

A Comparative Study between PCA and SOM for Plastic Surgery Face Recognition

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Abstract: Now a day, people are using various advanced technologies to solve their real life problem; affordability and the speed with which these procedures can be performed are one of the reasons. Plastic surgery is an example of one of the advanced technologies, which is used to transform a person's physical feature or rather appearance of various facial features (some time non-face features). In this paper we will explain how plastic surgery can affect the process of face recognition [1] [2] [3] and also describe two very popular face recognition techniques, PCA (Principal Component Analysis) and SOM (Self Organizing Map) for plastic surgery face recognition. We will also compare their performance. In case of a face recognition technique, we use database of face images where we can store face images of different expression, pose for the same person. Now for a given input image with different expression and pose the above two approaches PCA (Appearance based method) and SOM (Pattern recognition based) will work properly. Whereas, in case of plastic surgery face recognition, they may not give satisfactory result, but between these two techniques SOM is better than PCA and perform more accurately.

Keywords: Plastic surgery, face recognition, PCA, SOM and Feature Extraction

1. Introduction

Whenever we are recognizing face, we need to consider several challenges like pose, expression, illumination, occlusion and aging [5] – [13]. Apart from these challenges still there remains a less explored topic, which is plastic surgery. The concept of plastic surgery is becoming popular in the modern society; so we need to consider this new challenge as it often affect the face recognition process after surgery.

In this paper we are mainly focusing on the facial feature transformation process like lip, nose, eyes etc. Before going into the details I would like to give a brief overview of plastic surgery. The method of plastic surgery can be applied in two ways, one is to reconstruct some facial feature anomalies caused by some accident such as scars, defects, and another is cosmetic surgery used to improve the appearance of some facial features such as nose surgery, lip surgery, face lifting surgery. The process of plastic surgery can be applied to other body parts as well, but in this paper we are considering only the facial part because our main concern is to recognize face. However, even after decades of research, face is still an active topic because of the variability nature found on the face due to illumination. Pose, expression, occlusion and aging.

According to the recent statistics given by the American Society for Aesthetic Plastic Surgery for years 2008[4]:

- Every year, millions of American individuals undergo plastic surgery. In 2008 alone, more than one million facial plastic surgeries were performed.
- Currently percentage of women and men is 23 and 18 respectively, which is more than the percentage studied in last 5 years.
- The percentage of women individuals is higher than men. It is expected that in future 40% of women and 18% of men will go for plastic surgery.

In the following table we give age wise percentage of people undergo for plastic surgery:

Table 1: Statistical records of various age groups, who undergo plastic surgery process

| Range of age | Percentage of people undergo for plastic surgery |
|----------------|--|
| 0 to 18 years | 2% |
| 19 to 34 years | 22% |
| 35 to 50 years | 45% |
| 51 to 64 | 26% |
| 65 to above | 6% |

From various statistical reports we can see that, the popularity of plastic surgery among all age group and gender. Though the process of plastic surgery is beneficial to correct various facial impairment, but at the same time this can be dangerous also when any individual apply plastic surgery to hide their identity related to some crime or anti social activity.

So, if our face recognition process fails to meet f this new challenge, we will never identify those criminals or terrorist who are freely move around the world without any fear. Hence, it is our duty to develop face recognition, which consider plastic surgery and give a more save nation.

2. Types of Plastic Surgery

It is a process by which one can transform some facial features to achieve better appearance or to hide the identity. Now the transformation process can be applied on the entire face or some specific feature like eye, nose, mouth etc. of the face.

So primarily, we can classify the plastic surgery process into two distinct categories.

Local Plastic Surgery (LPS)

In this surgery process, an individual undergoes local surgery to improve the appearance of that particular feature or to correct the defects caused by some accident. Not only this, there are some other reasons one can do plastic surgery like to permanently remove some spots or by birth anomalies to hide their identity.

Whenever we reconstruct any facial feature, the post surgery face image looks different from the pre surgery face image. Hence, face recognition process may fails to recognize a face, which undergoes a plastic surgery process.

Global Plastic Surgery (GPS)

In this type of plastic surgery, an individual can reconstruct his or her whole facial structure such as face-lift to improve the aging related anomalies. Also, they can be used to cure some fatal accident. Here the resultant face after surgery may not looks like the original face image. The criminals can also misuse this type of surgery who wants to remain elusive from law enforcement and pose a great threat to the society despite all the security mechanisms in-place.

