Thermal Infrared Imaging for the Detection of Temperature Increase on the Head Surface Due to Motor Activity

1 Abstract

This paper presents preliminary findings using thermal infrared imaging for the detection of temperature increase on the head surface of a human subject due to the performance of simple motor activities. When a person performs a motor task activity, a particular area of the brain is activated due to neural activity which results in an increase of blood flow to the local vasculature. The experiment presented here consists of the statistical analysis of thermal infrared images captured using a mid-wave infrared camera from FLIR systems.

A healthy, male subject participated in this experiment, he was asked to perform finger tapping using his left hand while his right sagittal view was recorded. The subject was asked to perform finger tapping for 30 seconds and to rest for 30 seconds. The thermal infrared video was decomposed into individual frames and these were analyzed using the statistical one-tailed t-test. The preliminary results show that there is a temperature on the head surface in the area of the parietal lobe due to the performance of motor activity.

2 Introduction

Motor task activities cause the activation of different areas of the human brain depending on the task being performed. Different imaging modalities exist for brain activity mapping. These modalities include positron emission tomography, event-related potentials, electro- and magnetoencephalography, magnetic resonance imaging, and single-photon emission tomography. These non-invasive brain imaging modalities are used to explore the spatial and temporal organization of the neural systems supporting human behavior.

Thermal Infrared Imaging has many applications in different scientific, engineering, research, and medical areas. Different studies using thermal infrared images have been done to detect spontaneous emotional facial expressions [7], skin tumors [2], to recognize faces and facial expressions [6], frustration [4] and other emotions, as well as temperature increase on the ear and cheek after using a cellular phone [8]. The last study [6] is the closest related, statistically, to the experiment presented in this paper. In this paper we explore the idea of using thermal infrared imaging for the detection of temperature changes on the head surface of a human subject due to the performance of a motor activity. To the best of our knowledge no study has yet been done on this specific area of research.

3 Methods

Methodology

- The subject is a healthy, 25 years old male
- The primary equipment used for this study is a thermal infrared camera (Merlin™ InSb MWAR Camera, FLIR Systems). The FPA is a 320 x 256 matrix of detectors that are sensitive in the 1.5μm to 5.4μm range. The standard camera configuration incorporates a cold filter that restricts the camera’s spectral response to the 3.0μm – 5.5μm band.
- The camera has a 25mm lens with a field of view of 22 x 16.
- In the ThermaCAM™ software the following values were used for video recording:
  - Emissivity: 1.0
  - Distance: 1.0m
  - Relative humidity: 50%
  - Room Temperature: 20°C
- The subject was asked to sit on a chair for 30 minutes prior to the recording session.
- The infrared camera was placed on a tripod. The lights in the room were turned off to avoid reflections on the subject’s head that could influence the temperatures measured by the infrared camera.
- The right sagittal view of the subject’s head was recorded while the subject did 30 seconds of finger tapping using his left hand (ON activity) and 30 seconds at rest (OFF activity).

To test the hypothesis of increased surface temperature on the parietal lobe area caused by performing a motor activity a one-tailed t-test was applied to the region of interest shown in Figure 1. The null hypothesis is $H_0: \mu_{ON} \geq \mu_{OFF}$ and the alternative hypothesis is $H_1: \mu_{ON} > \mu_{OFF}$. The criteria for rejection is given by $t_1 \geq t_0, n_1$, $n_2$ are the group sample sizes, $t_1$ is given by (1).

$$t_1 = \frac{\mu_{ON} - \mu_{OFF}}{SE}$$

where $n_1 = 1500$ and $n_2 = 1600$ are the group sample sizes, in this case the sample sizes correspond to the number of individual video frames in each group sample.

4 Results

Preliminary results in this study show that there is a temperature change on the head surface in the area of the parietal lobe due to the performance of motor activity. In Figures 2 and 3, the mean temperature region within the area of interest is shown. The image in Figure 4 shows a visual representation of the t-values obtained after applying a one-tail t-test to the data. The red dark blue pixels represent the pixels that were found to have a statistically significant change in temperature as it can be seen from the color bar the pixels in dark blue have a t-value of zero, these pixels correspond to the pixels in which there was not a statistically significant change in temperature. The dark red pixels correspond to t-values in which the temperature change was statistically significant.

5 Discussion

The presented results show that there is a temperature change on the head surface in the parietal lobe area due to the performance of a motor task activity. Figure 4 shows a visual representation of the t-values obtained after applying a one-tailed t-test, further statistical analysis such as normality-based on statistical z-score will be performed in future work. The implementation of the Z score will take into consideration the temperature values at each pixel location in the selected region of interest in each individual frame. In future work multiple recording sessions will be done in order to offer a stronger validation of the preliminary results presented here.

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7 References