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Electronic Notes in Theoretical Computer Science 343 (2019) 35–55

Electronic Notes in Theoretical Computer Science

www.elsevier.com/locate/entcs

Emotion Recognition from Physiological Signal Analysis: A Review

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Abstract

Human computer interaction is increasingly utilized in smart home, industry 4.0 and personal health. Communication between human and computer can benefit by a flawless exchange of emotions. As emotions have substantial influence on cognitive processes of the human brain such as learning, memory, perception and problem solving, emotional interactions benefit different applications. It can further be relevant in modern health care especially in interaction with patients suffering from stress or depression. Additionally rehabilitation applications, guiding patients through their rehabilitation training while adapting to the patients emotional state, would be highly motivating and might lead to a faster recovery. Depending on the application area, different systems for emotion recognition suit different purposes. The aim of this work is to give an overview of methods to recognize emotions and to compare their applicability based on existing studies. This review paper should enable practitioners, researchers and engineers to find a system most suitable for certain applications. An entirely contact-less method is to analyze facial features with the help of a video camera. This is useful when computers, smart-phones or tablets with integrated cameras are included in the task. Smart wearables provide contact with the skin and physiological parameters such as electro-dermal activity and heart related signals can be recorded unobtrusively also during dynamical tasks. Next to unimodal solutions, multimodal affective computing systems are analyzed since they promise higher classification accuracy. Accuracy varies based on the amount of detected emotions, extracted features, classification method and the quality of the database. Electroencephalography achieves 88.86 % accuracy for four emotions, multimodal measurements (Electrocardiography, Electromyography and bio-signals) 79.3 % for four emotive states, facial recognition 89 % for seven states and speech recognition 80.46 % for happiness and sadness. Looking forward, heart-related parameters might be an option to measure emotions accurately and unobtrusive with the help of smart wearables. This can be used in dynamic or outdoor tasks. Facial recognition on the other hand is a useful contact-less tool when it comes to emotion recognition during computer interaction.

Keywords: emotion recognition, facial recognition, HRV, emotional intelligence, affective computing, state of the art, review

1 Introduction

The provision of personalized and adaptive solutions is of increasing importance when providing Information and Communications Technology (ICT) services to humans. Besides the ability to sense context the ability to understand the users emotions is therefore of interest. It has been shown that human-machine-interaction

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https://doi.org/10.1016/j.entcs.2019.04.009

follows natural and social principles on a human-to-human interaction basic. Ekman [24] pointed out the impact of reading emotions: "If B perceives A's facial expression of emotion, B's behavior toward A may change, and A's notice of this may influence or determine A's experience of emotion" [24]. For a successful affective computing three consecutive procedures are necessary: Detecting the emotions, the emotional behavior generation (synthesis, adaption and expression) and the emotion elicitation (figure 1).

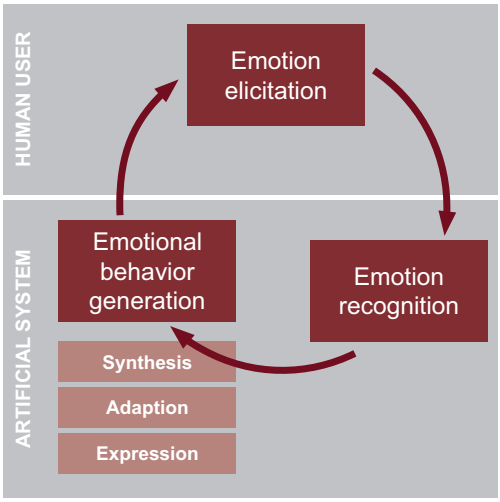

Fig. 1. Affective loop theory inlcuding emotion detection, emotional behavior generation and emotion elicitation. Image modified from A. Paiva [60].

Emotion recognition can therefore be considered as a crucial machine capacity in human-machine-communications. This review focuses on the technical procedures of emotion detection and their benefits and limitations for specific applications. It has been shown that communication between humans and computers benefits from sensor based emotion recognition since humans feel uncomfortable when emotions are absent [5]. According to Reeves et al. [70] people treat computers the same way as they treat people. Hence, computers should also respond to their users humanely. Benefits of human-computer-interaction in a social context were proven [10]. Emotions are further essential for motivation and learning [64]. Affective interaction could be beneficial while studying with the help of computers and could improve ones mental state. Emotion recognition on the side of the artificial system serves the effectiveness of the communication between the machine and its user and further serves to accomplish a certain goal: A joint action which is "any form of social interaction whereby two or more individuals coordinate their actions in space and time to bring about a change in the environment" [76] is going on between the artificial system and the human. Joint action should be improved on the side of the artificial system by adapting emotionally to the human. Ciceri et al. [16] explained the management of joint action between humans and computers and its emotional adaption in a graphic (figure 2).

It shows that on the side of the artificial system tasks and actions should modu-