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Annotated Database Construction Framework for Partially Occluded Face Recognition

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***Abstract*—** The need of face recognition exponentially progresses due to its applications in law and enforcement, commercial to security systems. The existing face recognition systems efficiently accomplish this task in the constrained environment. However, implementation of face recognition system in unconstrained environment still remains as a challenge. There major issues in unconstrained environment are facial expression, illumination and partial occlusion. The collection and collation of enormous individuals' data such as profile images of employee of an organization or citizens of a province for the creation of public dataset itself is highly complex. This paper presents a generic framework to construct an annotated database, especially for the partially occluded face recognition system. This Annotated Database Construction Framework (ADCF) has the provision to store the profile images and the facial components, along with the respective feature vectors. This ADCF felicitates the logical calibration of database contents to address the need of Partially Occluded Face Recognition System, with reference to the probe image. Hence, ADCF offers better scope for the researcher to precisely validate the authenticity of any face recognition system even with occlusion.

***Keywords*—** Annotated database; Partial occlusion, face recognition

I. INTRODUCTION

Database design and implementation plays a major role in any database driven information system. It facilitates the flow of information in and out of the system in efficient way. The efficiency of any information system depends upon three basic characteristics/ factors: Computational, Time, and Space Complexity. Time complexity is defined by the response time of database system, faster response time is expected for efficient information retrieval system. Theoretically, efficiently designed database system requires less storage space as well as low computational workload. In real time implementation of any database, database designer try to find the optimal balance among these three factors and their solution are highly problem specific [1]. Some database are designed to maximized the throughput as amount of transactions are more, whereas, other are highly optimized to store large volume of data. Although, new records will be added frequently in database, database design and implementation for face recognition system is more query specific. The basic concepts of database design are briefly explained here.

For design and development of database, designer have to follow some basic and most common concept of database. A well-structured database saves disk space by eliminating redundant data, provides access to data in convenient means as well as maintain data accuracy and integrity [2]. Usually a database model describes the logical structure of database. Relationships and set of constraints are applied on database to facilitate storing and retrieving of data. Normally, any efficient database design includes four phases: (i.) Requirement Analysis, i.e. identifying the purpose of database. (ii.) Tabularization of data, (iii.) Primary key generation and relationship analysis, and (iv.) standardization of tables using normalization [1]. In requirement analysis, database designer clearly understand the purpose of the database and all possible perspectives duly considered. Then visualization of database is achieved by grouping the related data into a single tables. Table consists of rows and columns. Rows are also called records and used to represents a set of attributes about an object, whereas columns (also known as fields or attributes) contains a single type of information that appears in each record. Appropriate data type is assigned to maintain the data consistency among records. Now, database designer decides to select set of attribute(s) used to uniquely identify any record in a given table, these set of attributes are called primary key. Set of attribute(s) chosen for primary key must be unique, unchanging and never be NULL [3]. Each

table can have relationships with one another, these relationship can be one of these:

One-to-one relation: only one instance of Table-1 has relationship with one instance of Table-2.

One-to-many relation: one instance of Table-1 is associated with multiple record of Table-2. For achieving the 1: M relationship, primary key of Table-1 is listed in Table-2 and works as foreign key.

Many-to-many relation: multiple instances of Table-1 are associated with multiple instances of Table-2. Typically many-to-many relationship is achieved through concatenation of 1: M relationships [4].

Finally, database normalization is used to correctly structure the tables. There are several normal form exists from first normal form to sixth normal form. However, first three normal form are most common. The First normal form ensures that each field of table consist one attribute only. Second normal form decrees that each of the attribute must depend on the primary key. And in third normal form each non-primary field is independent of every other column [5].

Rest of the paper is organized in four sections. Proposed work is explained in Section II. Mechanism of ADCF is explained in Section III. Result and discussion is coved in Section IV and Conclusion is presented in Section V.

II. PROPOSED WORK

Annotated database construction can be classified into two groups: semi-supervised and fully automatic database construction. In the former approach, detection of face, extraction and storage of face components and feature set is accomplished with human intervention. Whereas in latter approach, there is no need of human intervention for face detection, face component and feature extraction. The whole process is automated and system takes face image as an input image, process it and store the desired outcomes into the database. Here process involves face detection, facial component and feature extraction at global and/or local level, based on the method selected for face recognition. For saving the storage space, it would be recommended that developer must design a database in such a way that information redundancy should be minimized. If adapted face recognition techniques works on global feature extraction then there is no need to store local features, as it will occupies extra space to store local features with global features unless there is futuristic plan to execute hybrid face recognition method in near future. Similarly, for face recognition based on local features no need to store global features.

Although, database design for full face recognition is more query specific, the complexity level gets increases in terms of storage and query (response) for Partially Occluded Face Recognition (POFR). POFR system has to store additional information for each subject and sometimes multiple records are maintained for every individuals to enhance the recognition efficiency. Additional information for each subject may contains global and local feature sets, facial components along with their respective tags. Proposed system Annotated Database Construction Framework (ADCF) for POFR works on the principle of face recognition using hybrid technique. Database designed for Hybrid Techniques surely occupies additional storage space, but this scheme facilitates more flexibility to achieve higher efficiency rate than local and global approaches. ADCF store at least five types of data for each subject namely: Subject-ID, Face-image-ID, Face-component, Face-image and Face-feature set, see Table-1.

