IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-9, Sept. 2018 E-ISSN: 2347-2693

Predicting the Characteristics of a Human from Facial Features by Using SURF

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Available online at: www.ijcseonline.org

Accepted: 12/Sept/2018, Published: 30/Sept/2018

***Abstract*—** In the modern society everybody wants to be familiar with people's characteristics to predict and be aware of their reaction to diverse situation, though it's hard to understand psychological nature and characteristics of a person. For this reason, researches have been carried out in this direction to predict the characteristics of a person such as maturity, warmth, intelligence, sociality, dominance, as well as the trustworthiness. Here aim is to identify person's characteristics based on the facial features by using techniques such as SURF, which is going to be used for the extraction of the facial features and K-nearest neighbor classifier for identification of the characteristics of the human being. With the various features mentioned and by using the appropriate techniques, the characteristics of a person can be predicted. The overall performance of the proposed work has been estimated by well established dataset and results show that the proposed work has performed well.

***Keywords*—**Speed-Up Robust Features, Interest points,Character recognition.

I. INTRODUCTION

Physiognomy refers to the evaluation of person's characters or behavior from the outer appearance, specifically from the face. Face describes the behavior and characteristics of person such as intelligent, social, trustworthy etc. So the face plays very important role in recognizing the characteristics of person using image processing. This chapter describes fundamentals of image processing, literature review, problem definition, objectives of the proposed work, motivation and contributions of the proposed work.

The definition of personality is stated as "personality is a complex combination of traits and characteristics, which determines our expectations self-perceptions, values, attitudes, subject, and events and predicts our reactions to people. Some of the examples of personality traits are: independence, warmth, emotional stability, impulsivity, sensitivity, imagination, introversion-extroversion, dominance, suspiciousness, etc".

The impressions are formed, when we meet new people. From many sources these impressions are formed they are: their quality of clothes, the social roles they play, height and weight, their way of speaking, moving, and standing and the most important source is face. The face plays a very important part in social cognition and the facial expressions are signals of inner states such as emotions, intensions. The texture and shape of the face states the information regarding a person age, gender, and identity. The Short term surface behaviors like blinking of eyes, direction of gaze and facial gesture tells the person's mental as well as emotional state. Health conditions are indicated by texture and color of face.

The important overgeneralization effects consist of facial magnetism, gender, maturity as well as emotion. The overgeneralization effects involve morphological personalities that are coupled with cluster of personality characteristics. For example, attractive people generally are coupled with traits of positive personality. They are usually considered as healthier, potent, competent in a social context, moral, and intellectually competent than those less attractive people. Facial unattractiveness and abnormalities, in contrast, show negative responses and they consist of negative personality. Unattractive people are having not much competitiveness and ready to cooperate and they are too considered as more unintelligent, dishonest, antisocial and psychologically unsteady.

The of rest the paper is organized as follows, Section I contains the introduction of the importance and use of facial features for character recognition of a person, Section II contains the Related work carried out so far, Section III explains the methodology used in the proposed work, Section IV explains the results and discussion, Section V concludes the work with future work to be carried out.

II. RELATED WORK

Alberto Suarez et al. [1] in this study, the algorithm was proposed for generating the ensembles by switching class label of training examples. The method was proposed for randomizing outputs to generate classifiers. When the experiments were carried out by means of ensembles of the 100 classifiers that are small, it is shown that large ensembles are required to obtain asymptotic ensemble error rate, particularly for the high class switching value. The switching of class labels is compared with bagging and boosting techniques, which provides better error accuracies on several UCI dataset. Here it is concluded that randomly switched class labels may produce considerable error reduction, when more number of units with high class switching rates used.

Sheryl Brahman et al. [2] in this study, there are two studies reported. In first one, the holistic face recognition method which uses PCA for matching human classification of the faces at bipolar extremes of the characteristics such as warmth, dominance, trustworthiness and sociality. The PCA classifier matches well for rating of faces in average, high and low in traits like adjustments, trustworthiness, warmth as well as sociality, as compared to dominance. The second one describes possibility of synthesizing the faces, which are intended to show specific traits impressions in observer. The results of this second indicates that it can be expected to generate faces with high possibility to elicit particular impressions of user. It also presents first computational model of trait impressions of face and rather than attributes of faces that are identity and gender is further unique in using face recognition technology to classify social, or cultural, perceptions of faces.

