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Macro-to-micro transformation model for micro-expression recognition

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ABSTRACT

As one of the most important forms of psychological behaviors, micro-expression can reveal the real emotion. However, the existing labeled training samples are limited to train a high performance model. To overcome this limit, in this paper we propose a macro-to-micro transformation model which enables to transfer macro-expression learning to micro-expression. Doing so improves the efficiency of the micro-expression features. For this purpose, LBP and LBP-TOP are used to extract macro-expression features and micro-expression features, respectively. Furthermore, feature selection is employed to reduce redundant features. Finally, singular value decomposition is employed to achieve macro-to-micro transformation model. The experimental evaluation based on the incorporated database including CK+ and CASME2 demonstrates that the proposed model achieves a competitive performance compared with the existing micro-expression recognition methods.

1. Introductions

Emotion is an expression form of people's psychological activity, which directly reflects people's current psychological and mental states [1]. Under high pressure, people in stimulating source, such as the moment of effective stimulation source of voice, text, images, video and others, undergo rapid psychological changes. This is accompanied by short-term emotional and a subconscious revelation that does not appear under the control of thinking, called "micro-expression" [2]. Emotion is an expression of the inner psychological state, and micro-expression is the physical external manifestations of emotion. Emotion acts like the link that combines closely together the psychological state and the external manifestation. These three elements are interdependent and closely related. This makes it possible for us to judge people's emotions by studying the psychological behavior. So how to interpret the psychological behavior has become an important issue. In traditional sense, the research on micro-expression of psychological behavior depends on the professional personnel trained to judge and interpret, which inevitably adulterates a lot of subjective emotional factors. In this paper, we will try to analyze people's real emotional and psychological states through micro-expression signals relying on computer vision, pattern recognition and machine learning methods, which has a very important influence on theory and application.

As one of the most important forms of psychological behaviors, micro-expression is the revelation of a rapid and transient facial expression [2]. Micro-expression reflects patterns of facial muscle movement during various feelings periods and occurs with characteristics of short continued period, low intensity, and high difficulty to induce [3], which makes it one of the most potential physiological characteristics in the field of spiritual psychology and sentiment analysis.

Although the duration of the micro-expression is short, it can reveal the true feelings of the heart, so as to provide a reliable basis to judge the spiritual state of people. At present, in psychology, micro-expressions are generally classified as six basic types named anger, fear, disgust, sadness, happiness, surprise [4]. Due to the short duration of expression (1/25 s–1/5 s [5]), the weakness of intensity (only reflected on part of the facial motor unit [6]) and other factors, we face difficulties in micro-expression detection and recognition. However, with the rapid development of machine learning algorithms [7–12] and face recognition algorithms [13–15], micro-expression research has been paid more and more attention.

At present, the existing micro-expression databases (CASME I [16], CASME II [17], SMIC [18], Polikovsky [19,20]) of approximately seven kinds of micro-expressions. It is easy to cause the

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researchers to draw inaccurate conclusion of the psychological state on the subject being observed and not to efficiently find problems or avoid risks. Considering the above reasons, how to solve automatic labeling and recognition problems for the tested micro-expressions becomes a challenging task under a small number of labeled training micro-expression samples condition.

On the contrary, there are large amounts of macro-expression databases, each of which consists of vast labeled training samples compared with micro-expression databases. For instance, the CK+ database, expanded from Cohn-Kanade Dataset, includes 123 subjects, 593 image sequences. The last frame of each image sequence has the label of action units. In addition, among the image sequences, there are 327 sequences which have emotion labels, much more than that in the existing micro-expression databases. Thus, how to take advantage of the macro-expression databases at the area of micro-expression recognition has become an important direction of the research.

Transfer learning [21], a kind of method solves the question that how to take advantage of limited data, it can transfer knowledge learned from the existing data to help the studying in the future. The purpose of transfer learning is to help learning tasks in a new environment by knowledge learned from an available environment, so it won't make the same distribution assumption, as machine learning does. Thus, by using the main idea of transfer learning, it is able to take advantage of the quantitative superiority of macro-expression to recognize the micro-expression.

