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Multi-tasking deep convolutional network architecture design for extracting nonverbal communicative information from a face

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Abstract

Facial expressions convey not only emotions but also communicative information. Therefore, facial expressions should be analysed to understand communication. The objective of this study is to develop an automatic facial expression analysis system for extracting nonverbal communicative information. This study focuses on specific communicative information: emotions expressed through facial movements and the direction of the expressions. We propose a multi-tasking deep convolutional network (DCN) to classify facial expressions, detect the facial regions, and estimate face angles. We reformulate facial region detection and face angle estimation as regression problems and add task-specific output layers in the DCN's architecture. Experimental results show that the proposed method performs all tasks accurately. In this study, we show the feasibility of the multi-tasking DCN for extracting nonverbal communicative information from a human face.

Keywords: Neural network; Facial expression; Nonverbal communication

1. Introduction

Facial expressions provide communicative information and are defined as one or more movements of facial muscles for communication purposes. The role of facial expressions has been studied for a long time. One of the earliest studies was conducted by Darwin and Prodger (1998), who suggested that survival- and instinct-related emotions were developed to be delivered via facial muscle movements. Later, facial expressions were actively studied in the field of Psychology. One of the most well-known findings is prototypic emotional expressions by Ekman (1971) and Ekman and Oster (1979). He determined that there are six basic emotions (i.e., anger, disgust, fear, happiness, sadness, and surprise) conveyed universally in the form of specific facial expressions. Since Ekman's six basic emotions theory, it has been commonly accepted that the major role of the facial expressions is conveying emotions.

Motivated by psychological studies, most works on facial expression analysis were focused on developing an automatic emotion analysis system in the computer vision field. Many researchers built computer systems that recognised facial expressions and understand humans' emotional states. Some developed emotion recognition systems that performed analysis and evaluation of facial expressions (Ioannou et al., 2005). They used facial expressions as emotional cues. Likewise, others proposed facial expression

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recognition systems to recognise emotions from video sequences (Cohen, Sebe, Garg, Chen, & Huang, 2003). They proposed temporal and static methods for automatically segmenting and recognising facial expressions. These works were inspired by the fact that facial expressions are the most expressive way humans display emotions.

Automatic facial expression analysis systems can be applied to a wide range of industries, from robotics to healthcare. In the field of social robotics, facial expression analysis is critical to improving the quality of human-robot interaction. It allows personal robots to communicate naturally and to build social relationships with humans (Rani & Sarkar, 2004). Facial expression analysis technology can also be applied to the manufacturing industry. Recently, industrial robots have been required to collaborate with human workers. This requires the robots to consider human relations in their system environment (Guizzo & Ackerman, 2012). Furthermore, automatic facial expression analysis can be a great help for autistic children who suffer difficulty understanding social paradigms. A facial expression analysis system can teach children with autism how to recognise others' facial expressions and to understand social communication (Robins, Dautenhahn, Te Boekhorst, & Billard, 2005; Tapus et al., 2012).

The goal of this study is to develop an automatic facial expression analysis system for a nonverbal communications exploration. For example, recognised expressions and estimated face angles might be used to detect the desired receiver of the expressions or to identify possible triggers. A facial expression analysis system also should provide information for understanding the overall mood of the conversation, interpreting messages and intentions, and interaction between individuals to understand their relation. Fig. 1 illustrates our approach to facial expression analysis for extracting information for nonverbal communication analysis. To achieve this, few issues should be addressed. First, the system should perform multiple tasks including automatic face detection, features extracting, and facial expression analysis. Second, the system should analyse facial expressions accurately regardless of expressions, individual traits, and face angles. Lastly, the system should interpret the communicative components for understanding nonverbal communication.

Extracting nonverbal communicative information from the face is a very ambitious goal. At this stage of the process, we do understand that this study addresses only the part of the scientific challenge of extracting nonverbal communicative information from a face. We propose to control by reducing the scope of investigation to a specific information which is critical for communication analysis; emotions expressed through facial movements and the direction of the expressions. Nonetheless, we believe that this study will broad the range of discussion for automatic facial expression recognition research: previous works mainly concern about individual aspects and focus on developing system to extract different information. However, this study is motivated by communicative aspect. In biological signalling (Scott-Phillips, 2008) and engineering (Shannon, 2001), communication is the act of transmitting a message between two agents (either two humans or human and robot), with the purpose of benefiting both the sender and receiver. With this communication analysis perspective, our approach aims to extract information of direction of face which can be used for understanding the interaction.

In this study, we propose an automatic facial expression analysis system to extracting nonverbal communicative information from a face. Our main contributions are the following.

- We approach facial expression analysis with the intent of understanding nonverbal communication. We focus on a specific information which is critical for communication analysis; emotions expressed through facial movements and the face angle.
- The proposed method classifies expressions, detects the facial regions, and estimates face angles without using any hand-crafted features. The experimental results show that the proposed method achieve high performance in all tasks.

This section introduces our approach to facial expression analysis for understanding communication, rather than emotional analysis. Recent works on facial expression analysis will be reviewed in Section 2. We propose an automatic facial expression analysis to extract nonverbal communicative information (Section 3). Details of the proposed method will be explained. Experiments were designed to evaluate the performance of the proposed method, and results are analysed (Section 4). We conclude with a description of future studies.

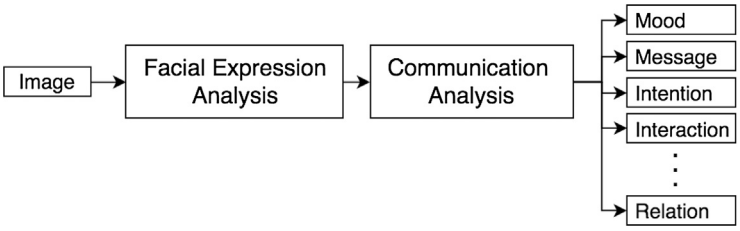

Fig. 1. Communication analysis framework.