Dario Maio et al. [3] this explains, the new face identification technique has been proposed. In this technique, Gabor filters are used for feature extraction to the fixed position the filters are applied. The features are extracted by using Gabor filters that fit in to same row of the square-meshed grid which are projected onto the lower dimensional space by means of KL. The features obtained through each sub-patterns have been used to educate Parzen Window Classifier, which are combined by using weighted sum rule. Here the outcome proves that, the variation in expressions or illuminations in image influences some sub-images than entire image. Hence it is concluded that partitioning of the entire image in to sub-pattern will permit to represents local information of the face image.

Loris Nanni et al. [4] in this study, it is stated that a face classification experiment is done by using mixture of collaborative methods. In this approach the set faces are collected using FACES, Single classifiers and ensembles were then trained to match the bipolar extremes of the faces in each of the six trait dimensions of maturity, intelligence, warmth, sociality, dominance, sociality, and trustworthiness. The performance is measured by using AROC, and averaged across all traits. As shown in results single classifiers, performed poor in the trait dimension of maturity. The conclusion is that machine learning methods, especially ensembles, are as capable of perceiving the social impressions of faces.

Loris Nanni et al. [5] in this study, a method is proposed to detect social meaning which people show in facial morphology by using the local face identification methods. For Developing solid ground truth is the first step in creating the system. For this purpose, the set of faces were collected which are having the following characteristic categories: trustworthiness, intelligent, warmth, sociality, dominance, maturity. The performance of the universal face recognition techniques are compared to local methods by applying diverse classification systems. The SVM classifiers or else Levenberg-Marquardt neural network are used in local face recognition technique. By using area under the ROC curve, system performance in each characteristic dimensions are compared. It is found that best performance can be obtained by using local techniques. Thus concludes that the proposed learning techniques are competent of predicting the social meanings shown by facial morphology.

Jordi Vitril et al. [6] in this study, the analysis of the forecast of dominance judgment is done. Here two description algorithms are used with collection of best classifiers at present. Here First algorithm is used to generate descriptor is Histogram Oriented Gradients (HOG), which characterizes shape of the objects based on the edge oriented histograms. The Second is Probabilistic Appearance Descriptor, where it characterizes texture of the image patches based on the frequencies of grouped randomly, where binary tests are done over the intensity of image . Two different experiments are carried out on the account of the descriptors used. The results show that, by using the machine learning techniques, it is possible to forecast the judgments of dominance.

Jordi Vitria et al. [7] in this study, it is compared that whether appearance and structure information of the face can be used for prediction of characteristic of people. Here they have adopted classification framework for the evaluation of the visual information cues, by using the standard machine learning algorithm. The two approaches evaluated are, the

first is a holistic representation model using facial appearance information and structural model constructed from the relations among facial salient points. The state of the art machine learning methods have been applied to derive facial trait judgment model from the training data and to predict a facial trait judgment value of any face. The evaluation is done by different classification approaches such as Gentle Boost, Support Vector Machine, Binary Decision Trees, K-Nearest Neighbor, Parzen-Window+Random Subspace. The experimental results show that, the prediction of the perception of the facial trait can be done by both holistic as well as structural approaches. The one of the best reliable prediction of facial traits judgment capable of obtained by using certain type of the holistic descriptions of the face appearance.

Odemir Martinez Bruno et al [8] in this study, DoG filters with q-Gaussian kernel is used to detect the edges of the texture images. The edges of the textures are extracted through the convolution of a difference of Gaussians filter (DoG) with the original image. The histograms of the gray levels are obtained from the filtered image, and then it will be used as an informational tool for classification. Here it is concluded that the use of DoG filter improves the hit rate of classifiers, and it is possible to extract richer information.

