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Racial Classification from Face

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Abstract*: *FACE is one of the major sources of social information like race, age, gender etc. At different levels of classification, prediction and identification face plays a major role, apart from other parts of the human body. As per literature Race is a form of classification for categorizing human beings in to groups based on geographic boundaries, physical appearances(including face), ethnicity and social status. In this paper we are trying to focus on different facial datasets those are currently available without any cost (but with licensing restrictions). Here, we are also representing our study of different works carried-out related with the racial classification and related topics.

Keywords*: *Race, ethnicity, race classification, ethnicity classification, cross-race effect, face dataset, facial features.

I. INTRODUCTION

Face carries varieties of information such as age, gender, race, ethnicity etc. In the last few decades, lots of researches were carried-out on face images at different levels processing by the computer vision community.

Race refers to classifications of humans into relatively large and distinct populations or groups often based on factors such as appearance based on heritable phenotypical characteristics or geographic ancestry, but also often influenced by and correlated with traits such as culture, race and socio-economic status. [1]

In this paper, we are trying to present our survey on 'How Race can be determined from Face' which includes different studies, approaches and experiments along-with their results. Also we have given our best to give a detailed information about the different image datasets based on facial images those are more or less extensively used the field of digital image processing.

II. WHAT IS RACE?

A **race** is a grouping of humans based on shared physical or social qualities into categories generally viewed as distinct by society [2]. First used to refer to speakers of a common language and then to denote national affiliations, by the 17th century the term race began to refer to physical (phenotypical) traits. Modern scholarship regards race as a social construct, that is, a symbolic identity created to establish some cultural meaning. While partially based on physical similarities within groups, race is not an inherent physical or biological quality [2,3]. Race is a type of identity which is created by the dominant groups in the socities throughout the ages. Humans are better at recognizing faces of their own race than faces of other races [4].

In ancient societies, people are divided based on their language, religion, class etc. So, there is no genetic biasness. If we go through the history, we will find that after conquering or on the victory of war the conqueror enslaved the conquered irrespective of physical characteristics.

III. RACE CLASSIFICATION

From history, due to different activities such as conquests, invasions, migrations, and mass deportations resulted in creation of a heterogeneous world population which symbolizes the co-existence of different races. Most of the anthropologists' over-decade unanimously agreed that Caucasian, Mongolian and the Negros are the three major distinct races.

Research has shown that it is more difficult for individuals to correctly identify people of another race than to identify same-race individuals (Chance & Goldstein, 1996; Malpass & Kravitz, 1969), and this *cross-race effect* is widely replicated in the literature (Bothwell, Brigham, & Malpass, 1989; Shapiro & Penrod; 1986). A number of theories attempt to explain the source of this bias in face recognition. [5,6]

Table-I, gives few of the physical characteristics of the above three races.

IV. FACE DATASETS

It is definite that for carrying out researches based on Face, we need a collection of facial images. Researchers require authentic datasets for comparing the results of their experiments. Although there are many datasets those are currently in use but the choice of the datasets is a very important task because there are other factors those play important role in image processing and these are like aging, expressions, lighting etc. The collection can be acquired,

- ✓ from existing standard face datasets/databases available in the internet either free or paid,
- ✓ by ourselves by taking pictures of the human faces belonging to different races with consultation with anthropologists, and
- ✓ by amalgamating the above two.

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There are different facial datasets that are used by the researchers in the world. They are namely,-

Table- I: Races with different physical characteristics

	Finds in	Skin	Nose	Lips	Forehead	Stature	Hair
Caucasoid	Europe, North Africa, and the Middle East to North India	Pure white-Rich brown	Thin & High	Thin	Long	Medium-Tall	Light blond-Dark Brown
Mongoloid	East Indies, China, Japan, and the adjacent islands	Yellowish tawny	Medium broad	Medium thin	Low	Medium	Black
Negroid	Africa and West Indies	Jetty black	Broad	Averted	Low	Tall/Medium	Black, crisp and curly

- *FERET Database:*

  It is [7] started as a program to establish a database of facial images gathered by different algorithm developers independently. In fact, Dr. Wechesler and Dr. Philips created the database where the images are collected in a semi-controlled environment. They maintained consistency in each of the images collected by maintaining the same physical setup for photography.

  This collection of facial dataset is initiated as a part of the FERET program. The images were collected during December 1993 to August 1996. It contains a total of 14,126 images of 1199 individuals.

- *SCface Database:*

  Scface[8] stands for Surveillance Cameras Face. It a collection of images taken in uncontrolled indoor environment using four to five video surveillance cameras of different qualities. It consists of 4,160 images with of around 130 subjects.

