Integrating Remote PPG in Facial Expression Analysis Framework

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ABSTRACT

This demonstration paper presents the FaceReader framework where human face image and skin color variations are analyzed for observing facial expressions, vital signs including but not limited to average heart rate (HR), heart rate variability (HRV) and also the stress and confidence levels of the person. Remote monitoring of the facial and vital signs could be useful for wide range of applications. FaceReader uses active appearance modeling for facial analysis and novel signal processing techniques for heart rate and variability estimation. The performance has been objectively evaluated and psychological guidelines for stress measurements are incorporated in the framework for analysis.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Demonstration

1. INTRODUCTION

Remote monitoring of facial and vital signs via a conventional off-the-shelf video camera using ambient light for detecting the photo-plethysmographic (PPG) signals and 3D modeling of the face is a very challenging task. For this purpose we demonstrate the FaceReader framework where human facial expressions and human vital signs are remotely observed for measuring the physical and psychological state of a person. The framework offers a non-invasive, passive monitoring of the signals for various purposes including, but not limited to, medical monitoring and diagnosis, user experience analysis and market research. With the help of 3D facial landmark modeling, head pose of the person can be accurately detected and the proposed measurements could be robustly performed during a natural state of head movement while the person is still facing the camera.

PPG based techniques depends on the reflectance properties of human skin for measuring the changes in oxygen saturation of the blood. The underlying principle is that the variations in blood flow due to heart beats would change the volume and the oxygen saturation of the blood in the vessels, which affects the skin reflectance. Remote measurement of such signals is useful for various reasons, e.g. attachment of a sensor could violate the hygienic conditions and cause discomfort. It could also be useful for measuring engagement between people under a stimuli. The most common way to acquire information about people's emotional responses is to use self-report measures. Marketing researchers will ask the consumers' opinion about a product. Self-report measures are problematic because of socially desirable answers, where people feel too uncomfortable to report their true feelings and instead provide a desirable answer. Furthermore, people often lack insight into their own affective responses, and the reliability of the answer decrease as the time between the emotional experience and the questions increase. Alternatively, physiological information is less sensitive to socially desirable answers, and has the important benefit that it can be collected continuously. Emotion researchers therefore often rely on physiological signals to study people's responses. The most commonly used measures are heart rate, and its variability. There is also a strong correlation between such responses and the level of endured stress [4], [6].

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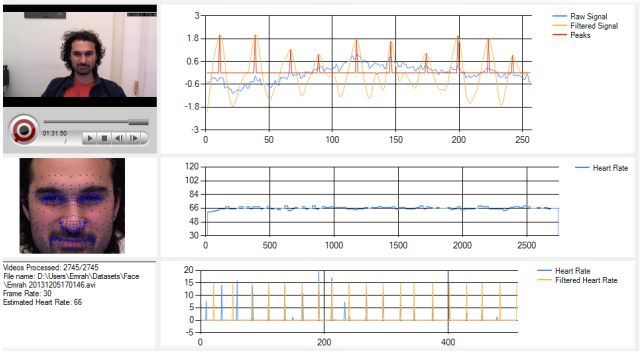

Figure 1: Heart rate monitoring could supply real-time feedback on the subject

2. METHOD

The facial landmark estimation is achieved using the active appearance modeling (AAM) technique [2] that has been improved and integrated in the FaceReader framework [3]. Using the selected facial regions, skin color changes are tracked for observing the periodic components caused by the blood volume changes at each heart beat. The details of the method is further explained in a prior work [7].

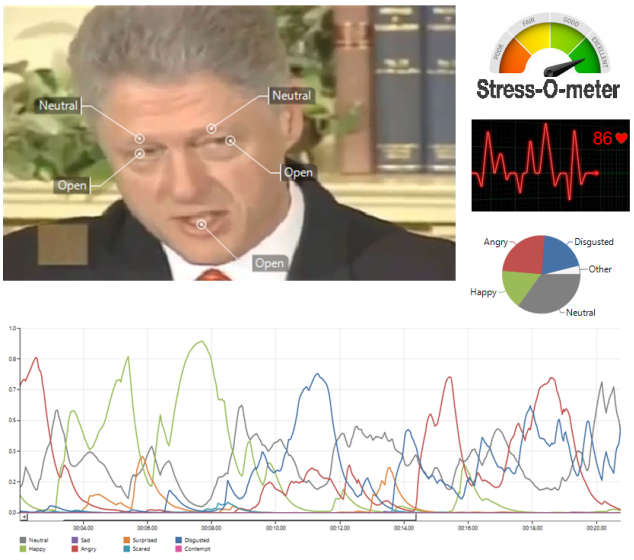

Figure 2: The reliability of verbal communication could be better evaluated with the accompanying physical and psychological analysis

2.1 Facial Expression Analysis

Apart from being the channel to identify other people, the human face provides a number of signals essential for interpersonal communication in our social life. The face houses the speech production center and is used to regulate the conversation by gazing or nodding, and to interpret what is said by lip reading. It is the direct and naturally preeminent means of communicating and understanding one's affective state and intentions solely based on a displayed facial expression. Personality, attractiveness, age and gender information can be extracted from one's facial appearance. Analysis of facial signals would be highly beneficial in many different fields such as security, behavioral science, medicine, communication, education, and human-machine interaction.

FaceReader is currently capable of automatically modeling an unknown face, in real-time, using a 3D face model with over 500 keypoints. Seven most prominent universal facial expressions are classified according to the following emotional states: anger, disgust, fear, joy, sadness, surprise and contempt, plus a neutral state. Furthermore, Facial Action Coding System (FACS) decomposes the face into 46 individual Action Units (AUs). FaceReader can automatically detect the 20 most commonly occurring AUs (see Figure 3).

2.2 Vital Signs Analysis

Body temperature, heart rate, blood pressure, and respiration rate are considered to be the vital signs, and are crucial in determining one's physical and psychological state. Remote monitoring of the changes in these signals supplies a strong medical indications for diagnostic purposes. These signs are further integrated into the facial expressions for a multimodal analysis [8].

3. EXPERIMENTS AND DEMO

The performance of the automatic facial expression recognition is tested on the Radboud Faces Database [5]. In order to validate the performance of the remote heart rate measurements, estimated remote PPG signal is compared with a ground truth signal from a contact PPG sensor. To our best knowledge, there is no publicly available dataset with ground truth PPG measurements that could be used to verify the performance of RPPG methods. Therefore, we have created a new dataset for evaluating RPPG measurements, where the ground truth PPG is provided and synced with the captured video [7]. In the demo session we provide a live demonstration with real-time facial expression feedback and heart-rate measurements.

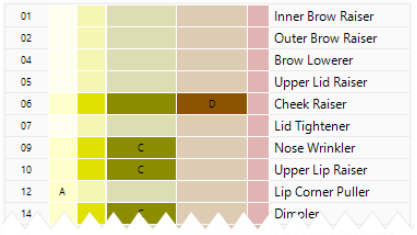

Figure 3: Examples of some action units with different levels of activation intensity

4. CONCLUSION

Automatic facial expression recognition with the extended capability of vital signs measurement offers a complete framework for understanding one's physical and psychological state. This can be used in a wide range of applications, creating a valuable research and commercial commodity. For more information, please visit [1]

5. REFERENCES

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