Odemir M. Bruno et al [9] in this study, the DoG filter is described, to perform edge detection and to carry out the feature extraction of image edge detection is valuable tool. Edge detection using DoG filter will reduce the quantity of information needs to be process, since the unnecessary information will be unconsidered. The DoG is compared with LoG, and the results show the better accuracy for DoG. Here it is concluded that, the proposed DoG method has lower computational cost and that gain in details of edge detection.

Hatice Gunes et al [10] in this study, the authors proposed a novel personality assessment method. Here the observers are asked to provide continuously the ratings along with multiple dimensions which range from starting 0 to 100 all along time with continuous explanation are generated in the space and time. Besides, the commonly used five traits, three more dimensions are introduced which are having the potential to measure the reliability of the perceived social and the trait judgments between the human subjects and virtual characters. Here outcome obtained shows the capability of proposed technique, the conceivable relationship between the extracted features, perceived trait as well as social dimensions.

Herbert Bay et al [13] has explained thoroughly the SURF descriptor, which is new scale and rotation-invariant detector and descriptor. Which equals or even some time outperforms earlier explained techniques with respect to repeatability, individuality, also robustness, but yet it can be capable of be computed and compared much quicker. Here the speed gain is mainly due to use of the integral images, which will considerably reduces the number of the operations for the simple box convolutions, independent of the selected scale. Here without the loss in performance and without using any optimization techniques the speed gain in the detector is achieved. This shows the one of the significant benefits as well as advantage for the many of on-line computer vision application and any machine learning approach.

III. METHODOLOGY

The computer-based predictions of characteristics from facial features have received interest in recent years, because characteristic prediction would be beneficial for different fields such as lawyers, business, and education. The proposed methodology is shown in fig 1. The modules used in methodology are image pre-processing, feature extraction by SURF, Labeling of class, k-NN and these are discussed below:

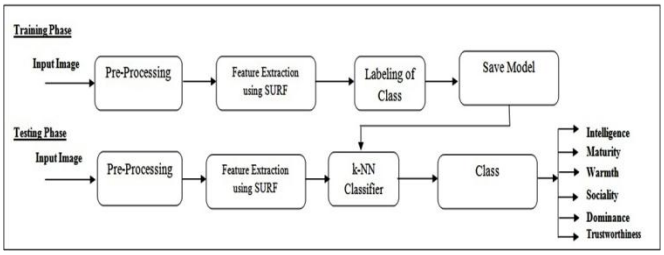

Fig.1: System Architecture

3.1 Image Pre-processing

Image pre-processing is a processing step which transforms the input image to a new image which is essentially similar to the input image but differs in some aspects like better contrast etc. Thus, it results in varying the brightness of individual image pixels. It focuses on removal of noise, sharpening the image edges, intensity normalization of individual pixels in the image, etc. Which is also known as image restoration as it reduces distortion and noise from the image. In this module, inconsistencies from the image are removed thus enhancing the quality and features of image.
Firstly, the image is resized to gain standard size 256×256 bytes using the resize operation. Then RGB image is converted to grayscale image using Color conversion operation by retaining the intensity of the image.

3.2 Feature Extraction by using SURF.

Here new scale and rotation invariant detector and descriptor, known as SURF [13] are introduced. The SURF is an algorithm which is fast, robust for the local, similarity not variant presentation and the comparison of the images. As in many other local descriptor-based methods, the interest points for a given image are defined as significant features from a scale-invariant representation. The SURF equals or

even some time outperforms earlier explained techniques with respect to repeatability, individuality, also robustness, but still it is capable of be computed and compared much quicker. The following are the three steps in which SURF works,

- Interest point detection.
- Orientation assignment.
- Fast indexing for matching.

Interest point detection

The interest point is detected by Hessian matrix approximation, which will grants use of the integral images, which will reduce the calculation time significantly [14].These images will fit in a more general framework of the boxlets [15].

