Measuring Stress, Anxiety, and Depression in PTSD Sufferers Using Micro-movements From Video

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***Abstract*— Heart rate variability (HRV) is commonly used to analyze stress, anxiety, and depression in persons suffering from post-traumatic stress disorder (PTSD). Heart rate can be visualized using micro-movements in the skin using the Euler video magnification (EVM) method. HRV may be used to help persons with startle reactions associated with PTSD This paper examines how heart rate can be captured from video using a tool designed for use by therapists and social workers that treat PTSD sufferers. We tested the tool against subjects with known heart rates taken using a fitness monitor. Also, the tool was tested against YouTube videos of individuals talking about their experiences with PTSD. Results showed that the tool was able to depict decreases in heart rate variability for individuals in the YouTube videos. However, the tool could not process videos with darker skinned individuals in our accuracy study.**

***Keywords*— health, stress, anxiety, depression, BPM, HRV, micro-movements, PTSD**

I. Introduction

The ability to measure heart rate is an essential feature of many technologies in affective computing and health informatics. Feelings of sadness, anxiety, and depression may be identified in humans through decreased heart rate and/or heart rate variability (HRV) [2][3]. With these measurements, scientists can, with greater accuracy, identify patients suffering from negative feelings often associated with post-traumatic stress disorder (PTSD). Technology applications that can verify and validate if a user experiences negative feelings may one day help therapists/counselors better diagnosis, treat, and develop interventions for PTSD sufferers.

Heart rate, measured in beats per minutes (BPM), captures the number of times in which the heart beats and pumps blood through the cardiovascular system in a given amount of time. Heart rate variability is the variation of time between each beat- the frequency beats. A lower measurement in heart rate variability can be an indicator of anxiety [2][3]. This paper will focus on using heart rate and heart rate variability as an indicator of sadness, anxiety, and depression often seen in PTSD patients.

II. Background

Millions of people in the US struggle with Post Traumatic Stress Syndrome/Disorder [4]. PTSD develops in humans after they have experienced one or more extremely stressful or potentially traumatic events that cause them to relive the events over and over. Physiological manifestations of PTSD in the human body include insomnia, irritability, impaired concentration, hyper-vigilance, and increased startle reactions [9]. Physical health complications include increased heart rate and decreased heart rate variability over time which may lead to hypertension and heart attacks.

PTSD is a life altering psychological disorder and can sometimes be hard to detect. However, technology has given therapists and patients renewed hope for new treatments and interventions to improve the quality of life for these individuals. If treated correctly, persons with this disorder can live a relatively normal life. Because of the seriousness of the disease and the need for detection solutions, we have developed a novel software solution that will help therapists and their potentially PTSD afflicted patients.

III. Related Work

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Numerous researchers have studied detecting stress, anxiety, and depression in sufferers of PTSD [5][6]. However, most of these techniques use invasive sensors to inform machine classifiers to assist in diagnosis of this condition. In [6], researchers use multimodal data including speech, electro-encephalography (EEGs), galvanic skin-response (sweat), electrocardiography (ECG), and head motion to perform diagnosis of PTSD symptoms without clinical intervention.

Researchers at USC, employ virtual reality, [5], to help PTSD sufferers cope with the fear and anxiety that accompanies startle reactions. In STress Resilience In Virtual Environments (STRIVE) system, patients are presented with virtual combat simulations where they must learn educational materials, stress management techniques, emotional coping strategies.

This research differs from previous studies by 1) realizing the therapist and counselor should not be taken out of the loop of diagnosis of patients and 2) using non-invasive gathering of physiological data from video to study occurrences of PTSD symptoms in patients.

IV. Theory

A. Image and Video Processing

In 2012, scientists at the Massachusetts Institute of Technology created open source software called Euler Video Magnification (EVM) that provided a method to process videos and analyze the frames to determine the heart rate of subjects in the video [8]. EVM magnifies the colors in the video and allows the heart rate biometrics of a person to be measured through the color fluctuations made visible in their skin. This can be visualized by separating the red, green, and blue (RGB) channels for each frame in the video.

B. Laplacian Pyramid and RGB Channels

Laplacian pyramid image processing [1] can be applied to video images to measure the BPM a person maintains during video frames. On average a video contains approximately 24 to 30 frames per seconds. Because the Laplacian pyramids can collect the difference between RGB channels of either an image or video frame, the Laplacian pyramid can enhance the RGB values to increase the average RGB values in an image.

Laplacian pyramids and RGB channels allows the video processing to focus on temporal variations with a focus on color variations in facial features.

