A New Approach to Local Plastic Surgery Face Recognition Using Near Sets

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***Abstract*— Pose, illumination and expressions are some of the problems recognized and studied in the domain of face recognition. The problems faced in recognition due to plastic surgery still remains a lesser explored topic in this domain. Our objective is to develop a classifier for facial images that have previously undergone some feature modifications through plastic surgery. We propose an approach based on near set theory for comparing pre and post surgical facial images. Our work concerns only geometrically obtained feature values and their approximation using near sets. Near set theory provides a method to establish resemblance between objects contained in a disjoint set, that is, it provides a formal basis for observational comparison and classification of the objects.**

***Keywords*— Plastic surgery, near sets, geometrical features.**

I. INTRODUCTION

In the area of face recognition, several approaches have been proposed to address the challenges of illumination, pose, expression, aging and disguise. However plastic surgery based face recognition is still a lesser explored area. Thus the use of face recognition for surgical faces introduces the new challenge for designing future face recognition system. [1].

Plastic surgery is a sophisticated operational technique that is used across the world for improving the facial appearance. For instance to remove acne scars, to become white, to remove dark circles and many more. Plastic surgery can be broadly classified in two different categories such as global plastic surgery and local plastic surgery. Global surgery changes the complete facial structure whereas in local plastic surgery certain parts of faces are changed. To recognize a face after plastic surgery might lead to rejection of genuine users or acceptance of impostors. To this challenge yet much literature is not available. Very few researchers till now have contributed in this field. In paper [1] authors have shown the comparative study of different face recognition algorithm for plastic surgery. Based on the experimentation carried out by authors it has been concluded that face recognition algorithms such as PCA, FDA, GF, LLA, LBP and GNN have shown recognition rate not more than 40% for local plastic surgery. Moreover, for global surgery it was merely up to 10%. Among all the algorithms, geometrical feature based approach has proven to a great extent comparatively for local plastic surgery

In this paper we take an opportunity to propose a new approach to plastic surgery based face recognition using near set theory [4, 5]. Our aim is to develop a classifier for facial images that have previously undergone some feature modifications through local plastic surgery. We propose an approach based on near set theory for comparing pre and post surgical facial images. Near set theory introduced by J.F.Peter, recognize objects by comparing the object's descriptions. Our work concerns only geometrically obtained feature values and their approximation using near sets. Once the features will be extracted a feature database will be formed. Using this feature values near set theory provides a method to establish resemblance between objects contained in a disjoint set, that is it provides a formal basis for observational comparison and classification of the objects. This approach will improve the performance in terms as comparison will be made between the objects in near sets only.

The paper is organized in following sections. Section1: gives a brief introduction; Section 2: overview on plastic surgery and near sets; Section 3: will focus on proposed approach followed by conclusion and future scope.

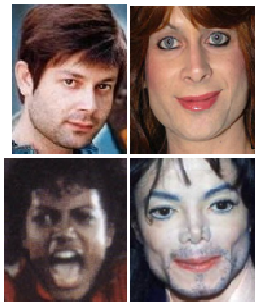
II. BASIC TERMINOLOGY

In this section we have given a comprehensive overview of some basic terminology on plastic surgery and near sets.

A. PLASTIC SURGERY

Plastic surgery being a new challenge to face recognition is a specialized area of surgery. It specifically involves the reconstruction of specific areas of the body that may have been damaged due to birth defects, trauma cases, burns or even disease. Plastic surgery also includes cosmetic surgery, which involves changing the appearance of a person through operations such as facelifts, rhinoplasty, liposuction and breast augmentations/implant. With respect to face recognition plastic surgery can be broadly classified in two categories.

1) Global Plastic Surgery: In this category, surgery changes the complete facial structure. The appearance, texture and facial features of an individual are reconstructed in such a way that the surgical faces are not same as the original one. This surgery can be boon to burned or severely injured patients. But there are people who have used it for changing their looks completely. For example, Michael Jackson from Hollywood and Bobby Darling from bollywood to name a few.



Before After

Fig 1 Examples of global plastic surgery. [2]

After global surgery, appearance of many people changes to such an extent that it becomes very difficult to recognize even with naked eye. The difference between pre and post surgery faces of the same individual are very large; in other word facial feature and texture gets drastically altered after surgery and hence this approach do not yield good result[1] . This makes face recognition under global plastic surgery an ineffective task.

2) Local plastic surgery: Local plastic surgery is used to correct certain defects, anomalies or to improve skin texture. It can be used to correct several features on face such as teeth structure, jaw, nose structure, chin, cheek, forehead and eyelids. Local plastic surgery will lead to some amount of changes in the geometric distance between these facial features. Such changes may lead to the verification accuracy. Few names of celebrities who have undergone local plastic surgery on different parts of faces are listed in figure 2.