- **Integral images**

Here box type convolution filters are computed fast because of characteristics integral images. Entry of the integral image $I_{\sum}(X)$ at the location $X= (x, y)^T$ will represent the sum of all the pixels in input image I within the rectangular region formed by the origin and x.

$$I\sum(x) = \sum_{i=0}^{i\leq x}\sum_{j=0}^{j\leq y} I(i,j)$$

Subsequent to the computation of the integral images, it will take three additions to calculate the sum of the intensities over any upright, Therefore computation time is not dependent on its size, which will play an important in our approach, as we are going to use filter with large sizes.

- **Interest points based on Hessian matrix.**

A Hessian matrix will be used as the base for the detector because of its good performance, here we are going to detect blob-like structures at the locations where determinant is maximum, which is in contrast to Hessian-Laplace detector [16], as well as we also rely on determinant of Hessian for the selection of scales [17].

At a Given point X=(x, y) in an image I, where Hessian matrix H(x, σ) in x at scale σ is explained as given following equation.

$$H(x,\sigma) = \begin{bmatrix} Lxx(x,\sigma) & Lxy(x,\sigma) \\ Lxy(x,\sigma) & Lyy(x,\sigma) \end{bmatrix} \quad (2)$$

Whereas Lxx (x, σ) is the convolution of Gaussian second order derivative $\frac{\partial^2}{\partial x^2} g(\sigma)$ with image I in the point x, similarly for the $Lxy(x,\sigma)$ and $Lyy(x,\sigma)$.

The Gaussians needs to be discretised and cropped (as shown in fig.2), which will guide to loss in the repeatability under the image rotations around odd multiples of the $\pi/4$, which will weakness holds for Hessian based detectors. The repeatability will attain a maximum around the multiples of $\pi/2$, this will happen since the filter shape is square. Even though this will reduce the performance slightly, but one can't overshadow benefit of the fast convolutions gained by discretisation as well as cropping. Since the real filters are not in ideal in any case, as well as given Lowe's success with his LoG approximations. The approximations are moved forward for the Hessian matrix even further with the box filters (as shown in fig. 2), which are second order Gaussian derivatives, which can be evaluated at a very little computational cost by using the integral images. As a result of this calculation time it is independent of the size of filter. Hence performance of the system is going to be equal or sometimes even better than discretised and cropped Gaussians. A 9×9 box filters are approximations of a Gaussian with σ = 1.2, which represent the lowest scale for the computation of blob response maps (as shown in fig.2). They have been denoted by notations Dxx, Dyy , and Dxy. Here weights applied to rectangular regions have been kept simple because for the reason of calculation efficiency. This gives rise to following equation,

$$det(Happrox) = Dxx\,Dyy - (wDxy)2 \quad (3)$$

Where the relative weight w of the responses of the filter is going to be used to balance expression for the Hessian's determinant, which is required for energy conservation between Gaussian kernels as well as approximated Gaussian kernels,

$$\frac{|Lxy(1.2)|F\ |Dyy(9)|F}{|Lxy(1.2)|F\ |Dyy(9)|F} = 0.912\ldots \cong 0.9 \quad (4)$$

Whereas the $|x|_F$ is a Frobenius norm, which is kept constant, as which will not have the considerable impact on the results. To keep Frobenius norm constant for the any size filter, the responses of the filters are normalized with respect to size. The approximated determinant of the Hessian represents the blob response in the image at location x and these responses are stored in a blob response map over the different scales, and local maxima are detected.

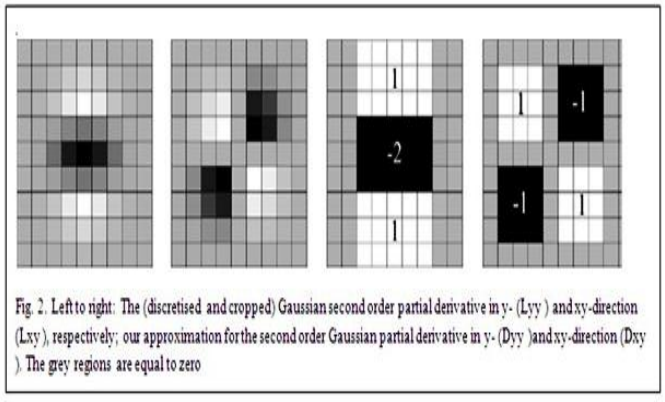

Fig. 2. Left to right: The (discretised and cropped) Gaussian second order partial derivative in y- (Lyy) and xy-direction (Lxy), respectively; our approximation for the second order Gaussian partial derivative in y- (Dyy)and xy-direction (Dxy). The grey regions are equal to zero