There are several types of surgeries which belong to either global plastic surgery or local Plastic surgery; we will explain it as follows:

1) Blepharoplasty (Eyelid Surgery): Eyelid is the thin skin that covers and protects our eyes. Blepharoplasty may be used to reshape both upper as well as lower eyelid in cases where excessive growth of skin tissues on the eyelid causes vision problem.



Figure 1: Example of Blepharoplasty (Eyelid Surgery)

2) Brow Lift: It is generally recommended for older patients who want to reshape their flagging eyebrows caused by aging.



Figure 2: Example of Brow Lift Surgery

3) Cheek Implant: It is used to improve the facial appearance and it can be divided into two classes, malar and sub-malar augmentation. In malar augmentation a solid implant is fitted over the cheek bone whereas in sub-malar augmentation implants are fitted in the middle of the cheeks where the person has a recessed (hollow) look.



Figure 3: Example of Cheek Implant Surgery

4) Forehead Surgery: In this type of surgery, we can remove the thick wrinkles from the forehead, which give a younger look.



Figure 4: Example of Forehead Surgery

5) Genioplasty/Mentoplasty (chin surgery): It is mostly used to reshape the chin including smooth rounding of the chin, correcting bone damages, and reducing/augmenting chin bones.



Figure 5: Example of Genioplasty/Mentoplasty (Chin Surgery)

6) Liposhaving (facial sculpturing): Here we can remove the excess fat from the skin surface especially in chin and jaw regions.



Figure 6: Example of Liposaving (Facial Sculpturing)

7) Lip augmentation: By using this surgery we can reshape or enhance the beauty of the lips with injectable filler substances.



Figure 7: Example of Lip Augmentation

8) Otoplasty (Ear Surgery): In this method we can change the size, shape and orientation of the ears.



Figure 8: Example of Otoplasty (Ear Surgery)

9) Rhinoplasty (Nose Surgery): It is used to reconstruct nose structure either to improve the appearance or to cure some bone damages caused by fatal accidents. Breathing problem can also be cured by reshaping (straightening or narrowing) the nasal structure.



Figure 9: Example of Rhinoplasty (Nose Surgery)

10) Craniofacial: This type of surgery is employed to treat by-birth anomalies such as Cleft lip and palate (a gap

in the roof of mouth), microtia (small outer ear) and other congenital defects of jaws and bones.



Figure 10: Example of Craniofacial

11) Dermabrasion: In this type of surgery we can improve the skin surface by removing all the scars, sun burns, dark irregular patches that grow over the face skin and mole removal.



Figure 11: Example of Dermabrasion

12) Rhytidectomy (Face Lift): Face lift surgery can also be employed to fight aging and get a younger look by tightening the face skin and thus minimizing wrinkles.



Figure 12: Example of Rhytidectomy (Face Lift)

13) Skin resurfacing (skin peeling): There are different techniques such as laser resurfacing and chemical peel to treat wrinkles, stretch marks, acne and other skin damages caused due to aging and sun burn. Skin resurfacing results in smooth skin with ameliorated texture.



Figure 13: Example of Skin resurfacing (Skin Peeling)

14) Non-surgical procedures: There are several non-surgical procedures for skin resurfacing, wrinkle removal, and acne/scars removal. For example, laser resurfacing for acne scars, photodynamic therapy or photo-rejuvenation treatments, and BOTOX or filler injections.

Table 2: Classification of various plastic surgery methods

| Type | Plastic Surgery Procedure |
|--------|---------------------------|
| Local | Blepharoplasty |
| | Brow lift |
| | Craniofacial |
| | Dermabrasion |
| | Forehead surgery |
| | Genioplasty |
| | Liposhaving |
| | Lip augmentation |
| | Otoplasty |
| | Rhinoplasty |
| Global | Rhytidectomy |
| | Skin resurfacing |

PCA (Principal Component Analysis)

PCA [14] is a very popular appearance based approach for face recognition based on the concept of Eigenface. As PCA analyses only the principal components, so we can achieve dimensionality reduction. On the other hand it yields 59.3% accuracy in case of non-surgery database, but the performance will decrease by 30% when we compare a post-surgery face image against a pre-surgery face image.

SOM Classifier

Self Organizing Map (SOM) [15] is a well-known artificial neural network, which uses unsupervised learning process. Here the learning process is dependent on the input data, which is known as unlabeled data and is independent of the desired output data. The success rate of SOM network is dependent on the number of training data we are using, higher training data means higher success rate.

