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Human Main Facial Expressions Recognition from the Fixed Images by the Modified Gabor Filter and its Simulation

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Abstract. Face is one of the most important communicative tools in humans' social interactions. As a person can recognize the other's feeling from his facial expression without saying a word. Facial expression recognition is a subject that has been aimed to develop the previous results by providing solutions through implementing and investigating the results of available algorithms in this paper. The use of averaging filter in facial expression recognition from the fixed images is a common method, however it has more errors. The other method is to use Gabor wavelets with a range of Frequencies and angles in spatial domain oriented to the input images. Although this method is highly accurate, it has time complexity and high memory usage due to the large-scale computations. In this article by segmenting the input image components into 5 parts and conflating the averaging filter with Gabor wavelets which has been derived for each segment with effective angles. In addition to the increase of previous methods' computational speed, its accuracy has been also increased. Furthermore, designing the graphical face with the name of Robofis in Webots simulation environment indicates an imitation of those facial expressions which had been recognized by the implemented methods.

Keywords: Facial Expression Recognition, Gabor Wavelets, Averaging Filter

1. INTRODUCTION

Undoubtedly, one of the main branches of Mechatronics engineering is the design and development of systems that can interact with human beings. The main areas of scientific researches within this field are the design of interfaces for creating an emotional relationship between them. This interaction can be started with sending human commands to the robot by some simple buttons and it can be extended into creating a complete emotional relationship between them. Recognizing humans feeling by their face is one of the methods which are considered one of the main communicative tools. From the point of Myography, the muscles of facial components get one of these following main seven states in various mental states: Normal, Angry, Unhappiness, Happiness, Surprise, Hate, and Fear which these states can reveal humans inner feelings and states better than other tools and interfaces. It is included in [17] that within peoples social interactions, 55% of information are exchanged through facial expressions, 38% through body movements, and only7% of information are exchanged through talking. Therefore, recognizing one's facial expressions and creating a change fittingly on the other's face is one of the necessities of successful social interaction. Thus, in the beginning it is going to be referred to the previous researches conducted in this field. The third chapter shall discuss implementing the available methods. The fourth chapter shall provide the proposed method and the obtained results from implementing the previous algorithms and new algorithm. In the final chapter the conclusion, the following topics, and suggestions for future researches shall be discussed.

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2. REVIEW OF RELATED LITERATURE

Referring to an automatic facial recognition system and its related states, Srivastav and Kant have divided it into three general stages within their studies.

Face Recognition

Extraction of facial features

Recognition of extracted facial expression

The first step in researches related to the face is the recognition of it from the other available components of an image. In that research, it has been referred to five methods for facial recognition, however due to the limitation of this study, they will be skipped. Two methods are usually exploited in the stage of features extraction; Geographical features, appearance. In the first method, by measuring the spatial variation of some parts of the face, for instance, the distance between the eyes, corners of the mouth, finding the tip of nose and its distance from eyes and mouth, eyebrows and eyes distance, and etc, the space and state of face components can be recognized. In the second method, since the appearance of the facial components is different from visual point, the texture and structure of facial components is exploited.

Ekman and Friesen were among the first researchers who studied the different states which could be happened for the face [16]. They investigated all states of a person's face and introduced each one as an action unit. Totally, 44 independent action units were defined for the face. In addition to the capability of these action units' occurrence, the mix of these states is possible to happen. It is put in [15] that if we investigate all movements of face components separately, over 7000 action units will be extracted. It is necessary to be said that the results of [16] are deployed as the main source of different facial expression in most of the researches related to the facial expression recognition. Huang and Tai (2012) have discovered a new method in addition to referring to six different methods for facial expression recognition in their article. The six aforementioned methods are: Principal Component Analysis (PCA), Linear Discriminant Analysis, Non Parametric Discriminant Analysis, Optical Flow, Fisher Weight Map, Local Binary Pattern.

Huang et al has exploited Speed-Up Robust Features in order to explicate their method. SURF is a method that the desired object can be found within an image including various objects. The output of this method is feature vectors that we are looking for it in the image. These vectors are also called Key point Descriptor. By using the normalized values of these vectors, Probability Density Function is derived. For extracting appropriate descriptors, the obtained PDFs by using equations, the divergence of KL is applied on these PDFs. Finally, by the use of WMV method (Weighted Majority Voting), the matching points recognized with human facial expressions are classified.

In [11], two methods of Fuzzy Logic and Case Based Reasoning are exploited. These two techniques are one of the best methods of intelligent classification that each one has advantageous and shortcomings.

The accuracy of this system would be developed by the increase of default cases. In this technique, the steady growth of the basic items causes computational complexity despite the improvement of response system.

