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Extraction of Facial Features for Detection of Human Emotions under Noisy Condition

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Abstract

Affirmation of human faces out of still pictures or picture progressions is an as of now making research field. There are an extensive variety of engagements for structures adjusting to the issue of face limitation and affirmation e.g. exhibit based video coding, face conspicuous confirmation for security structures, look area, and human-PC connection. The acknowledgment and region of the face, and furthermore the extraction of facial features from the photos, are fundamental. In view of assortments in illumination, establishment, visual point and outward appearances, the issue becomes complicated. This paper presents a novel method to extract human facial features for the detection of human emotions (such as "sad", "happy", "sorrow" etc.) under noisy conditions. This whole work constitutes better working of a video surveillance system. For detection and extraction of facial features simple formulae are used to represent skin color models depending on the range of HSV (Hue, Saturation, Value) values used for the detection of human skin. Here HSV color model is used because it is fast as well as compatible with human color perception. Additionally, implementation of Probability Neural Network (PNN) enhances the working of the surveillance system. Utilization of PNN expands the ability of surveillance framework as it can give the yield image regardless of whether the information image contains noise in it. The proposed algorithm for the entire task is developed using MATLAB software along with suitable Image Processing Toolbox (IPT).

Index Terms: Facial features, human emotions, video surveillance system, PNN.

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1. Introduction

The human facial examination is a basic research territory in the computer vision organize as a result of its recommendations on the progression of genuine human-computer intelligent frameworks. In current scenarios, a lot of research has been done on facial features even with noisy conditions. A face structure is mind-boggling, mainly made from the skin, muscles, delicate tissues and the skull [1]. The face outside form is affected by the skull and the development of the muscles connected to the skull created an assortment of appearances. Diverse subtleties in the individual face are essentially typified in the furthest layer of skin [2-4]. Robotics, machine vision, machine learning, surveillance system, medicine, artificial intelligence, are few applications where facial features or emotions recognition are very important. Facial features are customized and enhanced for they are the primary completely biological contrast between the people. Face demonstrating should completely portray each element in exactness thus it is nearer to the true value. Because of various articulations of an individual, the appearance can also demonstrate fundamentally extraordinary examples. The facial element definition and determination must be built up in the cranial structure and the facial muscle tissue structure as the facial muscles are level and thin [5, 6]. The human skull is made from 23 bits of bones firmly connected together. In this way, the component focuses on confront demonstrating must be picked based on the invariance law about the facial physiological structure. Another basic piece of the human facial investigation is Facial Expression Recognition (FER) since it is a critical bit of genuine visual human-computer correspondence, due to the high information content gave by human facial movements [7]. FER is revolved around separating a passionate substance from visual pictures. Systems for both still pictures and picture game plans have been created recognition of human faces out of still images or image successions is a currently creating research field. There are a wide range of utilizations for frameworks adapting to the issue of face restriction and recognition e.g. show based video coding, confront distinguishing proof for security frameworks, look location, and human-computer collaboration. The discovery and area of the face, and in addition the extraction of facial highlights from the images, are pivotal. Because of varieties in brightening, foundation, visual point and facial expressions, the issue is mind boggling. The preparation information normally comprises of images of various people with various hairdos, diverse enlightenment conditions and shifting facial expressions. There are various techniques used by the scientists in the back years for detecting face some of them are a neural network, machine learning especially deep learning, deformable template modal, Hough transform, motion detection, color analysis, active contour model etc. Here we use a neural network for extracting facial features.

The remaining work in the paper is organized as follows: Section II comprises of work on the removal or extraction of facial features. Section III represents the proposed method for the extraction of features. Section IV shows the calculation where Euclidean distance has been calculated between facial points. Section V presents the Probabilistic Neural Network approach for a noisy environment. The last Section VI presents conclusion acquired from the test result is given and future works are proposed.