In this paper, we proposed a macro-to-micro transformation model for micro-expression recognition, which aims at solving the difficulty of micro-expression recognition due to the limitation of data amounts. The proposed model combined LBP features of macro-expression and LBP-TOP features of micro-expression. Furthermore, feature selection was employed in the proposed model for removing redundant information. Finally, singular value decomposition is employed to achieve macro-to-micro transformation model. Extensive experiments on the popular CK+ macro-expression database and CASME2 micro-expression databases have shown that the proposed model outperforms the existing micro-expression recognition methods.

The macro-to-micro-expression model proposed in this paper established a bridge of relationship between macro-expression and micro-expression, which creatively combined the two kinds of features during the training process, and realized the micro-expression recognition by means of a linear transfer learning. Owing to the participation of macro-expression, the training sample set has been expanded and the available information is increased, thus the micro-expression recognition performance significantly improved.

The rest of this paper is organized as follows. Section 2 introduces the related works on recognition of micro-expression. The proposed macro-to-micro transformation model will be described in Section 3. Section 3 also includes the representation and selection of macro-expression and micro-expression features. Experimental results and analysis are given in Section 4. Section 5 concludes with a summary and a further discussion.

2. Related works

During the past years, many researches of micro-expression recognition appeared, most of which discussed the problem of micro-expression detection and recognition respectively. Given an expression video sequence, the purpose of detection is to judge whether the sequence consists of any micro-expressions, while recognition is to estimate the classification of micro-expressions appeared in the sequence. Fig. 1 shows the existing micro-expression recognition methods, which are mainly divided into two categories: feature representation and multi-linear subspace learning methods.

The feature representation methods are used to find efficient and robust micro-expression features and use them in the original micro-expression video sequence. At present, the main micro-expression features include: Gabor features [22,23], 3D HOG features [19], optical flow features [24,25] and LBP or LBP-TOP texture features [26–29]. Gabor features methods are based on Gabor filters for representing face images in different directions and scales of the features; this primitive method can only deal with facial muscles which have great changes of expressions. Thus it is not the true sense of the detection and identification [22,23]. 3D HOG method [19] captures micro-expression video sequences with a high-speed video camera and extracts 3D gradient histograms of ROI according to Facial Action Coding System (FACS). Optical flow method [24,25] extracts muscle movement information according to optical flow changes of facial action unit caused by muscle movement when micro-expression occurs. The classification and identification of the micro-expressions can be processed by this information. LBP-TOP [26–29] is a kind of texture features to describe the micro-expression for the extraction of micro-expression from video stream texture features to be a sequence of three directions, using micro-expression feature fusion in three directions in the classification process. These methods greatly enhance the effect of micro-expression, but due to micro-expressions' short duration and their low intensity, these methods are not robust in the micro-expression identification and classification.

Subspace learning method is based on the needs of micro-expressions in video sequences interpolation into a certain number of frames, and then directly handle the stream video sequence of micro-expressions, which can mainly be divided into two categories: tensor based subspace learning method [30–32] and sparse representation based on the tensor subspace learning theory [33]. Tensor-based subspace learning method extracts directly on the entire video sequence feature and retains the features of micro-expressions in video sequences of different directions, and to maintain the structure of micro-expression sequence, this method is vulnerable to face structure, pixel characteristics influence and may cause the wrong classification of micro-expression. In order to make feature extraction robust, the sparse technology needs to be used. Through the sparsity constraint, the micro-expressions which have been mapped have better classification ability, but this binding force is limited, still largely influenced by features of human faces, light, noise effects and it cannot really extract the micro-expression's feature robustly.

To sum up, micro-expression's duration is short and its intensity is weak. Hence the micro-expression features are vulnerable to the appearance features of faces, illuminations, noises and other factors. Thus, it results in difficulties on the feature representation and extraction of the micro-expression. At present, there are few samples in current micro-expression databases, and the number of existing methods of automatic micro-expression recognition is largely limited by the lack of labeled training samples and the difficulty of sample labeling. In this paper, a macro-to-micro transformation model was proposed to solve the problems above. The proposed model creatively used the macro-expression database for micro-expression recognition by means of transfer learning, which took advantage of the existing macro-expression database well. The model combined macro-expression features with micro-expression features in the process of training. Micro-expression samples were classified in the process of testing. Thus the relation between macro-expression and micro-expression was established to improve the micro-expression recognition accuracy.

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