorithm results from ISIT and presents the image formation algorithms using range and azimuth ABD/BSU/NSCL/LSR.

References

Inline Infrared Spectrometer for Photon Counting Detectors

Methodology

1. Formulate the problem: Identify the specific problem or issue that the spectrometer is designed to address.
2. Research and development: Conduct thorough research to understand existing solutions and potential challenges.
3. Design and prototyping: Develop a prototype of the spectrometer, incorporating feedback from initial tests.
4. Testing and refinement: Test the prototype in various conditions to identify areas for improvement.
5. Optimization and integration: Refine the design to enhance performance and efficiency.
6. Deployment and support: Prepare for deployment, ensuring that the spectrometer is compatible with existing equipment.

Results

The Inline Infrared Spectrometer demonstrates significant improvements over traditional systems in terms of sensitivity, resolution, and data accuracy. The spectrometer's ability to detect and quantify infrared radiation with high precision has applications in various fields, including environmental monitoring and industrial process control.

Conclusion

The Inline Infrared Spectrometer represents a breakthrough in photon counting detector technology, offering superior performance and reliability. Further research is needed to explore additional applications and optimize the spectrometer for specific industries and scenarios.
**Part-of-Speech Tagging of English-Spanish Code-Switched Text**

**Abstract**

Understanding English-Spanish code-switched text is a critical component in natural language processing. This work addresses the challenge of part-of-speech tagging (POS) for code-switched text. We propose a novel approach using a combination of English and Spanish tagging models to improve the accuracy of POS tagging in code-switched text. The proposed method is evaluated on a dataset of English-Spanish code-switched text, demonstrating significant improvements over existing methods.

**Methods**

1. **Data Collection**
   - Corpus Preparation: A dataset of English-Spanish code-switched text is compiled from various sources.
   - Feature Extraction: Features such as word order, morphological features, and contextual information are extracted.

2. **Model Training**
   - English-Only Models: Existing English POS taggers are fine-tuned on the English portions of the dataset.
   - Spanish-Only Models: Similarly, Spanish POS taggers are trained on the Spanish parts.
   - Hybrid Models: A hybrid model combining the strengths of English and Spanish taggers is developed.

3. **Evaluation**
   - The performance of the models is evaluated using standard metrics such as precision, recall, and F1-score.

**Results**

The proposed hybrid model significantly outperforms existing methods in handling English-Spanish code-switched text. The accuracy gains are particularly notable in capturing the unique linguistic characteristics of code-switched text.

**Conclusion**

The results demonstrate the effectiveness of our approach in improving the accuracy of part-of-speech tagging for English-Spanish code-switched text. Future work will focus on incorporating more advanced natural language processing techniques to further enhance the performance of our system.
A Tool for Generating Aspects from MEDL and PEDI Specifications for Runtime Verification

Outline

Overview

Background

Motivation

Approach

Tool

Evaluation

Conclusion
Error Correction and Clustering Gene Expression Data Using Majority Logic Decoding

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Results

The results of the majority logic decoding method were compared with the results obtained from the majority logic decoding method implemented in the Bioinformatics Library for Interpreting Gene Expression (BLIGE) tool. The results showed that the majority logic decoding method implemented in BLIGE tool produced more accurate results than the proposed method. The proposed method produced results that were close to the results obtained from the majority logic decoding method implemented in BLIGE tool, but the proposed method was faster and more efficient. The proposed method was also able to handle larger datasets than the majority logic decoding method implemented in BLIGE tool.

Methods

The proposed method consisted of two main steps: error correction and clustering. In the error correction step, the error correction algorithm was used to correct the errors in the gene expression data. In the clustering step, the clustering algorithm was used to cluster the corrected gene expression data. The clustering algorithm was based on the majority logic decoding method.

Error correction

The error correction algorithm was based on the majority logic decoding method. The algorithm consisted of two main steps: majority voting and logic correction. In the majority voting step, the majority logic decoding method was used to estimate the error probability of each gene expression value. In the logic correction step, the error probability was used to correct the error in the gene expression value. The correction was done by replacing the gene expression value with the value that was most likely to be correct according to the error probability.

Clustering

The clustering algorithm was based on the majority logic decoding method. The algorithm consisted of two main steps: majority logic decoding and clustering. In the majority logic decoding step, the majority logic decoding method was used to estimate the expression level of each gene. In the clustering step, the expression level was used to cluster the genes. The clustering was done by grouping the genes that had similar expression levels together.

Conclusion

The proposed method produced accurate results that were close to the results obtained from the majority logic decoding method implemented in BLIGE tool. The proposed method was faster and more efficient than the majority logic decoding method implemented in BLIGE tool. The proposed method was also able to handle larger datasets than the majority logic decoding method implemented in BLIGE tool. Therefore, the proposed method is a promising approach for error correction and clustering gene expression data.