Datasets

In order to test the accuracy of the tool to measure beats per minute and heart rate variability associated with stress, anxiety, and depression; we analyzed the tool's output against two datasets; 1) publically available YouTube videos of people describing their experiences with PTSD and how the disorder impacts their daily lives and 2) university students describing themselves to verify the accuracy of the EVM method. Each dataset is described in its own section.

Additionally, it is our assumption with this study that some PTSD subjects from the YouTube videos would experience some form of stress, depression, or anxiety retelling their stories about war and the atrocities they relived after returning back from deployments. With this assumption, we could also suppose a decrease in HRV for some of the participants in the videos.

A. Student Videos

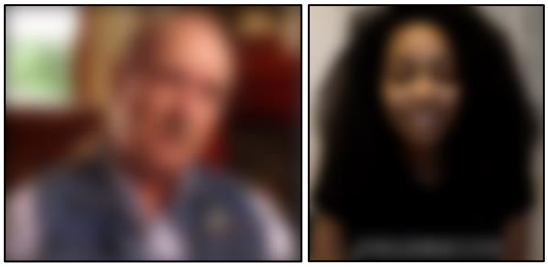
About four university students were asked to complete videos, in mp4 format, to test the accuracy of the tool to correctly calculate BPM and HRV. These videos were about three minutes long and students verified their heart rate using either a fitness monitor or by taking their BPM against their neck or wrist.

B. YouTube PTSD videos

Twelve publically available YouTube videos were gathered to test how accurate the EVM method was at depicting changes in HRV. Most videos included a veteran retelling their stories of returning back from deployments and startle reactions that occurred due to the atrocities they witnessed because of war. However, one video included a woman retelling her story of being sexually assaulted and anxiety that she has around men. Videos ranged from 2 minutes to 24 minutes. For each video, BPM and HRV were calculated at

one minute intervals for each video. These methods are described in the Methodology section.

Fig. 1 Video frames from University[1] and YouTube datasets. (Subjects faces are intentionally blurred out.)



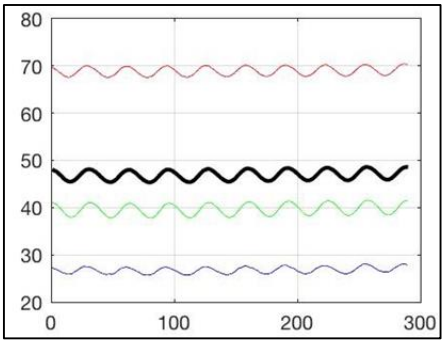
METHODOLOGY

In order to analyze the heart rate variability, Euler Video Magnification is applied to video frames to extract BPM. The Euler video magnification amplifies the color in the video with a Gaussian blur. The color variations in facial features directly relate to blood flow in the user. Blood flow relates to BPM, and BPM is used to establish heart rate variability.

A. Measuring Beat per Minutes

Each time the heart beats; blood flows through the body and face. For each heartbeat, there is a color peak that can be collected. A peak correlates to one heart beat per second. For every second, there is on average 24 to 30 frames per second for video.

Fig. 2 A line graph shows the average color variations in facial features that helps measure beats per minutes.



Red and black have the highest change in color, which provides an easier method to measure BPM.

B. Calculating Heart Rate Variability

Heart rate variability is the variance between heart beats. To detect decreases in HRV that may indicate post-traumatic stress disorder episodes within the video; Matlab analysis was used to identify the heart rate variability from the BPM and accompanying graph in Figure 1. Using the standard deviation of successive differences (SDSD), the heart rate variability can be measured to determine the heart rate variability.

To verify the heart rate variability of the SDSD and validate if the subject analysis suffered a PTSD episode during the video; other measures of heart rate variability can be applied. The root mean square of successive differences and the standard deviation of NN intervals were calculated; where NN intervals measured normal heart beats per minute.

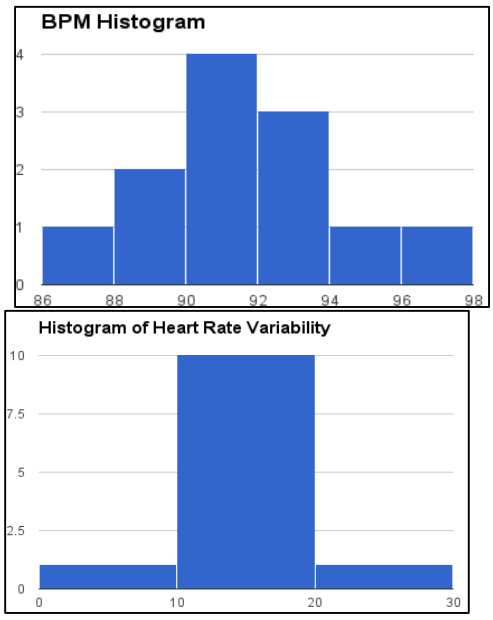
Fig. 3 Video frames from YouTube dataset with EVM method applied. Notice the slight red tint of the skin.

