An Enhanced Facial Expression Recognition Model Using Local Feature Fusion of Gabor Wavelets and Local Directionality Patterns

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ABSTRACT

Facial expression analysis and recognition has gained popularity in the last few years for its challenging nature and broad area of applications like HCI, pain detection, operator fatigue detection, surveillance, etc. The key of real-time FER system is exploiting its variety of features extracted from the source image. In this article, three different features viz. local binary pattern, Gabor, and local directionality pattern were exploited to perform feature fusion and two classification algorithms viz. support vector machines and artificial neural networks were used to validate the proposed model on benchmark datasets. The classification accuracy has been improved in the proposed feature fusion of Gabor and LDP features with SVM classifier, recorded an average accuracy of 93.83% on JAFFE, 95.83% on CK and 96.50% on MMI. The recognition rates were compared with the existing studies in the literature and found that the proposed feature fusion model has improved the performance.

KEYWORDS
Artificial Neural Networks, Facial Emotion Recognition, Feature Fusion, Gabor Wavelets, Local Binary Patterns, Local Directionality Patterns, Machine Vision, Support Vector Machines

INTRODUCTION

FER system has become a prominent area for many types of research. FER is still a progressive area due to its continuous emerging of new contributions. Emotional changes in a human face are essential in expression recognition. Effective recognition of expressions is possible whenever all the changes in facial emotions can be calculated properly since the intensity of the human feelings could be understood only by observing the emotion changes of a face. While communicating with others, these expressions play a vital role in carrying the original intentions of the speaker. And also the communication becomes effective only with emotions in a face. The concept of FER used in many applications and some trends in recent decades are video indexing, human-computer communication, data-driven animation. Since the emotion analysis deals with the environment around the machine and requires a prompt response from the machine using its acquired intelligence, FER is considered as an ambient computing problem. Most Psychology studies depend on the observation of the facial expressions, and they confer that the facial expressions can convey the human intentions by 55% which is more than verbal communication (Ekman et al., 1978), which is 7% only and paralanguage communication is 38%. These observations ensure that facial expressions are contributing a major
part in human-machine interactions. Hence, its significance in nonverbal communication, the
development of methods that can recognise and analyse the emotions become very eminent in emotion
intelligence systems. Automation of recognition and analysis of these facial features is also required
for the machines when performing facial expression recognition, but it is not easy, compared to task
by the human.

In the traditional facial expression recognition systems, two types of approaches are followed by
the researchers. Features are extracted either from the entire image data or from specific geometric
positions. When the entire image data is considered, a huge amount of data to be processed and most
of it is unwanted. Machine learning algorithms such as support vector machines would neglect most
of the data and consider only vital data is considered called support vectors. And traditional artificial
neural networks are very bad at small data such as geometric landmark positions. The ANNs require
a huge amount of data and a lot of training time for best accuracy. Whereas SVMs are very good at
classifying even with a small amount of data and less training times. It is important to choose a fine
blend of an appropriate feature extraction technique and the image data, which is either the entire
face image or geometric landmark positions. The novelty of the proposed model is the selection of
the feature extraction algorithm, which is applied to parts of the face image such as eyes, eyebrows,
mouth, and chin. Each modality expresses certain emotions in the face image. Features from these
parts are extracted separately and combined to generate the entire feature set.

Popular feature extraction methods such as local binary pattern, Gabor wavelets, and local
directional pattern are used in this paper. Sophisticated machine learning techniques such as
Support Vector Machine and Artificial Neural Networks were used to exploit potentials of feature
fusion techniques in the classification. Local binary patterns are very popular to handle issues with
illumination changes, lightning conditions. Local directionality patterns are very popular in solving
the orientation, non-monotonic illumination changes and random noise. Gabor wavelets are best
known to deal with the issues of different orientation and scale invariance issues.

The paper is organized into six sections. The first section is the introduction to the basics of
emotions, face features, feature extraction techniques, classification techniques, applications of FER,
techniques used in the paper and their importance. The second section is background, presents a
literature review of the FER in the recent past, highlighting the merits and demerits of the methods.
The third section is the proposed model for FER, which is feature-level fusion based FER. This
section explains the feature extraction and classification techniques used in the model and the fusion
mechanism followed. The fourth section is the experimental setup for validating the proposed model.
This section explains the datasets used in validation, software tools used and hardware requirements.
The fifth section is the results and discussion. Various analysis is performed, and a detailed discussion
is provided in this section. The sixth section is the conclusion, where some important findings are
highlighted, merits and drawbacks of the proposed models are discussed.

BACKGROUND

Many studies have been carried out so far based on the concept of feature-fusion. Itir (Erthugrul
et al., 2018) have proposed a framework of kinship synthesis and performed kinship verification
to know the relationship between estimated child expressions from parent videos to the real one.
They have employed this framework to the kinship of Smile (Dibeklioglu et al., 2012) and NEMO
Disgust (Dibeklioglu et al., 2015) data set. They have fused dynamics and appearances of the child’s
expressions, which were learned from the neural network and convolutional encoder-decoder network,
respectively. Wan (Chuan et al., 2014) has used fuzzy fusion to aggregate the local sub-features which
were extracted by applying PCA on the training subset. They have divided the original JAFFE database
image into many sub-images to obtain a new training subset corresponding to the same sub-image
position. Zhaoyu (Zhaoyu et al., 2011) has used feature-level fusion to develop a spontaneous FER
system by fusing the visible and thermal infrared facial images to rally the performance of expression
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