2. Literature Review

Facial detection becomes one of the pivotal methods of biometric identification [8, 9]. From last two decades, the recognition of face has become the successful application of image and video processing in computer vision. For enhanced execution in facial appearance recognition, the hugeness of location of facial purposes of intrigue i.e. eyes, nose, lips and so forth is unquestionable. Face position or alignment is an essential step and is usually done by detection and flat or horizontal locating of eyes. Facial point of detection is followed by extraction of features, where a selection of features effects the order accuracy. In a dynamic infra-red radiation alongside Kalman filtering is utilized for exact facial segments. Performance is enhanced by the utilization of both geometry and appearance features highlights. Here the underlying places of facial points of interest are made sense of utilizing face geometry, specified the situation of eyes, which is not helpful. The significant issue is the breakthrough choice which is done physically by coordinating the eye and mouth areas. A relative geometrical separation-based [10] approach is depicted which utilizes computationally costly Gabor channels

for point of interest identification. They utilized joined Support Vector Machine(SVM) and Hidden Markov Models (HMM) as classifiers. In [11], the face has been segmented into sixty-four (64) sub locales and investigated the normal facial areas which are dynamic for most expressions and distinct facial patches that are dynamic for specific expressions. Utilizing multi assignment sparse learning method, they utilized features of limited numbers of facial patches to organise facial expressions. Depending upon the work done so far by many researchers, face detection is mainly classified into four broad extents (1) Template Matching Methods (2) Feature-Based Methods (3) Knowledge-Based Methods, and (4) Appearance-Based Methods.

(1) Template Matching Methods [12]:

Template matching procedures use the pattern that starting now set away, and the decision to face incorporate detection begins from connections between the secured patterns and the information image. In this technique, it stores a few typical patterns to portray the face also or as an arrangement of facial features freely. It searches the area of faces in view of correlation values with a usual face design. The method faces a few challenges like that hard to represents the standard patterns fit for various: postures, facial appearance, orientations, light environments, and so on.

In his work, Yuille et al. [13], identified and portrayed the features of faces that utilized deformable layouts. In deformable layout formats, the feature of intrigue, an eye, for illustration, is depicted by a parameterized layout. These parameterized designs enable from the prior data about the typical condition of the highlights to deal with the distinguishing identification strategy.

(2) Feature-Based Methods [14]:

Feature-based methods utilize features, for example, shading, edge, and surface to discover faces despite when the lighting condition, scale, or stance change. It utilizes facial features, for example, skin color of face including lip, nose, eyes and ear for detection of the face. However, the technique could deal with changing lighting environments, out of the plane rotations or with in-plane turns. Hjemal and Low [15] additionally partition this procedure into three classifications: (1) Low-Level Examination (2) Feature Investigation, and (3) Dynamic Shape Demonstrate.

- **Low-Level Analysis:** This manages the division of visual highlights by utilizing the properties of pixels, grayscale level, and motion data. In [16], actualized an edge portrayal strategy for recognizing the facial features in stripe drawing by distinguishing the adjustments in the pixel properties. In [17], built up this additional to recognize human head layout. The edge-based construct techniques rely on the marked edges which are facilitated to a face show for the check. For the most part eyebrows, pupils and lips seem darker than surrounding areas, and in this manner, extraction calculations that can scan for local minima. Conversely, nearby maxima can be used to demonstrate the bright facial spots, for example, nose tips [18]. Discovery is then done utilizing low-level grayscale thresholding.
- **Feature Analysis:** This utilizes additional learning about the face and removes or expels the ambiguity makes by low-level examination. The main includes consecutive component looking methodologies in view of the relative position of individual facial features [18]. At first, noticeable facial highlights are settled which empowers less unmistakable highlights to be hypothesized.
- **Active Shape Models:** That are utilized to characterize the genuine physical and bigger amount appearance of features. These models were prepared by Tim Cootes and Chris Taylor in 1995. These models are discharged near a segment, to such a degree, to the point that they speak with the neighbourhood image, disfiguring to take the shape of the feature component [19]. Active Shape Models are factual models of the state of items which iteratively twist to fit to a case of the object in another image. The model works in following two stages: (1) Look in the image around each point for a predominant position for that point, and (2) Revive the model parameters to best match to these

newfound positions.