B. DATABASE

Plastic surgery database with 1012 facial images of 506 different individuals has been recently uploaded [3]. It has been created by different surgeons across the world. This database consists of pre surgical faces and post surgical faces in frontal pose.

C. NEAR SETS: AN OVERVIEW

The idea of near set was first presented by James Peter in the year of 2006. In near set theory, each object is described by a list of feature values. The word feature corresponds to an observable property of physical objects in our environment. For instance, for a feature such as nose on a human face, nose length or nose width will be the feature values. Comparing this list of feature values, similarity between the objects can be determined and can be grouped together in a set, called as near set. Thus near set theory provides a formal basis for the observation, comparison and recognition or classification of objects. The nearness of objects can be approximated using near sets. Approximation can be considered in the context of information granules (neighborhoods). Any approximation space is a tuple given in equation (1)

$$AS = (U, \mathcal{F}, \nu) \qquad (1)$$

where $\mathcal{F}$ is a covering of finite universe of object U, i.e., $\bigcup \mathcal{F} = U$ and

$$v: P(U) \times P(U) \rightarrow [0,1]$$

maps a pair of set to a number in $[0,1]$ representing the degree of overlap between the sets and $P(U)$ is a power set of U [4].

For a given approximation space $AS = (U, \mathcal{F}, v)$, we define a binary link relations $link_{\mathcal{F}} \subseteq U$

For any $X \subseteq U$, $\mathcal{F}$-lower approximation of X, and $\mathcal{F}$-upper approximation of X is defined respectively by (2) and (3).

$$\mathcal{F}_* X = \bigcup\{Y \in \mathcal{F} \mid v(X,Y) = 1\}, \quad (2)$$

$$\mathcal{F}^* X = \bigcup\{Y \in \mathcal{F} \mid v(X,Y) > 0\}. \quad (3)$$

The *lower approximation* of a set X is the set of all objects, which can be for *certain* classified as X.

The *upper approximation* of a set X is the set of all objects which can be *possibly* classified as X.

The lower and upper approximations of a set lead naturally to the notion of a boundary region of an approximation.

Let $BND_{\mathcal{F}} X$ denote the boundary region of an approximation defined as in [4].

Thus, the lower- and upper- approximations result in an increase in the number of neighborhoods used to assess the nearness of a classification.

III. PROPOSED APPROACH

The problem considered in this paper is how to approximate surgical faces that are qualitatively alike in one or more respects. The term qualitatively alike/near is used here to mean closeness of description of distinctive characteristic of faces. The term near applied to surgical faces or sets of surgical faces means closely related. Means the description of surgical faces partially or completely matches the description of earlier non surgical faces. The extent that description match is determine by considering the correspondence between measurement associate with the feature of objects that are in some sense near to each other. This near set will surely reduce the search space and in forth enhance the performance in terms of accuracy and speed. Near set has been already used for frontal face recognition [6]. This paper proposes a new approach to plastic surgery based face recognition using near set theory.

The overall approach as shown in figure 3 is basically classified into two modules; the module I defines the image processing technique such as feature extraction where as module II defines the procedure for finding near sets of objects under consideration, which helps in classification. The train set contains the pre surgical images and test set contains the post surgical images.

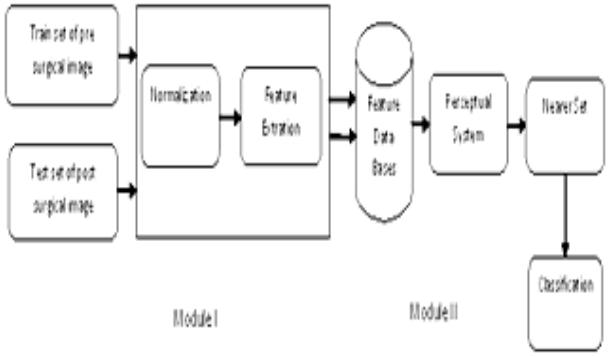


Fig.3 The overall architecture of proposed work

From the Table I we concluded that no well known algorithm have proved their accuracy to a great extent for plastic surgery. Moreover, one more aspect to be noted is that Geometric Features (GF), Local Binary Pattern (LBP) and GNN have proven their efficiency more than 30%.

Table I. Performance of face recognition algorithms on local and global plastic surgery. Verification accuracy is computed at 0.1% false accept rate [1].

