ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Automated Recognition Of Emotions From Facial Expressions Using Back Propagation Neural Networks.

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ABSTRACT

In everyday human interaction, facial expressions play a key role. Most of the automated emotion recognition systems recognize the basic set of six emotions anger, disgust, sad, happy, fear and surprise. However these basic emotions occur rarely rather communication happens through combination of one or more emotions. To promote human-machine interaction we propose an automated emotion recognition system. The proposed system is an intelligent system which uses artificial neural networks and digital image processing for emotion recognition. JAFFE database is used with 10 subjects bearing primary six emotions and a neutral expression. Neural network in the automated system is trained and tested against the database.

Keywords: Neural networks, JAFFE database, emotion recognition, human computer interaction, geometry-based features, holistic approach

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ISSN: 0975-8585

INTRODUCTION

With the advancement of information technology in our society, we are expecting that a large extent of computer systems should be embodied into our surroundings. These situations will impose needs and standards for new types of human computer-interaction methodologies. Lately, human-computer interaction has undergone many changes and accentuated a new objective: understanding the way people can perceive technology and experiencing it. Focusing on human reactions is necessary to understand the user's behavior during their interaction with different technologies and application programs.

In our day to day life, during the interaction between people and computers emotion plays an important role. As some believe, emotions are what make our interactions as human. On the other hand, compared to human moments which can be defined as human-to-human interactions, virtual moments have become more common for different types of transactions and tasks. In human moments there would be lot of emotional and intellectual attention on each other. Where as in virtual moments there is use of technology for the interactions. Regardless of the level of technological usage, the most common characteristic of every virtual moment is that face-to-face human moments are absent in an interaction.

Our work in this area concentrates on the relationship between the usability of an interface and user reactions. Explicitly, we aim to monitor user's impulsive and spontaneous facial expressions as a key to find out the status or degree to which level a user interface can satisfy the user.

Literature survey

Emotions are complex**.** It can be defined as, positive or negative experience that is correlated with a specific pattern of physiological behavior. But from the last two decades there has been lot of focus on human emotional information and started implementing them on the systems in computer science field. In our day-to-day life machines such as computers and applications based on computers have matured and reached a sophisticated level where they are being involved in our everyday scenario. Whether it could be at a personal, professional or a social level, interacting with the computers in natural way similar to the human-human interaction have become more essential recently. Our ability to deduce the emotional state of a user is the most crucial feature of human-computer interaction [1]. Through the emotions exhibited by the users while using different computer applications we can understand their behavior. Over the last few years, concentration of the researchers has been shifted to the aspects that deal with the user satisfaction together with the usability and functionality. In user experience, emotion is one of the powerful differentiators as they bring out instinctive responses to a website, interface or a product [2]. The common emotion we can notice in users when they are operating a computer application is frustration. When a study was conducted on British adults, it was identified that two thirds of users are violent and shout at their computers while using them due to dissatisfaction [3]. Facial expressions can be explained as non-verbal communication and strong means to display the emotions. When we talk about human cognition, emotions play a key and pivotal role in human communication. Humans are responsive and effectively communicate to the others emotional situation. This kind of ability and cognitive behavior to respond to human emotions should be achieved by the computers. Hence through expression recognition we can perceive the emotional state of a human and develop meaningful HCI interfaces [4]. Automated emotion recognition is one of the extensively researched fields in artificial intelligence and this has led to a successful progress. Researchers have been working on methods for recognizing the emotions such as "angry", "sad", "happy" or individual different facial expressions. Machines are gaining abilities to interpret and perceive human emotions so that they could respond positively and avoid escalation of negative feelings [5]. Intelligence can be defined as individual's global or aggregate capacity to purposefully act, think effectively and deal rationally with the environment. Our ability to understand and perceive other's behavior can be put forward as social intelligence. Coming to emotional intelligence, it is subset of the latter where we can identify and become aware of a person's affective state [6]. To observe and interpret different facial expressions and extracting emotions from them can be referred as one of the tasks of artificial intelligence. Research field on emotions is still young and progressing where each and every methodology has their own strengths and weaknesses. Approaches used for emotion recognition can be broadly categorized in to two types. They are geometry-based features or appearance-based feature recognition. Geometry-based depends on the shape of the face, angular, distances and trajectories. Latter concentrates on furrows and wrinkles caused of an expression [7]. Human-computer interaction and artificial intelligence are converging. These two are the fields divided by the same common ground. HCI researchers use