In [8], Gabor filter is exploited with the integration of LVQ- based methods. The purpose of this research is to extract the seven facial states in various facial frames of a person. Since

Bashial et al have deployed the neural networks of MLP in their previous researches. They have obtained better results in their recent research by exploiting LVQ instead of MLP.

3. FACIAL EXPRESSION RECOGNITION METHODS VIA FIXED IMAGES

In this part, it shall be referred to two common facial expression recognition algorithms which have been implemented. In this paper, the normalized image size is considered 256*216.

1.3. Facial Expression Recognition Using Averaging Filters

In most of the methods using the artificial intelligence, the education plays a crucial role on the results and the efficacy of those methods results. Therefore, if the education of system become more complete, their output will be more accurate and it will be closer to the outputs obtained by human. Calculating the average of the systems outputs is one of the common and general methods of education. It is known as averaging filters in digital image processing. In this method, all system outputs are classified into separate categories and the same types. Then the average of them will be calculated. Next, by calculating the absolute value, if the other output difference of the system which has not been included in the averaging process with that average number is closer to zero, the upcoming output will be more similar to that state. Equation (1) indicates this method:

Equation (1)

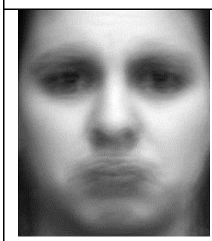
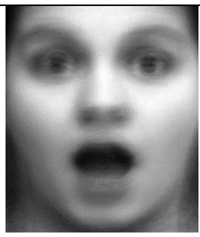
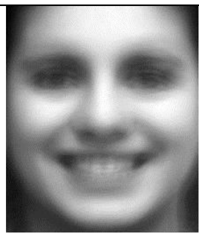
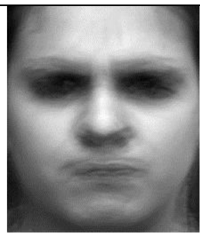
A=∑ (Previous Outputs)

B=(A/ The Number of Outputs)

C=|(B- New Outputs)|

In the above equation, as the value of C is closer to zero, the system's new output will be more similar to the average of the outputs of type A.

The first algorithm from the implemented methods for facial expression recognition of single-frame images uses the equation (1). First, the images of the normalized face are classified into four basic states, happiness, sorrow, anger, and surprise. Then an average image is obtained from each of facial expressions. This image is exploited as the averaging filter of the input images. Four averaging filters which are obtained from this part have been presented in figure 1.

Sorrow	**Surprise**	**Happiness**	**Angry**
			

Figue 1. The Averaging Filters of Four Basic Emotional Facial Expression

In this method, the education level is limited to this level. Now for recognizing the input facial expression, the received image will be normalized as above. Then the 2-D correlation between all above filters and the input images are computed. The output number has been know as the correlation coefficient of the two input images and will be compared with the other correlation coefficients of the system output

2.3. Facial Expression Recognition Using Gabor Wavelets

Gabor Filters are considered as one of the most useful tools for digital image processing and image components analysis. In image processing science, the digital images are investigated in two cases: spatial domain and frequency domain. In spatial domain, image processing algorithms are dealing with their pixels, space and features. However, in frequency domain, a response will be obtained within different frequencies and phases of the image by applying some wavelets known as filters. Based on the type of the received image and depending on the type of aimed output usage, the phase and frequency output of that filter will be deployed.

Since Gabor Wavelets provides the best response for the optimized position finding in both spatial domain and frequency domain. In this paper, this tool has been exploited as the base for extracting parts and features of facial components. The other important reason for selecting this wavelet for the desired topic is the striking similarity of the Gabor wavelets output to the produced wavelet of human vision relating to the his own environment. Figure 2 indicates the degree of this similarity.

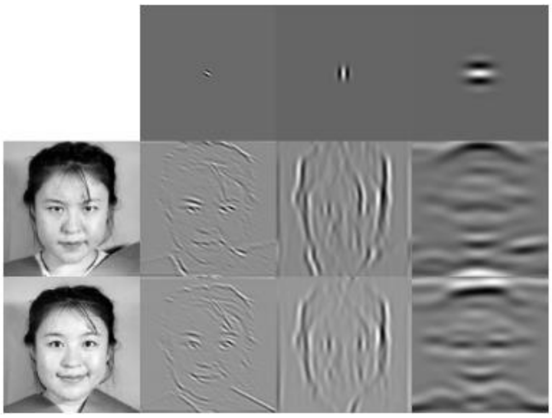


Figure 2. Applying Some Samples of Gabor Wavelets from Filters Bank to the Images of Face in Different Emotional States

In order to investigate this method, firstly, the input image will be normalized from the point of its size and type. Then by applying the 2-D Normalized Correlation of all obtained 8*5 filters, a matrix of 512*432 will be obtained for each filter that for calculating this computational function,256*216*8*5 multiplication operation are done which faces high time complexity.

