1. Problem Formulation

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.

2. Proposed Solution

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 region 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.

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.

Our system, due to its open and complex nature, will be analyzed making use of the concepts of Systems Dynamics.

Its characterization will have the following approach:

- Reconfigurability
- Modularity
- Scalability

The infrastructure concept to that we make reference 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 of the metadata corresponding to each image as support to the informational system and even they could be replaced by this one in conditions in which images are not available or they are not sufficient.

Definitions of 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.

\[ \Delta S = \sum_i \frac{T_i}{1} \ln \frac{T_i}{1} \]  

- In Mechanical Statistics: number of possible microstates or microscopic configurations of a system.

\[ S = k_B \ln \Omega(W) \]  

- In Information Theory (Shannon): uncertainty associated with a random variable, in this case, a message.

\[ H(X) = -\sum p(x) \log p(x) \]  

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

4. Conclusions and Future Work

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 an 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 possses an extraordinary social and ethic impact. It could be said that the direct result of this work would be the prevent of lost of lives and properties.

5. 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. It can be appreciated the difference in the quantities for each of them. Although not conclusive, the results are a token of what could be accomplished.

These images were processed using MATLAB.

New Orleans, March 2005  
New Orleans, August 2005


6. References