ISSN: 0975-8585

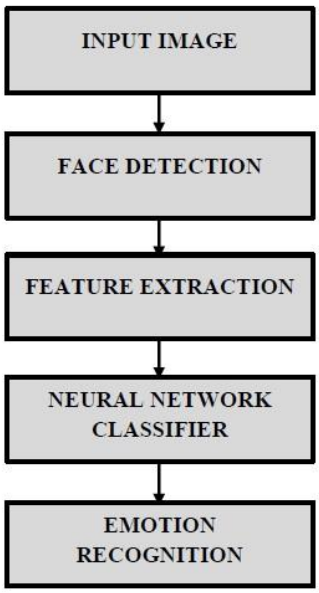
AI techniques in their toolset whereas in HCI literature machine learning applications are clearly visible. When we use techniques and methodologies from AI in to HCI we can produce intelligent user-interfaces (IUI). Through the development of IUI, we can improve HCI as smart technologies [8]. Every system used for emotion recognition with the help of facial expressions has one thing in common. First the system classifies the expression using an expression database. Second step comprises two stages, firstly extracting the feature and later classifying the extracted feature [9]. In human-computer interaction, to improve man and machine interaction a structure for intelligent system is developed using image processing and artificial neural network for facial expression recognition [10].

Proposed System

While working on the emotion recognition system, we should concentrate mainly on four factors. Face detection, feature extraction, classifier selection and classification of extracted feature. An ideal system should be able to recognize the emotion regardless of the age, gender and any other factor such as hair styles, moustache and beard **[12].**

Unlike to previous emotion recognition systems, advancements in present systems made them to recognize a face even in an arbitrary environment. A face can be detected as a whole unit or through recognizing specific features. It is known as analytic approach whereas former is known as holistic approach. In our system we are selecting the latter, analytic approach.

Figure 1: Proposed flow model



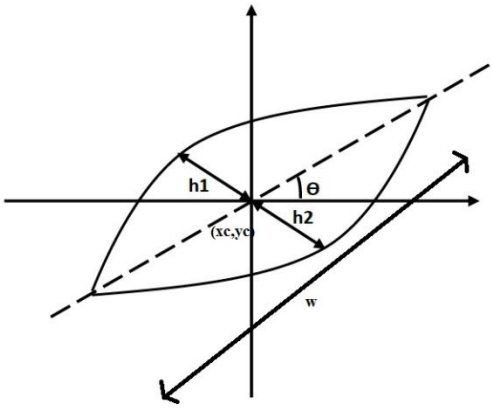
Facial expressions are the most immediate, powerful and natural means for expressing and communicating the emotions. Facial expressions help us express emotions faster than verbalize. Through facial feature extraction we try to reduce the data to least possible amount and excerpt required features which would be useful for the emotion recognition. Most of the automatic emotion recognition systems try to identify a set of basic emotions such as happy, anger, sad, disgust, surprise and fear. Though these are the basic emotions they occur very infrequently. Human beings show a combination of different facial features. During recognition of facial expressions, few regions in face play a key role and provide more information than other regions. Therefore for feature extraction face frontal image is subdivided in to regions R0, R1, R2, and R3….R10 as shown in table 1. A weight is assigned to each region and larger the weight, more important the region. For feature extraction, we track and detect the changes in facial.

State of the lips can be opened, tightened and closed. For tracking the features of lips we use the shape of it. We take the lip center position as (xc, yc), corners of the lips as (x1, y1) (x2, y2), angle between the

ISSN: 0975-8585

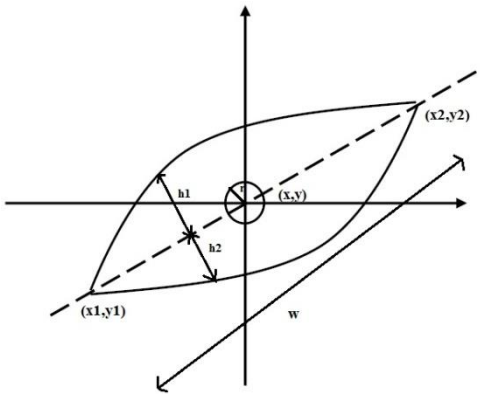
two lips are θ and the lip shape is calculated through the height and width between the two parted lips (w, h1, h2) as shown in the figure 2.