(3) Knowledge-Based Methods [20, 26]:

Knowledge-based method encodes the human learning or knowledge about the face into decides that express the association between facial features, for example, the discovery of a triangle in the face. These technologies rely upon rules that delineate the associations between facial features. These strategies or technologies are for the most part intended for the confinement of faces. Be that as it may, the exactness and proficiency of these techniques are enormously influenced by rules proposed for face recognition and detection. If high limitation rules apply, at that point it gives low acknowledgement rate while simple principles stretch false discovery rate.

(4) Appearance-Based Methods [21-22]:

Appearance-based methods, where not at all like the template coordinating methods, designs are found out by an arrangement of preparing pictures to identify faces. It relies upon an arrangement of guidelines, in view of human learning, to recognize faces. For instance, a face regularly incorporates two eyes, a nose and a mouth inside specific separations and positions with respect to each other. After then, these test images are connected to the trained model for face identification and proofing. There is no requirement for predefined models, and the best example is Neural-based face detection technique.

3. Proposed Methodology

The facial areas or patches which are dynamic within various facial articulations are considered in [11, 23]. It is accounted for that few facial patches are undeveloped amid elicitation of every essential appearance and some are restricted to a solitary manner. The outcomes show that dynamic patches are situated underneath the eyes, in the middle of the eyebrows, around nose and mouth corners. To expel these patches from defying picture, we should locate the facial parts at first took after by the extraction of the patches around these organs. In arithmetic, the Euclidean separation or Euclidean metric is the customary straight-line remove between two focuses in Euclidean space. With this separation, Euclidean space turns into a metric space. The related standard is known as the Euclidean standard. More seasoned writing alludes to the metric as a Pythagorean metric. A summed-up term for the Euclidean standard is the L2 standard or L2 remove. Out their change, paired picture indicates the separation from every pixel to the closest non-zero pixel. The Euclidean separation is the straight-line remove between two pixels and is assessed utilizing the Euclidean standard as shown in figure 1.

0	0	0
0	1	0
0	0	0

1.41	1.0	1.41
1.0	0.0	1.0
1.41	1.0	1.41

Fig.1. Image and Distance Transform

Euclidean Distance (ED)

The Euclidean separation is the separation between two focuses in Euclidean space. The two focuses P and Q in two-dimensional Euclidean spaces and P with the directions (p1, p2), Q with the directions (q1, q2). The line section with the endpoints of P and Q will frame the hypotenuse of a right-calculated triangle. The separation

between two focuses p and q is characterized as the square foundation of the entirety of the squares of the contrasts between the comparing directions of the focuses as appeared in figure 2. The two-dimensional Euclidean geometry, the Euclidean distance between two points a = (ax, ay) and b = (bx, by) is defined by equation 1 below:

$$d(a,b) = \sqrt{(bx-ax)^2 + (by-ay)^2} \tag{1}$$

Euclidean separation calculation registers the base separation between a segment vector x and an accumulation of segment vectors in the code book network or matrix cb. The calculation registers the base separation to x and finds the section vector in cb that is nearest to x. The ED or Euclidean distance or metric is the ordinary distance which represents the shortest path between two points and is given by the Pythagorean formula. Figure 3(a-b) shows two cases of three EDs between facial component focuses, d1 is the ED between best of the nose and external corner of the correct eye, d2 is the ED between Top of the nose and Inner corner of the left eye and d3 is the ED between Top of the nose and Left mouth corner. By utilizing this equation, as separation, Euclidean space turns into a metric space. The ED between focuses P and Q is the length of the line section interfacing them [PQ]. In Cartesian directions, if P = (p1, p2… pn) and Q = (q1, q2… qn) are two focuses in Euclidean n-space, at that point the separation from P to Q, or from Q to P is given by condition 2