Fig. 2

Orientation assignment

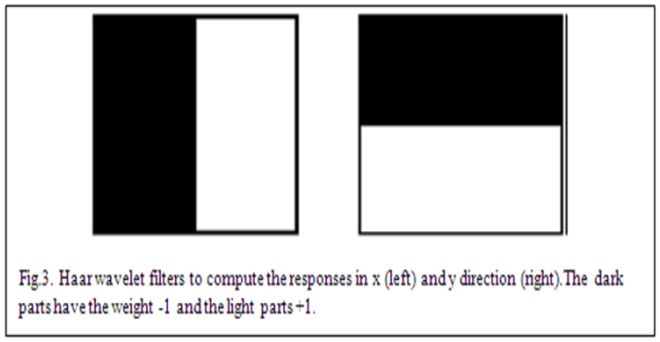

Fig.3. Haar wavelet filters to compute the responses in x (left) and y direction (right).The dark parts have the weight -1 and the light parts +1.

Fig. 3

The reproducible orientations for the interest points are recognized to avoid variations during image rotation. To do this Haar wavelet responses in x as well as y direction are calculated within the circular neighborhood for the radius 6s around interest points. An interest point is identified with scales, where it is a sampling scale dependent value. Similarly the wavelets sizes are dependent on scale, which is set to the side length of 4s. Hence for fast filtering purpose we use integral images (see the Fig.3).The calculation of responses either in x or y direction for any scale requires only six operations.

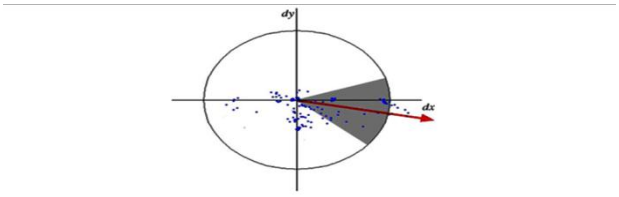

Fig.4 Orientation assignment : a sliding orientation window of size π/3 detects the dominant of the Gaussian weighted Haar wavelet responses at every sample point within a circular neighborhood around the interest point.

The responses are going to be represented as the points in the space with the horizontal response strength all along the abscissa as well as vertical response strength all along the ordinate after calculation of the responses from wavelet and also weighted with the Gaussian (σ =2s) centered at interest points. An dominant orientation is expected by calculation of the sum of all the responses within the sliding orientation of window size π/3 (as shown in fig.4). The orientation vector has been yielded by summed responses from the horizontal as well as vertical responses within the window. The longest orientation vector explains the orientation of interest points. A sliding window size needs to be selected cautiously, because small sizes will fire on the single gradients and large sizes will have a tendency to yield maxima in vector length which are not outspoken, where both are going to results in the misorientation of interest points.

- **Summing up of the Haar wavelet responses based on descriptors.**

The construction of square region centered around interest points as well as oriented along an orientation is done to extract the descriptors, this window size is 20s. The spatial information is preserved by splitting the region in to as small as 4×4 square sub-regions on a regular basis. Here computation of Haar wavelet response in to 5×5 on a regular basis spaced sample point is done to each sub-region. To keep things simple, we name d_x as the Haar wavelet responses in the horizontal direction, whereas the d_y as the Haar wavelet responses in the vertical direction (with size of filter 2s).Here the Horizontal as well as Vertical is defined as a relation of selected interest points orientation (as shown in Fig.5). To reduce the localization errors and also to enhancement of robustness, the responses d_x and d_y are weighted first with the Gaussian (σ =3.3s) centered at interest points.