- *Multi-PIE:*

  The original CMU PIE database has been very influential in advanced research in face recognition with variations in poses and illuminations. But due to the limited number of subjects, single recording session and only less in expressions, CMU Multi-PIE[9] database was collected. It contains 337 subjects captured under 15 view points and with 19 illumination conditions and that is up to four recording sessions.

- *Yale Face Database:*

  This database[10], of size 6.4 MB approximately, contains 165 grayscale GIF images. The images are of 15 subjects with 11 images per subject. The variations are in facial expression & configuration: center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink.

- *Extended Yale Database:*

  This database contains 16128 images of 28 human subjects. Though the no. of subjects are less but with 9 poses and 64 illumination conditions it is considered as useful dataset. [11]

- *MIT-CBCL face recognition database:*

  It is collection of the facial images of 10 persons. It has two types of training sets [12]:

  - High resolution pictures, including frontal, half-profile and profile view.
  - Synthetic images (324/subject) rendered from 3D head models of the 10 subjects. The head models were generated by fitting a morphable model to training images. The 3D models are not included in the database.

  The test set contains 200 images per subject with varying illumination, pose and background.

- *PolyU NIR Face Database:*

  In the Hong Kong Polytechnic University (PolyU), the Biometric Research Centre has developed the NIR Face Database. For this, they first designed a real-time Face Capturing Device (termed as NIR).

  In their paper [13], they referred 350 subjects but in release of the output database contains 335 subjects as some data were missed out while compiling. The face images per subject are frontal-normal, frontal-normal with expressions, with changing poses etc. Thus it contains overall 34,000 images, with 100 images per subject.

- *CVL Face Database:*

  This database[14] contains images of 114 subjects with 7 images per subject. This database is mainly deals with Caucasian. The images per subject are taken with a projection screen at the back with different side and frontal views with and without expressions.

- *Large Scale 3D Face Database:*

  It is a 3D face database[15]. Here in the databases the faces are provided with both texture and shape with the gender and race information. It is useful for variant face analysis tasks. The number of subjects in the database is more than 400. In this database the key facials points with semantic meanings are carefully labeled and aligned among different faces.

- *2D FACE SETS:*

  This is actually a multi-set dataset[16]. It contains sets:

  - **Aberdeen:** Contains coloured faces from Ian Craw at Aberdeen of 90 individuals. For each of the subjects there are 1 to 18 images, some with variations in lighting.
  - **Iranian women:** Contains coloured faces of Iranian Women of 34 individuals with a total of 369 images**.** The images per individual are mostly with smile and neutral in each of five orientations.

- **Nottingham_scans:** Contains monochrome images of Nottingham people. There are frontal images of 50 male and 50 female with neutral expression.
- **Nott-faces-originals:** Contains monochrome images of Nottingham people. There are a total no. of 495 facial images of 71 individuals, each with 4 expressions as frontal, 2 expressions with a ¾ view and 1 frontal with a cap.

- *MORPH:*

  This database[17] is of 55000 facial images. The no. of subjects is more than 13000. This huge collection was made in the span of almost 5 years, from 2003 to 2007. This database is useful for race as well as age related tasks. Here, the ages range from 16 to 77 (33 as median age).

V. LITERATURE SURVEY

In the field of computer vision and pattern recognition, the analysis of FACE is one of the most studied research area where lots of researches are carried out. Here we are trying to represent our study mostly in race related issues in a concise manner.

Kurzban and others carried out an experiment using unobtrusive measures, showing that categorizing individuals by race is not inevitable, and supporting an alternative hypothesis: that encoding by race is instead a reversible byproduct of cognitive machinery that evolved to detect coalitional alliances. The results show that subjects encode coalitional affiliations as a normal part of person representation. [18]

Holguin S. et al[19] focused on cross-race effect while determining the race from a face. A set of twenty "Racially ambiguous" facial composite images were created including facial features associated with both Blacks and Hispanics with the help of a facial composite production system, Face 3.0. Each and every participant is assigned a computer and the faces were displayed on the monitor. The participants had to identify the race as: "Black", Hispanic, Italian, Asian and Other by giving ratings with 9-point Likert type scale. For rating, the facial features were considered on widths of nose & mouth, lips, eyebrows, ears, chin and complexion. From the result they observed that there are differences in the classification view-point among the participants.

L. Eberhardt Jennifer and others [20] presented in their research paper about their studies for examining whether racial labels and stable individual differences together shape people's perception of, and memory for, racially ambiguous faces. In their experiment, they created faces by morphing a white face with a black face. Then they manipulated the actual racial labels assigned. Then they presented those face images to the participants who were known as entity theorists or incremental theorists.

Lu and Jain [21] had worked for two classes: Asian and Non-Asian. In their paper they proposed a classification algorithm. In the algorithm the examination of face images were performed at multiple scales. For betterment of the classification performance LDA was used. Their face image database contained 2,630 images of 263 subjects.