$$d(P,Q) = \sqrt{\sum_{i=1}^{n} (pi - qi)^2} \tag{2}$$

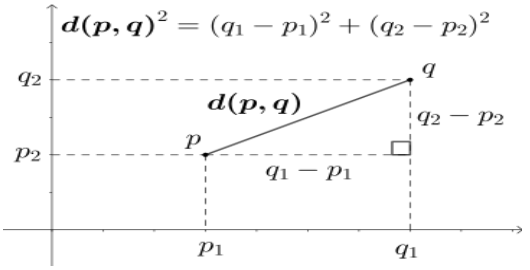

Fig.2. Euclidean Distance in R^2

(a) (b)

Fig.3(a-b). Two Examples of three EDs between Facial Feature Points

The ED between landmarks is used by most authors as a morph metric measure. Once the facial feature points are obtained, from a facial image or a two-dimensional face, they select some significant distances between them and compute the corresponding EDs, computed between all possible pairs of the 20 facial feature points, constitute a vector of 190 of the element. This vector gives the 2D image of the human face features and

it is used as an input in the classification algorithms for our automatic face recognition system. Therefore, the Euclidean method is the simplest method and is used to calculate the distance of next template. In our work, we would recognize three features eyes mouth and nose.

To decrease the mathematical complexity and in addition, the untrue detection rate, the uneven region of interests (ROI) for nose and eyes were chosen utilizing geometrical positions of the face. Both the eyes were perceived freely using Euclidean separation work arranged for each eye. The partition work re-establishes the vertices of the rectangular zone of recognized eyes. The eye centres or focuses are enlisted as the mean of these directions. Even nose position was equally identified utilizing distance function. In this work, for over 95% cases these parts were recognized legitimately. If the eyes or nose was not recognized utilizing distance function, the system depends on the point of interest facilitates identified by anthropometric face measurements. The circumstance of eyes was used for up-right face game plan as the spots of eyes don't change with outward appearances. The threshold value will be decided in such a way that it will incorporate with the one-tenth value of the total size of the image. Thus, this will come with a value in which further addition of threshold value will be done which in return provide the range of values which certainly holds the eye region. This calculation is adopted in the proposed algorithm and result obtained is mentioned in figure 4(a-c).

(a)

(b)

(c)

Fig.4(a-c). Sample Image and the Extracted Eye, Nose and Lips Region

Results showing the Extraction of Facial Features

The figure 5(a-e) below shows the outcomes of the algorithm when tested over different images. The results so obtained varifies the accuracy of the algorithm when applied over images having the even different background.

