A Study on Emotion Recognition System through Physiological Signals and Development of Smart Wearable Textile Devices for Elderly People

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The global population is ageing: virtually every country in the world is experiencing growth in the number and proportion of elderly people in their population. More and more elderly people not only pay attention to material requirements, but also to physical and mental health. While emotion plays a very important role in human's daily life, which can be used to assess the wellbeing of people and their quality of life. With the rapid development of affective computing, and the update of computer technology and artificial intelligence, emotion recognition using physiological signals attracts a variety of attention, which reflects objective and actual internal emotional state of people. Therefore, having a solution that continuously monitors the physiological signals of the person and assesses his or her emotional well-being could be a very valuable tool to support the daily life and healthcare of the elderly people.

The approaches for emotion recognition using physiological signals require the acquisition of physiological data accurately and comfortably under the state that a specific emotion is expressed. To collect physiological signals, some researchers have been doing their best to develop wearable devices, however, these systems still have some drawbacks, which are expensive, bulky, complicated and uncomfortable, with less acceptance to the elderly users. We should develop smart wearable devices for physiological signals measurement, which are comfortable, natural appearance, simple operation. Combing the deep learning methods allow the evaluation of emotion recognition algorithms on signals that can be conveniently captured in everyday scenarios, providing the means to integrate affect computing methods into a wide variety of tasks for eldercare.

In this thesis, the optimal signal channels fusion: EEG and ECG signals are selected based on the related works and the design of wearable devices based on fashion and ergonomics aspects are studied. The emotion recognition model is constructed by selecting the optimal fusion of signals and optimal data collection of signals, then verify the models. The application experiment was conducted on the elderly people to verify the real-time and interactivity of the emotion recognition system using the signals collected from our designed wearable textile

devices. The main contents of the thesis are as follows.

Part 1, we searched and got a deep understanding of the previous related research background and works, and research development progress of emotion recognition using physiological signals; have confirmed our research objectives and significances. The existing studies, including the ageing population, the effects of the emotion recognition, emotion models, emotion eliciting methods, commonly used emotion recognition methods, as well as the processes of emotion recognition, including the acquisition and filtering of physiological signal data, feature extraction and selection, are sorted out and summarized, laying a solid theoretical foundation for the follow-up research.

Part 2, we strove to build upon prior research in the field of emotion recognition for elderly people and explored new techniques for increasing the effectiveness of deep learning models for EEG and ECG signals. An experiment was performed on the young participants and collected their EEG and ECG signals with simulating video clips. It was found that with the time-frequency domain features: the spectrograms of EEG and RRI, binary emotional changes classification could be performed well by CNN, with an accuracy of 91.7% with EEG spectrograms, 93.1% with RRI spectrograms, and 94.2% with EEG and RRI spectrograms. This allows for the convenience of automatic feature optimization and feature fusion.

Part 3, it's to develop the smart wearable textile devices for EEG and ECG signals capture comfortably during long-term periods. Firstly, we developed a comfortable and user-friendly 4-channel EEG cap integrated with textiles for elderly people. The signals from the cap were strongly paralleled with the commercial wet electrodes. The flexible design improved the usability of the device, enhanced operational conveniences, reduced pressure, and made the device lighter, softer, more comfortable, and more natural in appearance. According to the factor analysis on two wearable EEG devices; the two factors: the materials properties factor and the design pattern factor were extracted when design wearable devices. This highlights the need to focus on the two factors when designing new wearable headsets in the future. According to the results of the development of the textile EEG cap, an ECG chest band combing smart textiles was developed using the same ideas and methods. The ECG signals collected from ECG chest band was highly correlated with the wet electrodes system, which is reliable and stable. Besides, the ECG chest band gained positive feedback on the assessment of the user experience.

Part 4, we conducted the application experiment on elderly people to verify the emotion recognition with our designed wearable textile devices. The EEG and ECG signals of the elderly subjects were collected through our designed textile devices under varying emotional states. We applied raw signals (EEG; ECG; EEG+ECG) to end-to-end deep learning neural networks

- adopting LSTM to learn features, to classify positive/negative emotions. The results show that combining EEG and ECG data to LSTM greatly improved the classification result, which is a very promising for emotion detection in future. The achievement of highly accurate on arousal and valence classification in this research suggests that emotion recognition in dimensional emotion models, even discrete emotions, will yield good results.

The research of emotion recognition based on physiological signals and the application of wearable textile devices has great development potential, and even can change the pattern healthcare for the elderly in future, so it has great research significance.