Qiu X, Z. Sun and T. Tan [22] proposed a method for ethnic classification, Asian and Non-Asian. In their paper they considered iris feature. Their ethnic classification was based on analysis of global texture of iris images. For their experiment they considered three iris databases namely CASIA, UPOL and UBIRIS. They had used a bunch of 2D Gabor filters to capture the global texture. They also used the AdaBoost to learn a classification principle from the feature set. The proposed method gave correct classification rate (CCR) of 85.95%.

Lu, Chen and Jain [23] tried to extract the information in facial images for ethnicity identification. They used Support Vector Machine scheme for this. In their paper they had also proposed an integrated method for identifying ethnicity and gender. This method was a combination of the registered range and intensity of images. Their database contained 1240 facial images of 376 subjects.

Lin, H. Lu and Zhang [24] proposed a novel approach for recognizing the gender, age and ethnicity with the help of facial images. The proposed system consisted with three modules namely Gabor Filter, Adaboost and Support Vector Machine(SVM). The dataset they used was FERET. For ethnicity, they considered three classes and they are: Mongoloid, Caucasian and African. For ethnicity they used three binary SVM classifiers. Before training they did preprocessing on the images in the dataset which includes rotation and scaling. They did one-class versus one-class training method and finally by voting the SVM final output decision was made. The result of the experiment showed a good performance on FERET dataset of frontal images.

U. Tariq, Y. Hu and T. S. Huang [25] demonstrated their attempt in identifying the gender and ethnicity from silhouetted face profiles. In their dataset, they generated the silhouetted face profiles from the 3D face models collected by Hu et al. [15]. The images are divided into four ethnic categories namely – Black, East and Southeast Asian, South Asian and White In their experiment they used shape context based matching. They coined a term "shape distance" and used the approach similar to what Belongie et al. [26] described. They calculated the distance (i.e., shape distance) of the test profile edges to the training profile edges. Their results were convincing for silhuoetted face profiles.

X. Duan and others[27], in their paper, mainly focused on the three ethnic groups present in China (Tibetan, Uighur and Zhuang). They created a face dataset on these groups. They have extracted two features of from the dataset created and they are Geometric Feature and Algebraic Feature. They used LDA to extract algebraic features. For geometric feature extraction, they created elastic templates for the three groups. Regarding the algebraic features, for predictions they used KNN classifier (considering Euclidean distance as the distance function). The experiment showed that with k=5, the KNN achieves the best result as per this experiment is concerned [Tibetan: 77.1%, Uighur: 78.5%, Zhuang: 81.4]. And regarding the geometrical features, C 5.0 was adopted as training algorithm. This experiment showed a better performance than the performance related with algebraic features.

The correct rate of recognition is achieved for Tibetan is 88.6%, Uighur is 90% and Zhuang is 94.2.

S. Md. Mansoor Roomi[28] and others, in their research paper, proposed an methodology for classifying the Caucasian, Negroid and Mongoloid races. Their methodology consisted of (i) Detection of Face Region using Viola-Jones Appearance Method, (ii) Obtain the skin color suing Gaussian Distribution from the detected faces, (iii) Use of edges for other feature extraction and (iv) Automation of Race classification. For their experiment they used the FERET dataset. The experiment showed the Fp(False Positive) as 8% and the accuracy as 81%.

Ghulam Muhammad et al.[29], in their paper, presented a race recognition system from facial images. They used the FERET dataset. In the system, first, WLD(Weber Local Descriptor) histogram is extracted from normalized face images and then Kruskal-Wallis feature selection technique is used to select the best discriminated bins [29]. The WLD, a very robust and powerful local descriptor and has two components namely- differential excitation and gradient orientation. They considered five major race groups- Asian, African or American Black, Hispanic, Middle-Eastern and White (with a total of 1180 images). The face images are normalized and then cropped maintaining the pixel sizes at 60x48. Here in the experiment, the block sizes were varied as- (20×16), (20×12), (10×16), (10×12) and the whole (60×48) on which WLD was applied (for each of the blocks). While carrying out with the whole image size the average accuracy was 74.09, which was much lower than PCA (as carried-out). But when they considered the rest of the blocks for applying WLD the performance have increased. It was observed that the best performance, in terms of average accuracy, was 96.68% when the block size is (10×16). But with the block size of (10×12) the average accuracy was down to 95.85%.