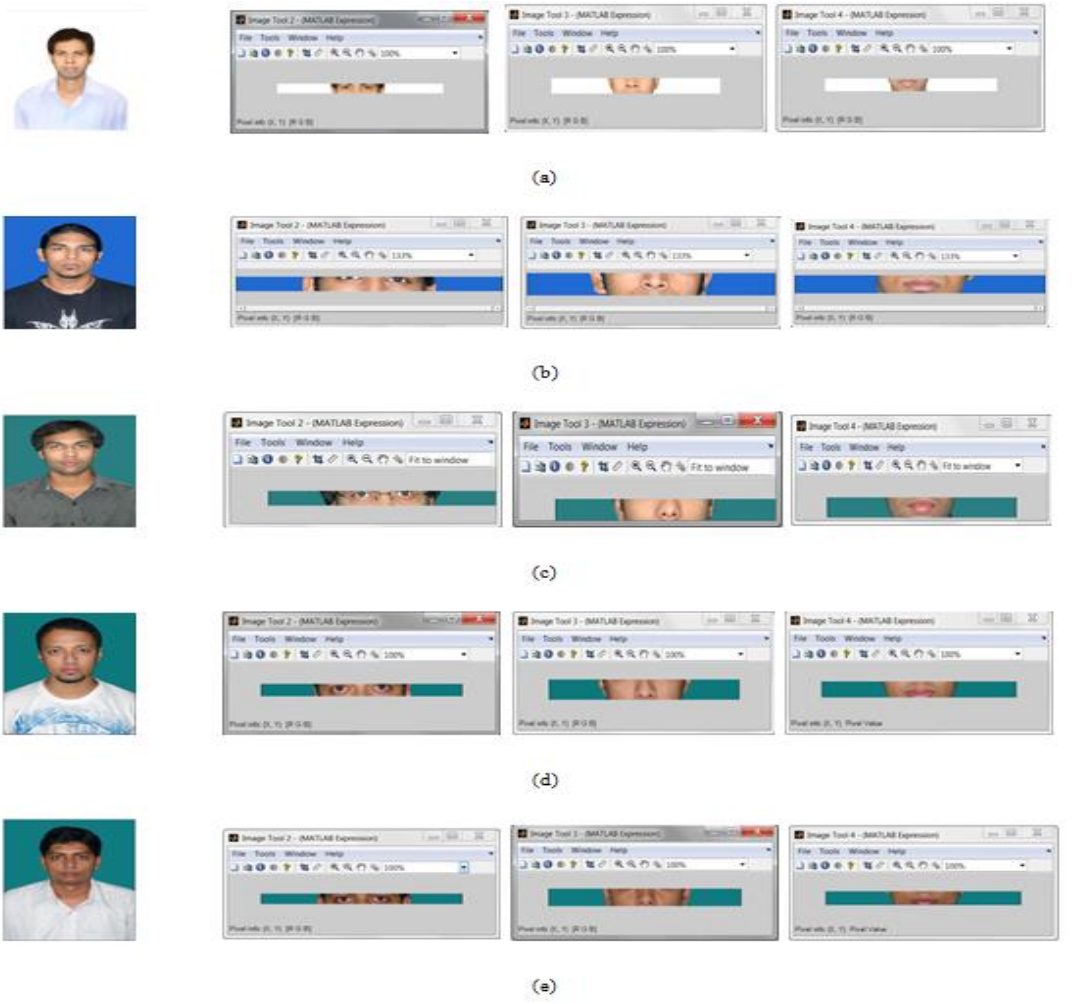

Fig.5(a-e). Sample image and the Extracted Facial Features

4. Euclidean Distance calculation between the Facial Feature Points

Figure 6 provides the distance between the feature points so obtained. This is calculated to record distances for generating a training set. As the distance obtained from features of an image remains constant for different images of the same person. This data obtained from figure 6 further incorporate in training and testing of images.

Image	Distance between Left Eye to Right Eye	Distance between Left Eye to Left Nose	Distance between Right Eye to Right Nose	Distance between Left Eye to Left Lips corner	Distance between Right Eye to Right Lips corner
	44	33	33	50	49
	66	51	50	78	76
	39	27	27	43	43
	65	44	48	70	72
	67	49	46	68	67
	62	51	49	69	67
	63	44	42	68	66
	64	25	47	66	64
	74	55	53	74	75
	61	46	42	68	66

Fig.6. Euclidean Distance between the Facial Features

Now once the trained pattern is obtained it is checked over different images of which data is present in the training set using Probabilistic Neural Network (PNN) which is an efficient and a powerful tool used for a surveillance system. Table 1 shows the execution chart for the face include extraction calculation.

Table 1. Execution Chart of a Proposed Algorithm for Face Feature Extraction

No. of Sample Images	**Facial Features**	**Error in Feature Extraction (%)**	**No Feature Extraction (%)**
75	Nose	3.56	5.33
	Lips	8.00	
	Eyes	5.33	

5. Implementation of Probabilistic Neural Network (PNN) to detect true image under Noisy Condition

Implementation of Probability Neural Network (PNN) advances the working of the surveillance system. Use of PNN increases the capability of surveillance system as it can provide the output image even if the input image contains noise in it. The working and algorithm of PNN are discussed as below.

A. Working of Probabilistic Neural Network

The PNN shown in Figure 7 is a neural system demonstrate straightforwardly executes the Bayes methodology for design characterization in its learning pattern [24]. It adapts momentarily in one go through the information tests and can plan complex choice limits that rough the Bayes ideal breaking points.