Procedure	PCA	FDA	GF	LFA	LBP	GNN
Local Surgery	22.2%	22.9%	32.0%	24.4%	34.5%	38.8%
Global Surgery	2.8%	8.2%	7.0%	7.8%	9.5%	10.6%

Based on the above conclusion and facts, it can be said that recognizing someone based on facial geometry makes human recognition a more automated process. Suppose an image which is a pre plastic surgery face in our case can be represented as $\mathcal{F} \in O$, where O is a non empty finite set of objects/faces and $\mathcal{F}$ can be defined

as a set of features $\{f_1,f_2,f_3,.....f_n\} \subseteq A$, where $1 \leq n \leq |A|$.

We extracted the geometrical features using the algorithm in [7, 8]. In our approach, we explore three different types of surgery with nine facial features like nose length, nose width and distance between some fiducial points etc as listed in Table II. Among these nine features we initially concentrated on three facial features such as Nose Length (NL), Nose Width (NW) and Distance between Eye Balls (EBD) for calculating the nearness measure.

Table II. Feature names

Types of surgery	Features Name	Symbolic Representation
Rhinoplasty (Nose surgery)	Nose_length	NL
	Nose_Width	NW
Blepharoplasty (Eyelid surgery)	Eye_ball_dist	EBD
	Eye_lip_dist	ELD
Lip Augmentation	Eye_nose_dist	END
	Nose_lip_dist	NLD
	Angle_EL	AEL
	Angle_EN	AEN
	Angle_NL	ANL

Based on the above features the plastic surgery facial decision system is shown in Table III with eight facial samples. Suppose in the Table III, x_1 to x_4 are the pre surgical faces and x_5 to x_8 are post surgical faces. Suppose, x_1 is a pre surgical face of one subject and x_8 is the post surgical face of the same subject.

Table III. Sample decision table

Object	NL	NW	DEB	d
x_1	14	11	06	0
x_2	11	09	03	1
x_3	13	11	02	1
x_4	12	10	04	1
x_5	12	10	06	0
x_6	14	12	03	1
x_7	11	09	04	1
x_8	14	11	02	0

As a first step neighborhood of feature NL denoted as $N_{NL}(B)$ will be calculated.

Based on the notation used in [4, 5],

Let $D = \{x \in Object \mid d(x) = 1\}$

$=\{x_2, x_3, x_4, x_6, x_7\}$,

B= {NL, NW, DEB}, where B is the set of features.

The following neighborhoods are in $N_{NL}(B)$

$B_{NL}(x_1) = link_{NL}[x_1] = \{x_1, x_6, x_8\}$

$B_{NL}(x_2) = link_{NL}[x_2] = \{x_2, x_7\}$

$B_{NL}(x_3) = link_{NL}[x_3] = \{x_3\}$

$B_{NL}(x_4) = link_{NL}[x_4] = \{x_4, x_5\}$

$B_{NW}(x_1) = link_{NW}[x_1] = \{x_1, x_3, x_8\}$

$B_{NW}(x_2) = link_{NW}[x_2] = \{x_2, x_7\}$

$B_{NW}(x_4) = link_{NW}[x_4] = \{x_4, x_5\}$

$B_{NW}(x_6) = link_{NW}[x_6] = \{x_6\}$

$B_{EBD}(x_1) = link_{EBD}[x_1] = \{x_1, x_8\}$

$B_{EBD}(x_2) = link_{EBD}[x_2] = \{x_2, x_6\}$

$B_{EBD}(x_3) = link_{EBD}[x_3] = \{x_3, x_8\}$

$B_{EBD}(x_4) = link_{EBD}[x_4] = \{x_4, x_7\}$

The Upper approximation based on the features, denoted by

$$(N_{NL}(B))^*(D) = B_{NL(x1)} \cup B_{NL(x2)} \cup B_{NL(x3)} \cup B_{NL(x4)} \cup B_{NW(x1)} \cup B_{NW(x2)} \cup B_{NW(x4)} \cup B_{NW(x6)} \cup B_{DEB(x2)} \cup B_{DEB(x3)} \cup B_{DEB(x4)}$$

$$= \{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8\}$$

Next, the lower approximation based on the features, denoted by

$$(N_{NL}(B))_*(D) = B_{NL}(x_2) \cup B_{NL}(x_3) \cup B_{NW}(x_2) \cup B_{NW}(x_6) \cup B_{EBD}(x_2) \cup B_{EBD}(x_4)$$

$$= \{x_2, x_3, x_4, x_6, x_7\}$$

Finally, the boundary region can be obtained as,

$$BND N_{NL}(B)(D) = (N_{NL}(B))^*(D) / (N_{NL}(B))_*(D) = \{x_1, x_5, x_8\}$$

This set will be termed as a "near set" relative to neighbourhood of nose length $N_{NL}(B)$. This means that objects x_1, x_5, x_8 can certainly be classified. The extent that descriptions of these objects match is determined by considering the correspondence between measurements associated with features of objects.