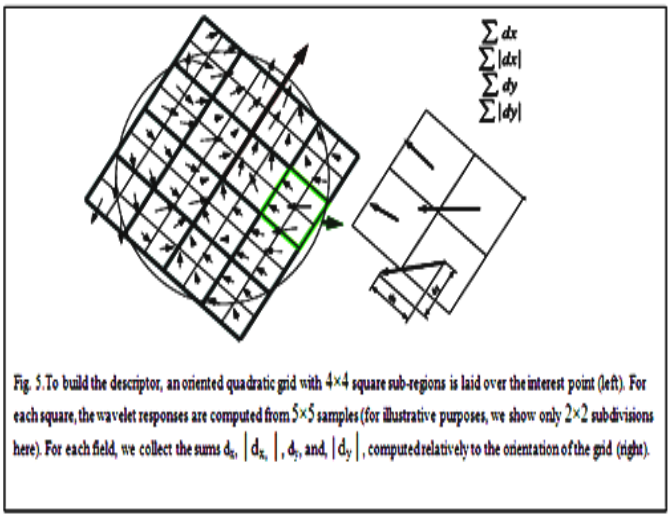

Fig. 5.To build the descriptor, an oriented quadratic grid with 4×4 square sub-regions is laid over the interest point (left). For each square, the wavelet responses are computed from 5×5 samples (for illustrative purposes, we show only 2×2 subdivisions here). For each field, we collect the sums d_x, $|d_x|$, d_y, and, $|d_y|$, computed relatively to the orientation of the grid (right).

Fig. 5

The first set of the entries in the feature vector are formed by summing up wavelet responses d_x as well as d_y over the each of the sub-region. To bring in the information about polarity of the intensity changes, we are going to extract the sum of absolute values of responses $|d_x|$ and $|d_y|$. Therefore each of the sub-region will have 4D descriptor vector V for the underlying intensity structure $V = (\sum d_x, \sum d_y, \sum |d_x|, \sum |d_y|)$. The descriptor vector length 64 is achieved, by concatenating these 4×4 sub regions. By turning of the descriptor in to unit vector, the wavelets responses are not-variant to bias in the illumination as well as non-variance to contrast are achieved. The properties of descriptors are shown in fig.6, where three distinctively different image of intensity patterns within the sub-region. Hence distinctive descriptors are the combination of the local intensity patterns.

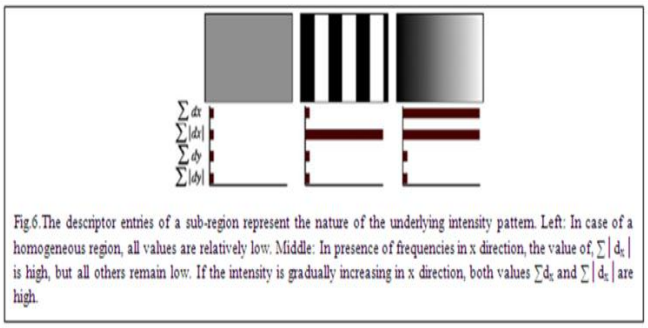

Fig.6.The descriptor entries of a sub-region represent the nature of the underlying intensity pattern. Left: In case of a homogeneous region, all values are relatively low. Middle: In presence of frequencies in x direction, the value of, $\sum |d_x|$ is high, but all others remain low. If the intensity is gradually increasing in x direction, both values $\sum d_x$ and $\sum |d_x|$ are high.

Fig. 6

Both SURF and SIFT focuses on the spatial distribution of the gradient information, but SURF works better than SIFT practically in any situations. The SURF is less sensitive to noise than SIFT (as shown in fig.7), because it is going to integrate the gradient information within the sub-patch, where as the SIFT depends on orientations of the individual gradients.

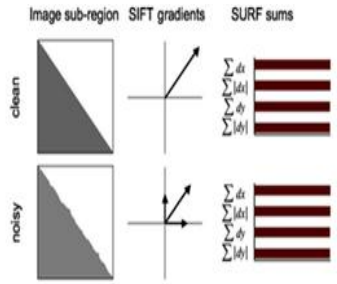

Fig.7. Due to the global integration of SURf's descriptor. It stays more robust to various image perturbations than the more locally operating SIFT descriptor.

