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A wavelet-based approach to emotion classification using EDA signals

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A B S T R A C T

Emotion is an intense mental experience often manifested by rapid heartbeat, breathing, sweating, and facial expressions. Emotion recognition from these physiological signals is a challenging problem with interesting applications such as developing wearable assistive devices and smart human-computer interfaces. This paper presents an automated method for emotion classification in children using electrodermal activity (EDA) signals. The time-frequency analysis of the acquired raw EDAs provides a feature space based on which different emotions can be recognized. To this end, the complex Morlet (C-Morlet) wavelet function is applied on the recorded EDA signals. The dataset used in this paper includes a set of multimodal recordings of social and communicative behavior as well as EDA recordings of 100 children younger than 30 months old. The dataset is annotated by two experts to extract the time sequence corresponding to three main emotions including “Joy”, “Boredom”, and “Acceptance”. The annotation process is performed considering the synchronicity between the children’s facial expressions and the EDA time sequences. Various experiments are conducted on the annotated EDA signals to classify emotions using a support vector machine (SVM) classifier. The quantitative results show that the emotion classification performance remarkably improves compared to other methods when the proposed wavelet-based features are used.

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1. Introduction

Emotion understanding plays an important role in effective social communication among human beings. It can affect different aspects of human life such as learning, innovation, creativity, motivation, decision making, perception, and social interaction (Canento, Fred, Silva, Gamboa, & Lourenço, 2011). Hence, emotion recognition has remained one of the most important research topics in areas ranging from psychology (Kim, Bang, & Kim, 2004; Rigas, Katsis, Ganiatsas, & Fotiadis, 2007) to computer science (Blain, Mihailidis, & Chau, 2008). Researchers have been working on developing intelligent systems with the ability of recognizing emotions (e.g. facial expressions) for a variety of applications such as assistive devices and smart human-computer interfaces (Blain et al., 2008; Oberman, Winkielman, & Ramachandran, 2009). A possible application of automated emotion classification methods would be monitoring the emotional states of individuals suffering from socio-emotional disorders and eventually give them feedback about their emotional status.

In recent years, there have been efforts to develop wearable assistive devices that can recognize individuals’ emotions from either facial expressions or biological signals (e.g. electrodermal activity) and give feedback to the user (Poh, Swenson, & Picard, 2010). The success of these assistive systems depends on how accurately machine learning algorithms can recognize emotions from biological signals. If successful, the systems could be a tremendous benefit to individuals, such as children with autism, who may use wearable devices to understand their own emotions and feelings, and eventually adjust their social behavior accordingly (Goodwin et al., 2016; Lord, Ruter, & Le Couteur, 1994; Prince et al., 2017). Hence, it is important to investigate and evaluate emotions/expressions caused by different social activities and stimuli and their effects on biological signals.

The human body responds to external emotion stimuli in various ways such as facial expressions, increased heart rate (HR), opening of the eye aperture, as well as sweating of the skin. Emotion recognition using biological signals has been studied in various multidisciplinary literature ranging from psychology to computer science (Atkinson & Campos, 2016; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000; Calvo & D’Mello, 2010; Gamboa, 2008; Haag, Goronzy, Schaich, & Williams, 2004; Perez-Gaspar, Caballero-Morales, & Trujillo-Romero, 2016; Whang & Lim, 2008). To gain access to these bio-signals, different electrical devices and sensors are needed, which are directly attached to specific

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