Tumpa Dey [30] presented a procedure for automatic detection of facial landmarks in her research paper. The face dataset, used in the experiment, was created by Tripura University which consists of North-Eastern Indian people. The images are with eight different expressions: Neutral, Anger, Laughter, Sad, Surprise, Fear, Disgust, Closed Eye. The facial landmarks are – corners of left - right eyes, left & right eyebrows, lip corners, nostrils. The detector has two modules- (i) Morphological Opening Operation for background estimation and uniform background creation, and (ii) Use of Fast Corner Detector for detection of facial landmarks (mentioned above). The fast corner detector uses a Corner Response Function (CRF) that gives a numerical value for the corner strength at a pixel location based on the image intensity in the local neighborhoods [30]. In the experiment 105 frontal images of 15 persons each with eight different expressions are used. The experiment yielded Average Mean error as 0.2716.

Shiji. S. K.[31] performed an experiment on face recognition based on PCA (Principal Component Analysis). Here, in the experiment, the eigen-faces were considered for the definition of the face spaces. Also here, the PCA and LDA methods were combined where PCA was applied to preprocess the facial images and then LDA was applied to the low dimensionality images. Finally neural network was implemented for the classification of face images based on its computed LDA features.

H. Han and Jain[32] presented a methodology for automatic estimation of the race, gender and age from the face images collected in unconstrained manner. Their methodology was consisted of: (i) face normalization of input face images, (ii) extraction of features from the processed facial images, (iii) use of SVM (Support Vector Method) approach for the estimation of age, gender and race. The datasets, they used for the experiment, were ***Images of Groups*** [33] database (with 28,231 images) and an extended version of the public-domain ***LFW*** database. The LFW database contains mainly the celebrities, public figures etc. (with 15,699 images). Experimental results showed that demographic estimation from unconstrained face images remains a very difficult problem; the proposed approach, nevertheless, significantly outperforms the state-of-the-art methods in unconstrained scenarios, and generalizes well to the scenarios of cross-database testing and semi-constrained sensing conditions [32].

K. Saha, Bhattacharjee and Bhowmik[34], in their paper, studied the facial structural differences between the various tribes and non-tribes of the north-east India. The aim of their study was to carry out a comparison of anthropometric values of Mongolians in the north-eastern region of India of similar socioeconomic status with special reference to five states: Assam, Mizoram, Tripura, Nagaland and Manipur [34]. They took facial images of mongoloid people from different states, e.g., Tripura, Reang, Chakma, Debbarma, Jamatia, Darlong, Mog, Halam etc. With these images they tried to measure the distances between the facial feature points. They also tried to find out the differences in the facial structures of different tribe/non-tribe, male/female etc. The result of their study showed significant differences between the male and female tribes/non-tribes.

Momin and Tapamo[35], in their paper, proposed a model for ethnicity classification form facial images. They considered the races- Asian and Non Asian (as Two Group); Asian, White and Black (as Three Group); Asian, Indian, White and Black (as Four Group). Their proposed model was based on Gabor Filters using four different classifiers. The four classifiers they used for classifying features are: K-means, Naive Bayesian, Multilayer Perceptron and SVM. The dataset used by them was a combination of 3 different datasets. Overall the dataset contained 511 images where 52 images from ***Indian Face*** Database, 199 images from ***Asian Face*** Database and 260 images from ***MORPH*** database (with different facial expressions, illuminations and expressions). Their method had given accuracies: 99.60% for Asian and Non-Asian; 90.21% for Asian, White and Black; 87.67 for Asian, Indian, White and Black. The experiment also showed that nose and mouth is more informative as compared to the eye.

S. Masood et al. [36], carried out two experiments in relation with the ethnicity classification problem. They, for their experiments, considered three ethnic groups namely- Mongoloid, Caucasoid and Negroid. The face dataset they used was

FERET. The two experiments were carried-out using ANN and CNN respectively. In the 1st experiment, they (i) calculated Geometric Features, (ii) extracted Skin Color and (iii) calculated Normalized Forehead Area. For the network, they used, out of 447 images (from FERET), 320 were used for training, 37 for validation and 97 for testing. In the 2nd experiment, they used a pre-trained model [37] for the extraction of features from the samples (both training and testing). The used Network consisted of 13 convolution layers. After performing the feature extraction, training and testing was performed. The result of the experiments showed superiority of CNN over ANN as the accuracies were 98.6% and 82.4% respectively irrespective of costs. It also showed that time taken for extraction of features and training of the network by CNN is more than ANN.

VI. CONCLUSION

We divided our survey in two parts: (i) about the different recognized facial datasets and the (ii) about different procedures and methods adopted by various researchers from feature selection to race and ethnicity classification. From the survey, it is noticed that the face can precisely give the race. The survey shows that in the last few years, lots of researches are carried out and which basically signifies a tremendous progress in the learning process of race from facial images. In this survey we tried to provides, more or less, all the existing facial image datasets and also a comprehensive review of the advances in race.

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