4. FACIAL EXPRESSION RECOGNITION BY THE PROPOSED ALGORITHM

In this previous part, two types of facial expression recognition algorithms for fixed images were investigated that each of them had their own advantages and shortcomings.

Therefore, a method will be suggested in this part that will increase the computational accuracy of averaging method and using the advantage of Gabor Filters. In addition, the computational time and the accuracy of recognition in the two previous cases will be improved. In this method, the first purpose is to reduce the processing time and computational operation, and the second purpose is to increase the accuracy of recognition in both two previous methods. So that the below method is suggested:

a) In order to reduce the computational volume in the operation relating to the correlation functions, it is necessary to exploit some parts of the input face image and the averaging filters in our computations which is effective on the type of facial expression. Therefore, the face images will be divided into 5 parts (left and right eyebrows, left and right eyes, and mouth). These components are exploited to recognize a person's emotional state more than the other face parts. Figure 3 indicates some samples of this stage's output. The size of frame, eyebrows 56*88, eyes 41*66, and mouth 71*126.

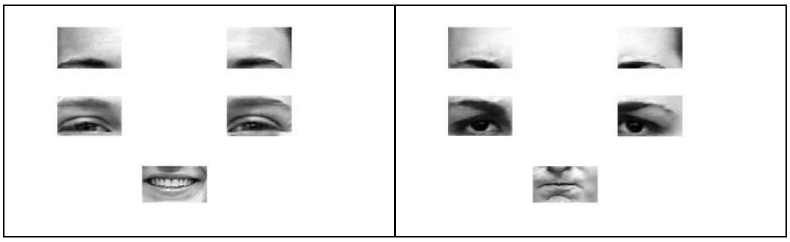


Figure3. Samples of Facial Components in Two States of Angry(Right) and Happiness(Left)

b) As it is referred in the previous part, applying Gabor Wavelet Filters in frequency domain has a feature that if some parts of the image with angles in line with the applied wavelets on the image will present the highest response on those parts. In this stage by this feature, all Gabor filters of five face components which were introduced at the stage A will be extracted fitting with the size and angles of each section.

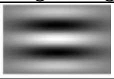
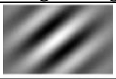
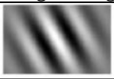
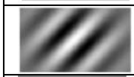
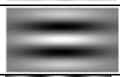
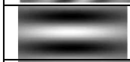
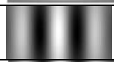
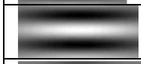
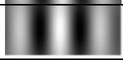
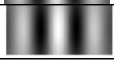
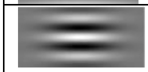
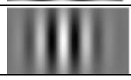
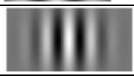
The angles of table1 have been considered empirically for these components.

Table 1. The Angle and Directions of Reformed Gabor Filters for Different Facial Components.

2(degrees) Angle	2(degrees) Angle	1(degree) Angle	The name of part
40	20	0	Left Eyebrow
180	160	140	Right Eyebrow
90	45	0	Left Eye
90	45	0	Right Eye
90	45	0	Mouth

In this stage, it is necessary to obtain the reformed Gabor filters of each part of facial components through the aforementioned angles in table1. Table 2indicates the bank of Gabor Wavelets Filter which are extracted from this stage. All these filters have been selected with the frequency of 5 due to the high accuracy of main filter bank's fifth frequency and as a regard to the images of main facial components which are presented in the figure 4, there are only the general parts and the details are not required. Now 40filters from Gabor filter bank which some of them were useless for recognizing parts of facial components states are diminished to 15 filters. As it is obvious from the filters images in table 2, the filters' size and angle of each parts of face are different from the other parts.

Table 2. The Reformed Gabor Filter Bank in Different Angles and Parts.

3degree angle	2degree angle	1degree angle	The name of part
			Left Eyebrow
			Right Eyebrow
			Left Eye
			Right Eye
			Mouth

In this stage the Gabor filters of each part and parts of all 4images from averaging filter of basic facial expressions have been obtained. So that the correlation between them must be computed in order to extract the features of each part. Now we have 4 main states. Each image consists of five parts. Each part is defined within three different angles. Furthermore, each parts filter must be applied to the same part. So in general N correlation operation with different sizes is needed. The N can be obtained by the equation 2

Equation (2)

N= The number of main parts of each face*(the number of main facial expression*the number of each part's filter)

N=5*(4*3)

As a result, 60 Gabor filters which are applied to main parts of the face are available with different angles and sizes.

