Pattern Recognition System to Classify Student's Emotion using Forehead Wrinkles

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ABSTRACT
Facial expressions play an essential role in communications in social interactions with other human beings which deliver rich information about their emotions. Here, we propose an efficient method for identifying the expressions of the students to recognize their comprehension from the facial expressions in static images containing the frontal view of the human face. Our goal is to categorize the facial expressions of the students in the given image into two basic emotional expression states – comprehensible, incomprehensible. In this paper, Facial expressions are identified from the wrinkles of the forehead. Our method consists of three steps, Forehead detection using Knowledge based system, Wrinkle extraction using Edge detection method and Emotion recognition using Pattern Recognition system. The proposed method is tested on the images from YALE and JAFFE Face databases.

Keywords: Facial Expression, Pattern Recognition, Wrinkle Density, Comprehensible, incomprehensible.

1. INTRODUCTION
Virtual environments may be used for a plethora of pedagogical purposes [7]. There is an increase in virtual schools worldwide and it is suggested that education mediated by computer is considered very important for the future [15]. Different researchers suggest that the visual representation of the participant in a virtual environment, possibly in a virtual classroom, increases the potential for person-to-person collaboration and interaction [17]. With the ubiquity of new information technology and media, more effective methods for Human Computer Interface are being developed which rely on higher level image analysis techniques which has its wide applications in automatic interactive tutoring, multimedia and virtual environments. For these tasks, the required information about the identity, state and intent of the user can be extracted from images and make the Virtual tutor to react accordingly, ie. by observing a person's facial expressions. The automatic identification of facial expression has become an active research area[18]. Faces are rich in information about individual identity, and also about mood and mental state, being accessible windows into the mechanisms governing our emotions. The most expressive way humans display emotions is through facial expressions. One of the key action units in the face to expose expression is forehead. In the virtual environments, for the computer to interact with humans, it needs to have the ability to understand the emotional state of the person which is also applicable for the virtual classrooms too. This research was specifically focused on the facial expressions of the student and the way they express their comprehension through the forehead in the virtual lecture. The aim was to understand the comprehensiveness of the students so that the Virtual lecturer can make them understand during the virtual lectures.

[5] In the classroom, teachers and students--both consciously and unconsciously--send and receive nonverbal cues several hundred times a day. Teachers should be aware of nonverbal communication in the classroom for two basic reasons: to become better receivers of students' messages and to gain the ability to send positive signals that reinforces students' learning while simultaneously becoming more skilled at avoiding negative signals that stifle their learning. A teacher can also use student's facial expressions as valuable sources of feedback. When delivering a lecture, a teacher should use student's expressions to determine whether or not to slow down, speed up, or in some other way modify his presentation. The basic strategy of optimizing the classroom behaviour is that the teachers must have the capability to feel students' minds changing; they must be good at observing student's facial expression, manner and every action and movement. This helps the teachers to understand their own weakness, discover it and change it.

[10]Students use smiles, frowns, nodding heads and other cues to tell teachers to slow down, speed up or in some other way modify the delivery of instructional material and to express whether they have understood or not. Momentary expressions that signal emotions include muscle movements such as raising the eyebrows, wrinkling the brow (*the forehead or eyebrow*), rolling the eyes or curling the lip. [12] When students are feeling uncomfortable, they may have lowered brow, drawn together brow, horizontal or vertical *forehead* wrinkles, and have a hard time maintaining eye contact as shown in Fig.1.

Figure.1 Facial Expressions

Detecting facial landmarks (such as position of Forehead, eyes, nose, mouth, etc.) play an important role in face recognition systems [14]. In practical face recognition system, these subsystems determine the denotation behind the expression of the recorded images.[6] This paper, however focuses on the robust and accurate detection of a landmark point - forehead on the face and classifying the expressions accordingly using the wrinkles on it.

Approaches for the recognition of emotions from facial expressions can be are divided into two main categories [3]- target oriented and gesture oriented. In the former, recognition of a facial expression is per formed using a single image of a face at the apex of the expression. Gesture-oriented approaches extract facial temporal information from a sequence of images. Transitional approaches were also developed that use two images, representing a face in its neutral condition and at the apex of the expression. Here we employ a transitional approach and our proposed work consists of three steps, namely Forehead detection, Wrinkle extraction and Emotion recognition.

The remainder of this paper is organized as follows. The methods adopted in this paper are presented in section II. The experimental results on the Yale face database are discussed in section III. Finally, a conclusion and directions for future work are briefly covered in the last section.