IV. CONCLUSION

This paper presents an approach to find the nearness between the pre plastic surgical face to the post plastic surgical face using the concept of near set. In this paper we reviewed the different face recognition algorithms and their application

to plastic surgery face recognition. For our work we extracted three features for nearness measure. Using those features we have shown the process of calculation of near set which will assist in classification.

Future work will consist of experimentation and more concrete results.

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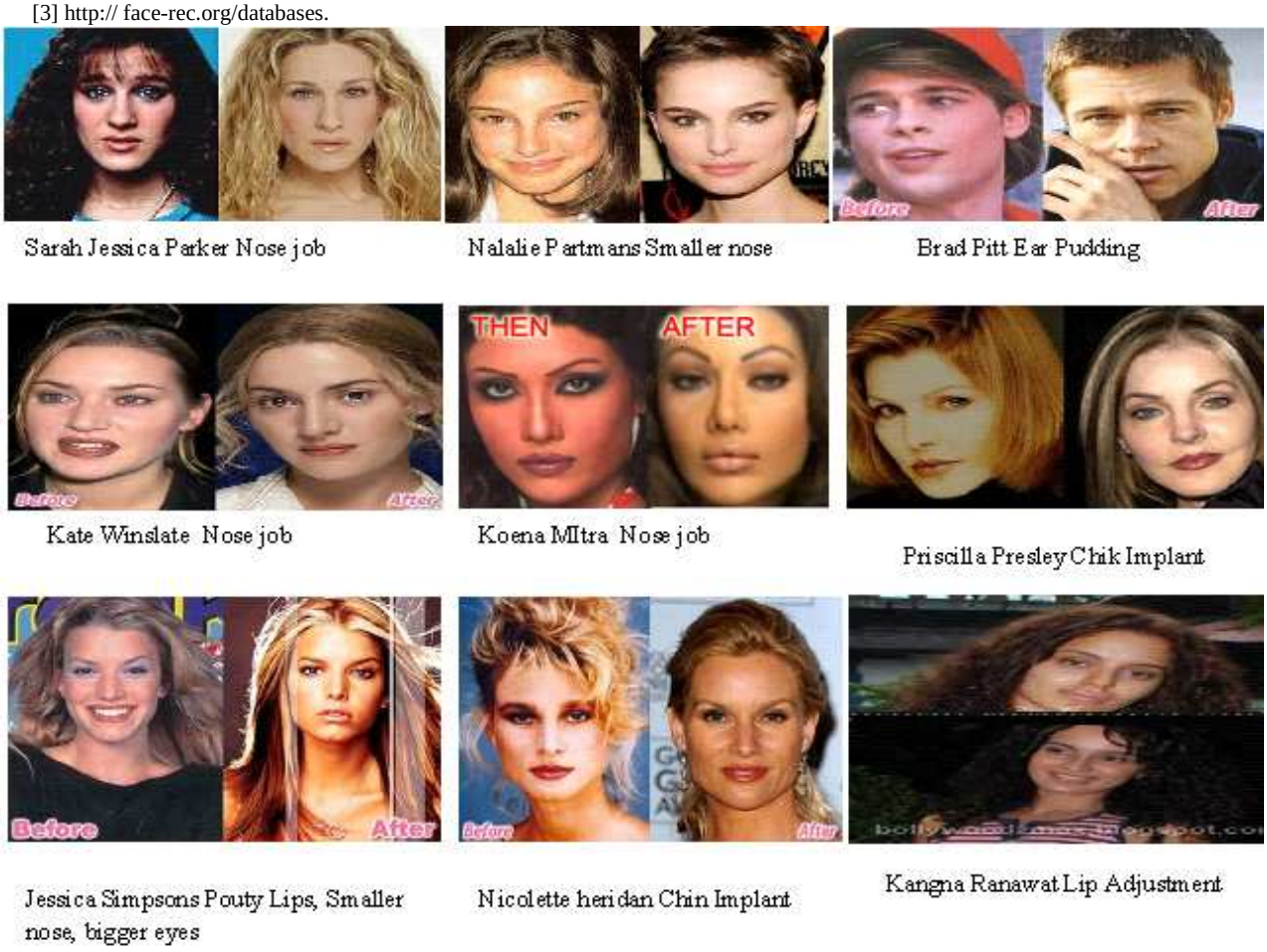

Fig 2 Examples of local plastic surgery on different parts of faces [2].