D: Now for recognizing the input facial expression, the correlation of each part with the related filters of previous stage must be computed after dividing the input image into five parts.

E: The output of previous stage is the matrixes of correlation results between blocks of each parts of the input image and the obtained Gabor filters in stage C. These matrixes would be changed into a number by applying the Matlab function corr2. These numbers are the special numbers of each matrix (each part of the facial component).

F: In this stage we have 4main emotional states out of each 5main parts of the face that the reformed Gabor filters have been applied on them. For recognizing the input facial expression, firstly, the corresponding elements of each part from 4states will be plus and divided into the number of all parts. The obtained number indicates the recognized average of face's general state.

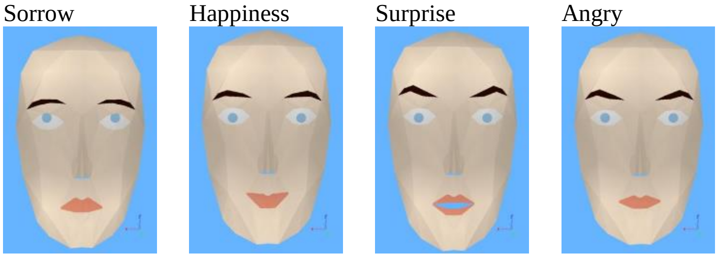
G: Finally, each of the 4 final obtained states is larger it will indicate the state of the input image

5. EVALUATION AND SIMULATION OF ROBOFIS FACE

In this chapter, the results of each algorithm's implementation will be presented on each of facial expression separately, and the implementation results of each state will be compared, and a conclusion will be obtained. Therefore, in addition to using the Cohn-Kanade AU-Coded Facial Expression Database which has relatively a lower quality, some images were obtained from the researchers face in order to evaluate the implemented algorithms appropriately. These images were normalized to the size of 256*216 after converting them from RGB to Grayscale format and cutting their waste parts. Furthermore, Robofis[1], the face which has been designed as the simulation of four main emotional states in Webotz environment is presented in table 3.

Table 3. Simulation of four main emotional states in Webotz environment.

Sorrow Happiness Surprise Angry

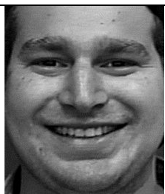
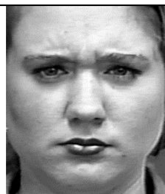


It is necessary to mention that all programs are implemented within a computer system equipped with Intel Cori7 processor with operating frequency 2.48GHz, main memory 8GB and graphic card memory 2GB. In addition, all simulations are done by Webotz and MATLAB software with version of 6.2.4 and 2011 respectively.

In order to get a better result, these evaluations will be investigated by 20sample images which have not been exploited in the related filters education. In each chapter, the result of only four input images with their taken images of researcher and the recognized and imitated images of that state will be presented.

In the recognition algorithm by averaging filters, 4filters of main states were extracted that by applying correlation function on them the output result are revealed. Out of 20 presented images for this algorithm, 12cases were just recognized correctly. In the second algorithm, by applying the extracted Gabor filters and applying them on the images, 16cases were only recognized correctly. However, in the proposed method, which is the merger of the reformed averaging and Gabor methods, there was just one error detection out of 20applied input images which shows a significant progress in comparison to the previous methods. The simulation results of this method can be seen in table4.

Table 4. The obtained results from applying face images to Gabor algorithm.

Correct Recognition			Correct Recognition		
Correct Recognition			Correct Recognition		

6. CONCLUSION

In this paper, considering the importance of human-machine interaction, two cases of emotional state recognition methods from the fixed face images were dealt. So that based on the deficiencies of each method, an algorithm was presented that by maintaining the relative accuracy of previous methods, a progress on time was also obtained. Table 5 shows the results of these methods evaluation based on the implementation time for each input image.

Tabele 5. The time comparison of represented algorithms.

Fixed images			Algorithm
Proposed	Gabor	Averaging	
0/352	1/0704	0/00013	Implementation Time(second)

Out of 50 images which were investigated for state recognition, 60%, 90%, and 85% success were obtained respectively in averaging, Gabor, and the proposed algorithms. At the end, it is assumed that by increasing the speed of these methods, the aforementioned methods can be deployed in the daily interactions of human with the mobile robots. In addition, by extending these algorithms in the multi-frame mobile face images we can exploit it for lip reading and speech recognition in all languages and dialects.

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