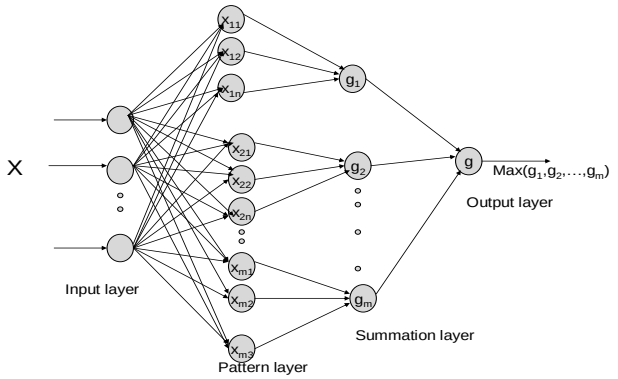

Fig.7. Probabilistic Neural Network Model [25]

The system is prepared by information of known order. At that point it utilizes the preparation information to create conveyance works that are thus used to evaluate the probability of an information design being inside a few given classes. In a perfect world, the procedure can be joined with from the earlier probability of every class to decide the doubtlessly classification for a given information design [23].

B. Probabilistic Neural Network Algorithm (PNN) [25]

When an unknown input is fed to PNN it will calculate the Probability Density Function (PDF) of the individual class using the equation-1.

$$g_i(X) = \frac{1}{n_i} \sum_{k=1}^{n_i} e^{-\frac{\|X - X_{ik}\|^2}{\sigma^2}} \tag{3}$$

Where,

X = unknown (input)
X_{ik} = "k^{th}" sample
n = number of training inputs
σ = smoothing parameter

The class will be recognized in which the PDF i.e. the '$g_i(X)$' is maximum. Preparing the PNN is expert by creating an example hub, interfacing it to the summation hub of the objective class, and assigning out the information vector as the weight vector. In N-class issues, N summation hubs will be made, one for each objective class.

6. Results using PNN

In this experiment images of 10 different persons are used whom database is already trained. Now the PNN is applied to these 10 different persons as shown in figure 8. The output of this PNN will detect the face with whom the maximum similarity is obtained. To calculate the efficiency of PNN, the experiment is extended for the noisy image. So, some noise density is incorporated in the test image and then all the images are tested individually using the algorithm and the result so obtained is shown in figure 9. The range of noise density so added is chosen from 0.00 to 0.15.

Fig.8. Dataset of 10 Different Images

Using PNN algorithm the experiment is continued with noisy images and the accuracy is shown in figure 9

Fig.9. Accuracy of detection at a different value of Noise Density

For noise density ranging from 0.00 to 0.05 the image is accurately detected but after 0.05 the detection is false. Thus, using PNN in the algorithm the hazy image can also be accurately detected which in turn rises the efficiency of the surveillance system. The performance of the algorithm was estimated after adding the noise to the image and is shown below by Table 2.

Table 2. Performance chart for Image Detection under Noisy Condition

No. of Images in a Dataset	Added Noise Density	Nature of Outcome
10	0.00	True image detection
	0.05	True image detection
	0.10	Two images are detected
	0.15	Three images are detected

7. Conclusion

The present examination is all about computer vision for detecting human sentiments or inward mental circumstance through outward appearance. For a future robot to work or live gently with a human it will be important to exhibit ability for perceiving outward appearance of a robot under the state of our day to day lives. This is claiming the outward appearance has the most essential part of nonverbal correspondence among people. Although the methodology for perceiving outward appearance has been gotten impressive consideration over the span of computer vision investigate, the present stage is much better from the objective of humans likeability particularly from the purpose of power to wide range lightning conditions and capacity for understanding human sentiments or psyche. This paper contains the best possible investigation and appropriate technique for the identification of human face and the facial features. Here the results clearly detected the facial parts (eye, nose & lips), even hazy images are well detected with accuracy by using probability neural network.

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