Table 1. Tables attributes

Fields used for Tables		
Field	***Purpose***	***Remark***
Subject_ID	Unique ID for each candidate	Work as PRIMARY KEY
Face_image_ID	Unique ID for each subject	Work as ALTERNATE KEY
Face_image	Subject face image	Full cropped face of the candidate
Face_component	Store facial components	Set of facial component
Face_featureset	store facial features	Set of facial features

III. MECHANISM OF PROPOSED FRAMEWORK

The proposed framework facilitates two major task:

- Annotated Storage Mechanism
- POFR based on query image.

Annotated Storage Mechanism:

Annotated storage mechanism is based on the principles provided by [6], where face is searched in an input image based on local and global feature sets. Present face is examined through facial geometry to ensure the precise face detection. On the successful completion of face detection, face alignment is performed then face component and its associated features set for each components are stored in different tables as given in Fig. 1 and Fig. 2. Each new subject (Candidate) has assigned unique identity namely Subject_ID that facilitates candidate's face recognition in query process. All associated data of every subject is stored in different tables that conform to the standard of Third Normal Form. In Fig. 3, Table-1 contains the candidate unique id (PRIMARY KEY) named Subject_ID and its corresponding Face_image_ID that works as an (ALTERNATE KEY) for future enhancement of database.

All other tables and their records are linked to unique subject through Face_image_ID only. Table-1 may contains some additional fields about each subject such as subject name, Social Security Number (SNS) / Aadhar Number and Address as per the system requirement. Table-2 contains the Face_image_ID and its corresponding subject's three different cropped face images or their URL based on system implementation. To achieve better recognition efficiency more than three different samples per subject can be archived. Storing more samples per subject offer direct tradeoff between recognition rate and computational cost. More the number of samples per subject means more computational cost. The requirement of number of samples per subject is based on adapted face recognition algorithm. In Fig. 3, Table-3 to Table-6 stores the face component data or their URL, three different samples of each subject is stored here. Similarly, Table-7 to Table-10 stores the feature sets in triplets of each subject. The number of table for storing the facial components and feature sets may varies based on the number of facial components being selected for face recognition. Minimum four Tables are required to store major face components like Nose, Left eye, Right eye and Mouth.

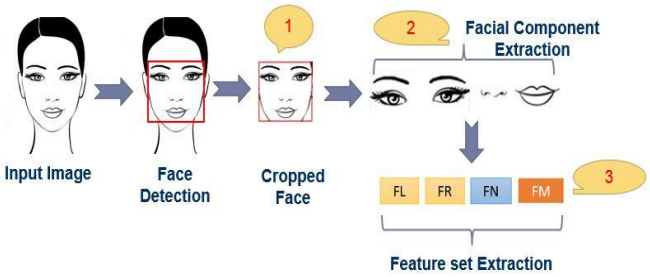

Figure 1. (Facial Component and Feature set Extraction)

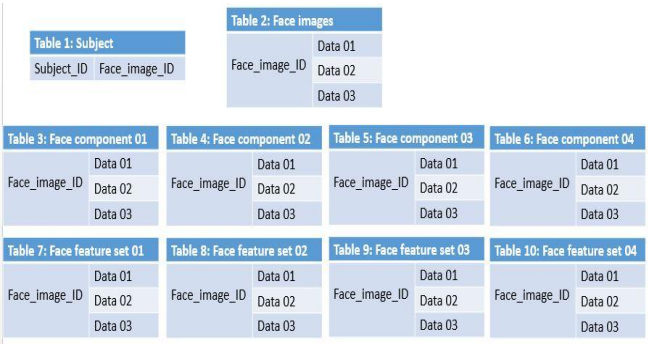

Figure 2. (Subjects data and associated information stored in different tables)

POFR based on query image:

Second part of this system facilitate the Partially Occluded Face Recognition based on query image. Query image can be full face image or partially occluded face image. In both scenario, query image is processed through the mechanism presented in [6] that includes skin segmentation using [7] that follows occluded face component detection, facial component extraction and features extraction along with tag information. Tag contains the information about the occluded face component. Based on tag information, database schema is selected to process the query image to find recognized face in the database. Suppose database is designed in such a way that Table-3, Table-4, Table-5 and Table-6 contains the data about left-eye, right-eye, nose, and mouth respectively, and similarly, Tabel-7, Table-8, Table-9 and Table-10 contains the information about feature set of left-eye, right-eye, nose, and mouth respectively, See Fig. 2. And suppose left-eye is occluded in query image then Tag will contain the information about this occlusion. Based on this occlusion, corresponding schema will be selected for matching purpose where Table-3 and Table-7 shall be excluded from matching process as these component and features are missing in query image, see Fig. 3. Here, query image's components and feature sets will be compared with several (three in this example) facial component and feature sets of every individuals using the mechanism provided in [8]. Comparison of query image features with more than one feature set of same individual increases the probability of precise matching at the cost of computational complexity. Based on experiments author find that minimum three slight variation copy of each individual is required to increase the probability of accurate matching. The number of schema required for different type of occlusion is directly depend upon the number of facial component selected by the face recognition algorithm. As mentioned in [6], suppose only four major facial components are considered for face recognition then sixteen ($2^{(4)}$ = 16) different schemas are required to cover all possible occluded situations.