Figure 2: Lip shape



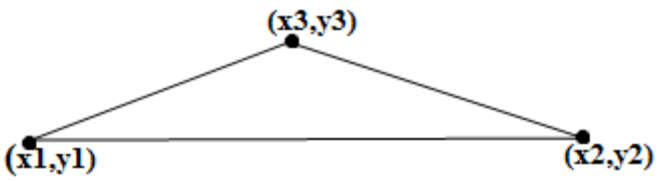
Information about the state of an eye is provided by the iris. If the eye is open, part of the iris is visible. Radius and parameters of the iris is (r, x0, y0). Radius acts as a boundary between the whites and the iris. The contour of the eyes is modeled with two parabolic curves and parameters (h1, h2, w) and an angle of orientation θ. The outer and inner corners are defined by (x1, y1) and (x2, y2). When the eyes are completely closed they are modeled by a thin line with the above mentioned parameters (x1, y1) and (x2, y2) as shown in figure 2.

Figure 3: Eyes



EYEBROWS: Feature extraction from eyebrows is defined in a triangular form the parameters (x1, y1), (x2, y2), (x3, y3) as shown in figure 3.

Figure 4: Eyebrows



During feature extraction, detailed facial features are extracted. These parameters can be described as Action Units [7]. Facial Action Coding System has been developed for interpreting the facial expressions and can use Action Units (AU). They can occur in a combination of two or more AUs or singly. AUs are known as

additive when they occur in a combination. In additive appearance of component AUs doesn't change with combination where as in non-additive appearance,

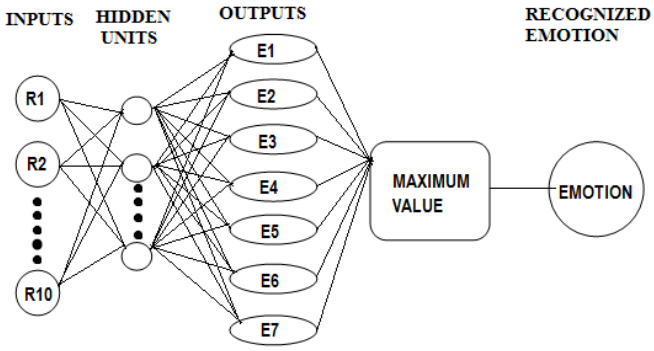
Components do change. FACS helps us to understand the details of the facial expressions through its descriptive nature. Example for non-additive is AU 1+2. When AU 2 alone is taken into account, it is visible that both outer and inner eyebrows are raised. This expression is similar to the AU 1+2 appearances (AU). In our approach we are using JAFFE (Japanese Female facial Expression) image database. Database contains 10 female subjects with each providing seven types of different expressions. Happy, sad, angry, surprise, neutral, disgust and fear. Size of each image is 256 X 256. Only gray scale images are available in JAFFE image database. These images are fully formed expressions without any ambiguity and publicly available for non-commercial use**.** All the expressions provided in JAFFE database are multiple AU expressions **[11]**.

Table 1: Facial regions and their descriptions

REGION	DESCRIPTION
R1	Movement of the top lip
R2	Movement of bottom lip
R3	Lips narrowed together and lowered
R4	Horizontal movement of mouth corners
R5	Horizontal movement of right mouth corner
R6	Movement of left brow
R7	Movement of right brow
R8	Left and right eyes wide open
R9	Left and right eyes tightly closed
R10	Left and right eyes partially opened

Features Representation and Classification

Figure 5: Neural network classifier model



An artificial neural network is the most commonly used classifier for emotion recognition. It is preferable because it can handle noise better than other models. Neural network can be best described as information-processing system which has been inspired by the human nervous system and its working. Similar to human brain artificial neural network has large number of interconnected elements (neurons) works through transferring and processing information between them to solve a particular problem **[13]**.

Similar to the most of the object recognition models, our system is also a three layered feed-forward network as shown in Figure 4. They are an input layer, hidden and output layer. The input for the system is 256X256 gray scale face frontal imager from JAFFE database. It contains 10 female subjects with 7 expressions such as happy, sad, angry, disgust, fear, surprise and neutral **[14]**. The set of inputs for the first layer of neural network model are the regions which are previously described in our feature extraction module. Therefore number of neurons for the input layer in the model is 10 and the neurons vary to get an optimum result in the hidden layer. Finally the output layer can have 7 neurons and it is a sigmoid function where expected output value is in the range [0, 1]. Neuron in the output layer is converted to binary **[15]**.