Best results can be obtained by having descriptor division in 4×4 for sub-region, where as finer subdivisions are less robust and may increase the matching time too much. A short descriptors with 3×3 sub-regions perform to some extent worse, but it will allow very fast matching and still it is acceptable.

Matching by using fast indexing.

A sign of the Laplacian is included in underlying interest points for the purpose of fast indexing during the matching stage, where blob type structure contains the interest points. Bright blobs with the dark backgrounds from the reverse situation are distinguished by sign of the Laplacian. This feature will help in fast matching without additional computational effort, which is computed during the detection phase only. Only the comparison of the features is done during the matching stage, if they posses same type of the contrast (as shown in fig.8). Therefore, this minimum information will allow the faster matching with no compromise with the descriptor performance, which is advantageous to advanced indexing method.

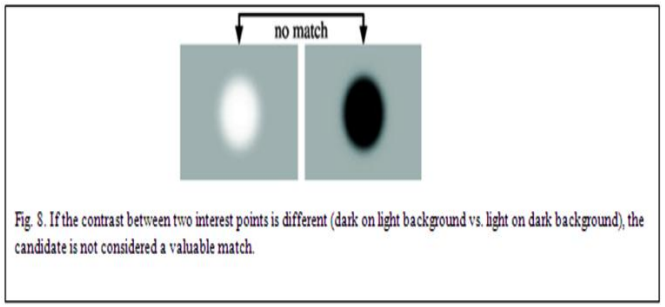

Fig. 8. If the contrast between two interest points is different (dark on light background vs. light on dark background), the candidate is not considered a valuable match.

Fig. 8

3.3 k-NN classification:

Here the simple algorithm called as k-NN is used, which will store the available cases and depending on the similarity measures it classifies new cases. This algorithm is used in the statistical estimation as well as pattern recognition applications as non-parametric method. In the k-NN distance is calculated by following three functions and we have used Euclidean function,

$$\text{Euclidian} \sqrt{\sum_{i=1}^{k}(xi - yi)^2} \quad (5)$$

$$\text{Manhattan} \sum_{i=1}^{k}|xi - yi| \quad (6)$$

$$\text{Minkowski} \left[\sum_{i=1}^{k}(|xi - yi|)q\right]^{1/q} \quad (7)$$

- We have implemented a k-NN model by following the below steps:

1. Take Input from SURF Descriptor.
2. Take Input from save model.
3. Initialize the value of k.
4. Comparison of the features from test data to training data (save model) is done in following steps for predicting the class of the test data. To achieve this repeat from 1 to until all training data points are compared,
   1. The distance between the testing input and each row of trained information (save model) will be computed by using Euclidean distance as a distance metric (by using equation.5).
   2. Based on the k values arrange the calculated distances in ascending order.
   3. Selection of the top k rows of the array.
   4. Selection of the most repeated class from these rows of array.
   5. Prediction of the class is returned.

IV. RESULTS AND DISCUSSION

Here we have used the dataset produced by Brahnam and Nanni [5] to check the performance of our system. The following are the samples of dataset used for experimentation.

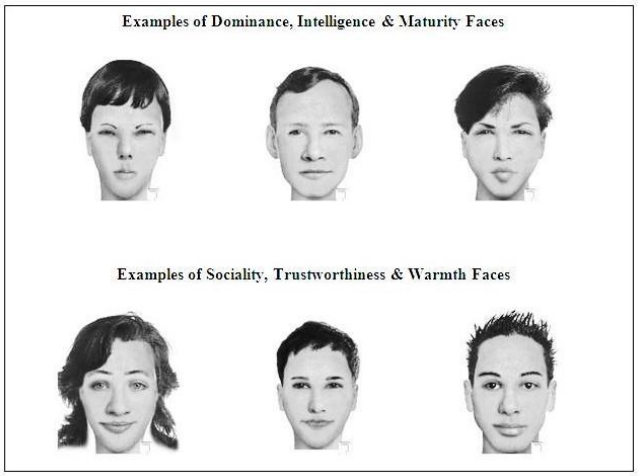

Figure 9: Above Figure shows the Samples of Dataset used for Experimentation [5] (Figure reproduced from Brahnam & Nanni. 2009)