2. METHODS

Initially the acquired original images are converted into gray scale images. Pointing the centers of two eyes on each face image, all images are properly rotated, translated, scaled and cropped into 100×100 pixels. Images are then subjected to some image pre-processing operations. The image pre-processing phase includes contrast enhancement, illumination Normalization, filtering and Face Localization [1]. In our work, such a preprocessed image is taken the forehead block is extracted from the image using knowledge based technique and its corresponding edge image is obtained by applying the Canny edge operator to get the wrinkle information on the forehead block. Then confirm the presence of wrinkles when ther is change in expression using Rule-based system and recognize the emotion from the extracted facial features using Pattern Recognition system. The actual process is described in the following sections.

2.1. Forehead Detection

Experienced teachers will often look at their students' face to gain their attention, to judge their level of interest and at the wrinkles on the forehead to see how well they understand the material being taught.

Forehead is defined as the part of the face above the eyebrows containing pixels in the face image [13]. It is one of the most dominant and reliable features of the face which provide a constant channel of communication. For frontal face images, the significant facial regions (hair forehead, eyes, nose, mouth) come in a natural order from top to bottom [2]. As shown in Fig.2

Hair → Forehead → Eyes → Nose → Mouth

Figure.2 Order of Facial regions

Based on our knowledge the eyes are present in the upper portion of the face region.[16] Hence forehead is also present in the upper portion of the face region. So we need to search for forehead only in the upper quarter portion of the face image. This block is extracted from the grayscale image as shown in Figure3.

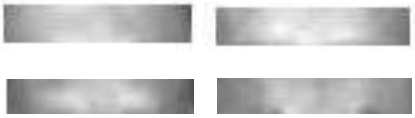

Figure 3. Forehead Block

2.2. Wrinkle Extraction

Wrinkling the forehead is a signal expression shown by the students when they were not able to follow the lectures. To identify the exact representation of the wrinkles on the forehead, edge detection method is being used.

Edge detection is extensively used in image segmentation when we want to divide the image into areas corresponding to different objects. Edge detection is a critical element in image processing, since edges contain a major function of image information [11]. The reason for this is that edges form the outline of an object. This means that if the edges in an image can be identified accurately, all of the objects can be located and basic properties can be measured. Since computer vision involves the identification and classification of objects in an image, edge detections is an essential tool [4]. Edge detection method finds the edges in the given image and returns a binary matrix where the edges have value 1 and all other pixels are zero. The output of edge detection should be an edge image or edge map.

We have adopted an Edge detection method, which is robust for varying *frontal* view of the human face. Here we use the Canny Edge detection method, which seeks out areas of rapid change in pixel value. Edges will be available on the forehead block if it has wrinkles. Hence the wrinkles are represented by the edges in the forehead block as shown in Fig 4.

Figure. 4. Edges representing wrinkles

2.3. Emotion Recognition

After detecting the edges on the forehead region we perform the emotion recognition by comparing the forehead block of the image with neutral expression ($\mathbf{B_1}$) with the forehead block with wrinkle expression ($\mathbf{B_2}$). A pixel is labeled as a wrinkle pixel if its pixel value is 1 in the edge image. The following wrinkle feature is defined to quantify the degree of the facial wrinkles.

Wrinkle Density is defined as the density of wrinkles in the area A[8], defined by

$$D_A = \frac{W_A}{P_A} \qquad (1)$$

where $\mathbf{W_A}$ is the number of wrinkle pixels in area A and $\mathbf{P_A}$ is the number of pixels in A.

The above feature is extracted from the forehead area, $\mathbf{D_A}$ value for $\mathbf{B_1}$ and $\mathbf{B_2}$ are compared. This study confirms the presence of wrinkles on the forehead due to change in the expression from the neutral state by the following rules :

Rule 1: $\mathbf{D_A}$ value of $\mathbf{B_1}$ is 0 and $\mathbf{D_A}$ value of $\mathbf{B_2}$ is greater than 0.

Rule 2: $\mathbf{D_A}$ value of $\mathbf{B_1}$ is greater than 0 and $\mathbf{D_A}$ value of $\mathbf{B_2}$ is greater than $\mathbf{D_A}$ value of $\mathbf{B_1}$.

In Rule1, $\mathbf{D_A}$ value of $\mathbf{B_1}$ is 0 as there is no wrinkle on the forehead and hence no edges will be detected on this block. $\mathbf{D_A}$ value of $\mathbf{B_2}$ is greater than 0 which confirms the presence of wrinkles on the forehead indicated by the presence of edges

In Rule2, $\mathbf{D_A}$ value of $\mathbf{B_1}$ is greater than 0 as there be a chance of hairs falling or due to the presence of any scars on the forehead and hence edges are detected on this block. $\mathbf{D_A}$ value of $\mathbf{B_2}$ is greater than $\mathbf{D_A}$ value of $\mathbf{B_1}$ which confirms the presence of wrinkles on the forehead indicated by the presence of more number of edges than the $\mathbf{B_1}$ block.