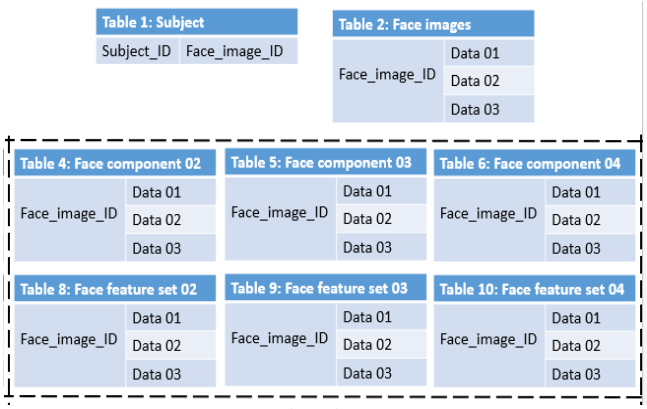

Figure 3. (Schema used for left-eye occlude query image)

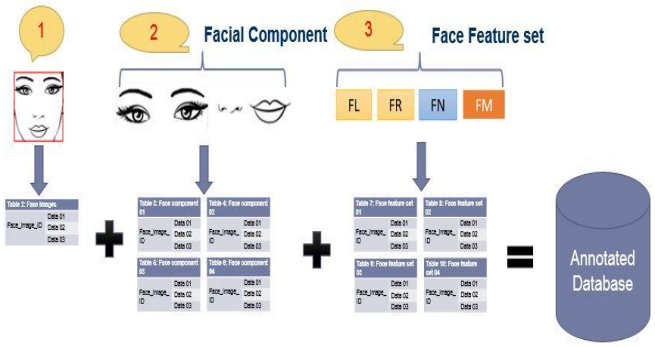

Figure 4. (Annotated Database Construction)

IV. RESULTS AND DISCUSSION

This framework broadly accomplishes this task in two modules namely, *annotated storage mechanism* where, related data of each subject is stored in different tables, while maintain the criteria of third normal form and *POFR based on query image*, where appropriate schema is selected based on the type of occlusion. This framework is tested on 2D face dataset of face images from University of Stirling and on profile image database constructed by authors, from public domain images. Fully automated database Construction approach is followed from face detection, cropped face extraction, facial component extraction to feature set extraction, (Fig. 4). All extracted components are stored in respective tables. In query part, 88% recognition rate is achieved using feature set extraction through Maximally Stable External Regions (MSER). Figure 5 shows result of the randomly selected query image in which left eye is missing. This sample result is obtained using [8]. Three samples per subject is enough to achieve better results in POFR using ADCF.

Figure 5. (Result of POFR based on query image using MSER)

V. CONCLUSION

The proposed approach is used to design the database construction framework for partially occluded face recognition. Proposed ADCF felicitates the logical calibration of database contents to address the need of Partially Occluded Face Recognition System, with reference to the probe image. Hence, ADCF offers better scope for the researcher to precisely validate the authenticity of any face recognition system even with occlusion.

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Mr. Ashish Kumar pursed Bachelor of Science from Chaudhary Charan Singh University, Meerut, India in 2001 and Master of Computer Applications from The Gandhigram Rural Institute – Deemed to be University, India in year 2011. He is currently pursuing Ph.D and working as Project Fellow in Department of Computer Science and Applications, The Gandhigram Rural Institute – Deemed to be University, India since 2012. He has published several research papers in reputed conferences including IEEE, Springer Series and it's also available online. His main research work focuses on Digital Image Proessing, Artificial Intellengence, Machine Learning and Medical Imaging. He has 3 years of teaching experience and 5 years of Research Experience.

Dr. P. Shanmugavadivu pursed Bachelor of Science from K.N. Govt. Arts College, Thanjavur, India in 1987. She pursed Master of Computer Science and Applications from Regional Engineering College, Trichy, India in 1990 and Ph.D. in Digital Image Processing from The Gandhigram Rural Institute – Deemed to be University, India in 2008. She is currently working as Professor in in the Department of Computer Science and Applications, The Gandhigram Rural Institute – Deemed to be University, India. She has published more than 22 research papers in reputed international journals including SCI and 31 research papers in edited volumes. Her main research work focuses on Medical Image Analysis, Image Restoration, Image Enhancement, Image Segmentation, Content – Based Image Retrieval. She has 24 years of teaching experience and 15 years of Research Experience.