ISSN: 0975-8585

Table 2: Neural network outputs and its interpretation

ANGER	DISGUST	HAPPINESS	FEAR	SAD	SURPRISE	NEUTRAL	NEURAL NETWORK OUTPUT
1	0	0	0	0	0	0	ANGER
0	1	0	0	0	0	0	DISGUST
0	0	1	0	0	0	0	HAPPINESS
0	0	0	1	0	0	0	FEAR
0	0	0	0	1	0	0	SAD
0	0	0	0	0	1	0	SURPRISE
0	0	0	0	0	0	1	NEUTRAL

Experimental Setup

The experiment is conducted on JAFFE [Japanese female facial expression database] database with 10 female subjects. An automated emotion recognition system has been developed in MATLAB. The system takes the image as an input from the database and analyzes the given facial frontal image. Eyes, mouth and eye brows are used as features for the facial region recognition. The emotion recognition process is divided into two phases. In the first phase, images are taken as input and neural network classifier is developed and trained to recognize facial areas through extracted features. The classifier is trained for different images bearing the categories of emotions such as happy, fear, sad, disgust, surprise, anger. After every category is processed extracted emotion is classified and stored in the database. Testing the classifier for the emotion recognition from the still images come in the second phase. Trained classifier is simulated and executed to test the data for the emotion recognition.

RESULTS

The experiment has been conducted on the JAFFE database to evaluate the performance of the facial expression recognition system. All the experiments are conducted in MATLAB R2008b environment under windows 7, Intel® Core™ i3, with 2.30 GHz. In the database there are 10 subjects with seven expressions: happy, sad, disgust, fear, surprise, anger and neutral (see figure x for some examples). In our experiments we use cross-validation strategy to perform the experiments. In this strategy we divide the database randomly into segments which contains all facial expressions. We train 10 segments each time and one segment is used for testing the classifier. This process is repeated 20 times. To obtain the final performance of result for our method, recognition rates and time taken to process the image is noted and the average is taken down.

Figure 6: Sample of images from JAFFE database

Table 3: Emotion Recognition Rates

EXPRESSION	RECOGNITION RATE
ANGER	60%
DISGUST	100%
HAPPINESS	70%
SAD	50%
SURPRISE	80%

ISSN: 0975-8585

FEAR	50%
NEUTRAL	80%

In table 4 there is a confusion matrix which explains about the correct and false recognition numbers for the facial expressions under cross-validation strategy.

Table 4: Confusion Matrix

	ANGER	DISGUST	HAPPINESS	NEUTRAL	SAD	SURPRISE	FEAR	TOTAL
ANGER	16	2		2				20
DISGUST		20						20
HAPPINESS	2		14				2	20
NEUTRAL				20				20
SAD	2	2		2	10		2	20
SURPRISE				2		16	2	20
FEAR		3	2	2	2		11	20
TOTAL								140

CONCLUSION

Human face and different human emotion have drawn the attention of the fields such as psychology, computer science and cognitive sciences for more than a decade. Recognizing and interpreting the human facial expressions is one of the major research areas which help us and keep us on track to understand and perceive the human emotions. Researchers and professionals have done tremendous work on the area of recognizing the facial expressions to conceive the importance of their role played in understanding various emotions. The current system focuses on recognizing emotions with the automated facial expression recognition system. By training neural network classifier system has been able to understand the correlation between facial feature patterns and the human emotions. Our system divides the emotion detection problem into two levels. In the first level we do face detection and later feature extraction. Second level moves in the direction of training classifier and emotion detection.

From our working we believe as one might understand that neural networks work better with the facial expressions with multiple features and mixture of emotions. As the number of features in an image increases, stronger the expression is. Stronger the expression, an emotion can be easily detected. While working on the system few problems were encountered due to face orientation. Problems with face orientation were solved by adjusting the locations during feature extraction and also through training the classifier with the varying face orientations and making the system learn the changes.

Future Work

When interpreting emotions, human beings try to understand and acknowledge information related to the situation, voice, facial expressions, body gestures and information about the specific person. Similarly, automated emotion recognition system would need information from a wide variety of cues. From the context of Human Computer Interaction, understanding user difficulties from facial expressions and spontaneous emotions is still an unexplored area. Through proper understanding of issues and improving their applicability may lead to development of many novel approaches to measure the software usability problems. Study that has been performed under a controlled environment and the subjects expressions were not natural but provoked. But to handle spontaneous facial expressions that happen in real-time environment new techniques and measures have to be introduced into the expert system and should be pertinent to HCI context.

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