This section explains the results obtained from the proposed work. The overall performance of any system is computed based on the parameter such as accuracy is calculated by:

$$\text{Accuracy} = \frac{\text{The number of images correctly recognized}}{\text{Total number of images}} \times 100 \quad (8)$$

In the proposed work, accuracy is calculated by using the total number of images that are recognizing correct characteristics. i.e. total number of images that recognizes intelligent, dominance, maturity, sociality, trustworthy, and warmth characteristics.

Table:1 Overall performance of the Proposed System

Confusion Matrix (in Terms of %)						
Dominance	94.5	0	5.5	0	0	0
Intelligence	5.5	94.5	0	0	0	0
Maturity	11.11	27.77	61.11	0	0	0
Sociality	0	22.22	5.5	72.22	0	0
Trustworthiness	5.5	22.22	0	0	72.22	0
Warmth	0	22.22	0	0	16.66	61.11
	Dominance	**Intelligence**	**Maturity**	**Sociality**	**Trustworthiness**	**Warmth**
Predicted Label						

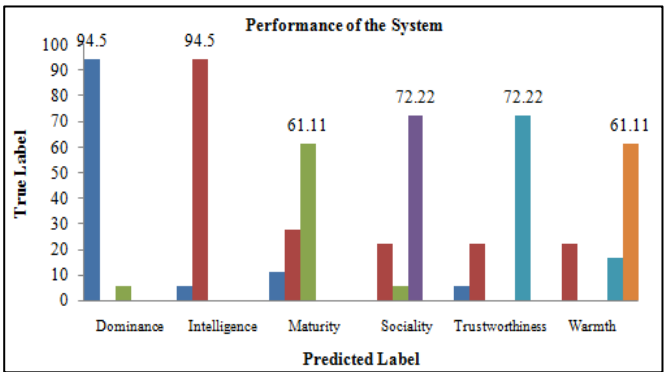

Fig. 10

The following figure shows the F1 Score for the proposed system which is Harmonic Mean of Precision and recall and it is calculated by:

$$F1 = \frac{2}{\frac{1}{recall}+\frac{1}{precision}} = 2.\frac{precision.recall}{precision+recall} \quad (9)$$

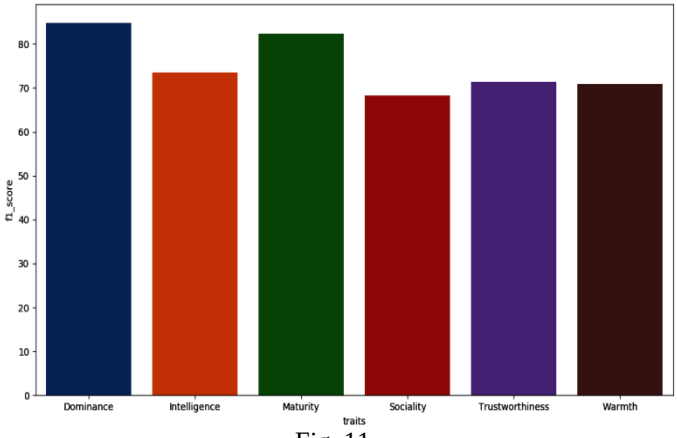

Fig. 11

V. CONCLUSION AND FUTURE SCOPE

It is very important to understand the nature and the characteristic of a person before dealing with them. Especially in the field of crime investigation, the investigators observe the facial features of the convict such as eyes, nose, mouth and forehead to keep track of him. Facial features are helpful for psychologists also to predict the characteristics of the person. The proposed methodology predicts the characteristics of person based on facial features. In the proposed work, the image preprocessing is carried out using the techniques such as face features extraction is carried out using SURF descriptors and k-NN with brute force matching for classification, The overall accuracy achieved by the system is 76% . In future the accuracy of the proposed system can be increased by applying diverse combination of feature extraction and Classifier combination.

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