V. RESULTS

Results showed that many of the twelve subjects tested using the YouTube Videos had a BPM in the range of 90-92 and HRV in the range of 10-20.

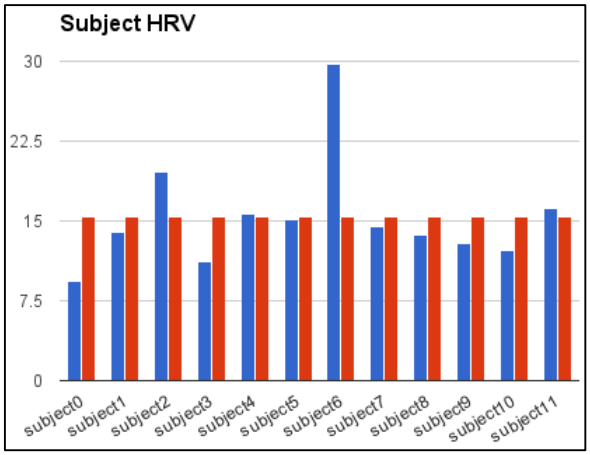
[1] https://www.youtube.com/user/veteransPTSD

Fig. 4 Histograms of BPM and HRV calculated from YouTube datasets.



Subjects 0, 1, 3, 5, 7, 8, 9, 10, ad 11 showed an increase in heart rate variability. Subjects 2, 4, 6, and 11 showed a decrease in HRV while recounting their PTSD experiences during the YouTube videos.

Fig. 5 HRV of subjects taken from the YouTube videos..



The study to test the accuracy of the EVM method to capture BPM from video segments proved error-prone. Of the four subjects that provided videos, only one was able to be processed by the tool. Unfortunately, after testing segments of the video, we learned that the method employed cannot be used against all skin colors. In particular, darker skin tones would cause the video method to black-out all frames of the video. This is talked about more in the Discussion.

VI. Discussion

Results from this work showed that the EVM method for identifying micro-movements can be accurately applied to individuals with lighter skin color. The videos tested by the university students showed that some persons could not accurately obtain measurements for either BPM or HRV. This may be due to the process within the EVM method that separates the RGB channel to obtain the micro-movements. This process uses the amount of blood flow in the cheeks and skin, which can more accurately be obtained from lighter skinned individuals. Since our PTSD symptom tracker tool is developed to help therapists identify stress, anxiety, and depression in PTSD sufferers; it must be noted that the EVM method in its current form is not sufficient. Currently in the US, African-Americans and Hispanics, with darker and lighter skin tones, are twice as likely as whites to develop PTSD [9]. Therapists must be accurately able to identify symptoms of PTSD and develop coping strategies and treatment options. Technology developed from this study will need to be able to process all skin colors. In the next section, we describe how this algorithm might be modified to work on all skin tones.

VII. Future Work

A. *Steerable Pyramids*

The current EVM algorithm used in our PTSD tool does not process videos with darker skin. To remedy this, we will continue to test the EVM method against different variations of skin tone, noting when the method fails. In addition, the method will be modified using multi-scale, multi-orientation band-pass filtering to produce the pyramids, also called steerable pyramids [7]. Steerable pyramids note the texture of the skin and use different filters for each level of the pyramid, unlike LaPlacian that only applies Gaussian filtering.

B. *Creating Usable Interface for End Users*

Currently the PTSD tracker tool only allows the therapist to upload videos and output the HRV and

BPM for the entire video. The output of the tool is printed to the command-line. For the next iteration of the tool, an interface for the application, built in a Python environment will be developed around a MatLab wrapper to utilize the EVM functionality. The functionality for the interface was determined by interviewing potential users of the tool to determine their must-have and desires for an application. Common feedback was that the tool could help with patient assessments by providing printable graphs that note the users HRV over an extended set of sessions. This would help them determine if the interventions or methods used in the therapy sessions were effective in reducing the symptoms of PTSD such as stress, anxiety, depression.

Additionally, the user will be able to upload, segment, and view their patient sessions in the tool. Then the user would be given the ability to view average heart rate and heart rate variability. As heart rate variability changes significantly, the user would be notified by flagging the place and time in the video so the therapist could easily refer to specific moment. Also, an area will be provided so that therapists can document the topic, notes about the events talked about, and any other observations about the patient.

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