The extracted features are subsequently assembled into feature groups to label the emotion patterns of the students selected from two of the forehead expressions [9]. The Patterns classify the emotions of students in the classroom as comprehensible, incomprehensible. Here we performed the recognition of two basic emotions of students as – comprehensible, incomprehensible, by the following Patterns:

Pattern1: $\mathbf{D_A}$ value of $\mathbf{B_1}$ is equal to $\mathbf{D_A}$ value of $\mathbf{B_2}$ then the student is said to be in **comprehensible** state.
Pattern2: $\mathbf{D_A}$ value of $\mathbf{B_2}$ greater than $\mathbf{D_A}$ value of $\mathbf{B_1}$ then the student is said to be in **incomprehensible** state.

3. EXPERIMENTAL RESULTS

3.1Algorithm:

Input: Preprocessed test face image from face image database.
Output : Emotion state – Comprehensible or Incomprehensible .
Steps:
1. Detect the Forehead region using Knowledge based system.
2. Feature such as wrinkle is extracted from the face image by using Edge detection method.
3. Wrinkle Density is calculated for images in neutral state and the images with different expressions.
4. Confirm the presence of wrinkle using Rule-based system
5. Classify the expressions using Pattern Recognition system.

This algorithm is applied on various face images containing the frontal view of the human face using Matlab7.0. We used different face images from Yale database [19] and JAFFE database available in the World Wide Web. Some of the test face images taken as sample from face image database are shown in Fig 5.

Figure 5. Sample face images

This study includes survey from hundred (100) students of an autonomous college both from postgraduate and under graduate level. Considering the survey along with the results of previous researches, the following expressions of forehead block are considered to be the expressions which measure the comprehension level. The positive expressions include - No wrinkles on the forehead and the negative expressions include wrinkles on the forehead as shown in Fig.6. Their corresponding edge images are shown in Fig.7.

a. Expressions for the emotion state comprehensible

b. Expressions for the emotion state incomprehensible

Figure 6. Forehead blocks

c.Edge images for the emotion state comprehensible

d. Edge images for the emotion state incomprehensible

Figure 7. Edge images for Forehead blocks

The wrinkle densities for Pattern2 - incomprehensible state of the sample images are obtained and they are tabulated in Table1 and pictorially represented in a chart in Fig.8.

TABLE 1. Comparing Wrinkle Densities

Rules	**Block**	**Wrinkle Density -D_A**
Rule1	Block in neutral state - B_1	0
	Block with wrinkle expression -B_2	0.0402
Rule2	Block in neutral state with hair falling on the forehead - B_1	0.0020
	Block with wrinkle expression with hair falling on the forehead - B_2	0.0724

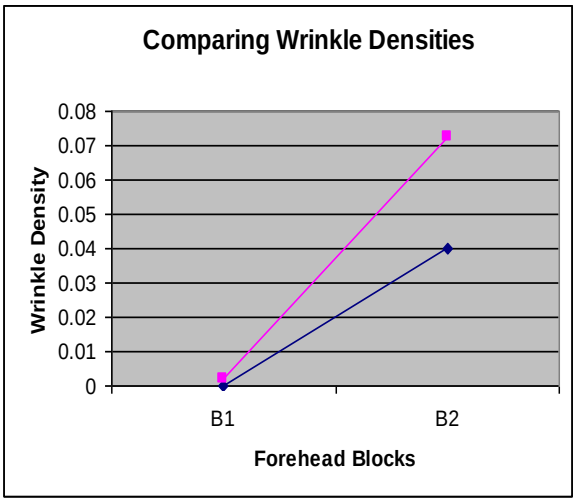

Figure 8. Wrinkle densities of the Blocks

Results show that the proposed method is simple and efficient which helps the teacher to identify their student's emotions. The performance of the proposed method is evaluated by the Recognition rate (RR). The recognition rate of this method is 98%. The small deviation in the performance is because of the chances of hair falling in the forehead region which may be interpreted as wrinkles in the edge image sometimes.

4. CONCLUSION

Recent research documents tell that the understanding emotional expressions play an important role in the development and maintenance of social relationships. By accurately interpreting another's emotions, one can obtain valuable information. All people thus certainly a teacher uses student's facial expressions as valuable sources of feedback. When delivering a lecture, a teacher should use student's expressions to determine whether or not to slow down, speed up, or in some other way modify his presentation. This paper presents a Pattern recognition system which uses the features from the forehead region for recognizing the comprehension level of the students from their facial expressions which will be helpful for designing a virtual tutor. The Recognition Rate can still be improved by concurrently considering more features from different action units of the face.

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