SOM can also be termed as topology preserving map. There is a competition among the neurons to be activated and only one neuron that wins the competition is fired and is called the "winner". Kohonen rule is used to learn the winner neuron and neurons within a certain neighborhood of the winning neuron. This rule allows the weight of neuron to learn an input vector so this makes it perfect for

recognition. Hence in this system SOM is used as classifier.

For the same training set of face images, these two approaches perform in different way. In case of PCA, if the post-surgery face image cannot be recognized by the help of pre-surgery face images. Whereas in the SOM classifier, they can be recognized correctly using large number of epochs.

3. Experimental Results

Here we will show how the performance of PCA differs from the performance of SOM. At first we will show the results produced by PCA. PCA is a principal component based approach, which uses the concept of eigenface for face recognition. In this traditional face recognition process we can correctly recognize those faces, which have the same appearance. Hence in case of plastic surgery face recognition, if the post surgery face differs from the pre surgery face it may happen that the PCA will not recognize them properly. The following diagram is a screen shot of a PCA based face recognition system, where the left-hand side image is an input image and the right-hand side image is the recognized face image. As there is no such image with same appearance is stored in the database, the algorithm will show an error message that it is an "unknown image".

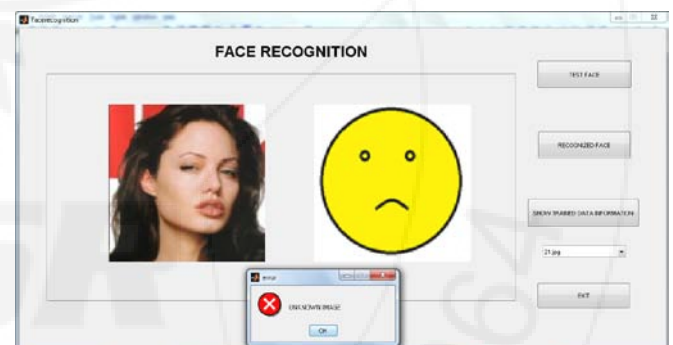
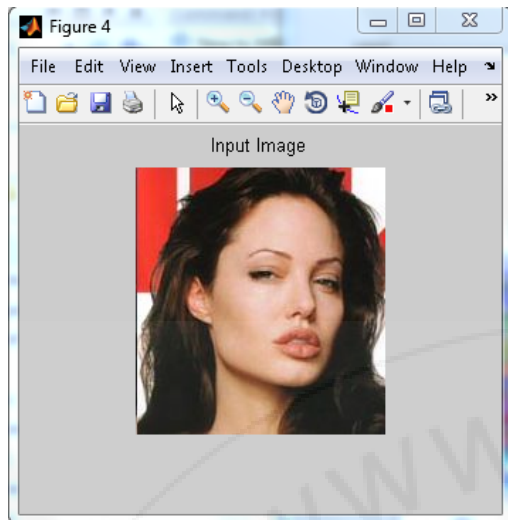
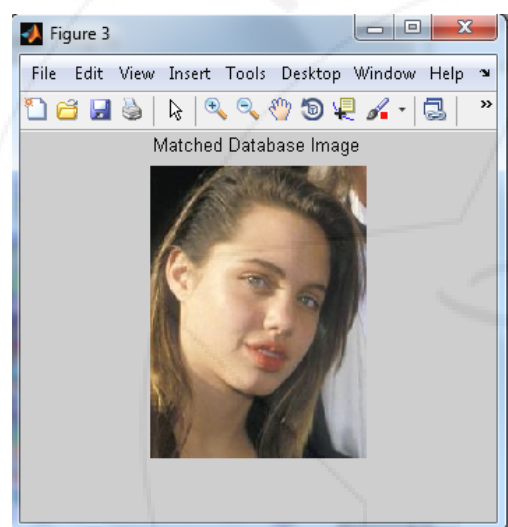


Figure 14: Screen shot of a PCA based Face Recognition System

On the other hand SOM is an unsupervised ANN based approach, which can be effectively used in pattern recognition problem such as face recognition. The main concept behind this face recognition process is that, we consider two classes or patterns like 'known' and 'unknown'. When an input face image is given to the system, the system will look for a face image, which will best matches. Hence for plastic surgery face recognition, SOM does not require that both the input image and the stored database image must have the same appearance. In the following diagram we show how SOM performs. Here the left-hand side image is the input image and the right-hand side image is the database image, which will best match the input image. We see that though they are different from each other, they are correctly recognized. Other two diagrams show the weight vectors (Fig. 15), which is used to measure the Euclidean distance (Fig. 16) between two images.



(a)



(b)

Figure 15: (a) Original image, (b) Matched database image recognized by SOM

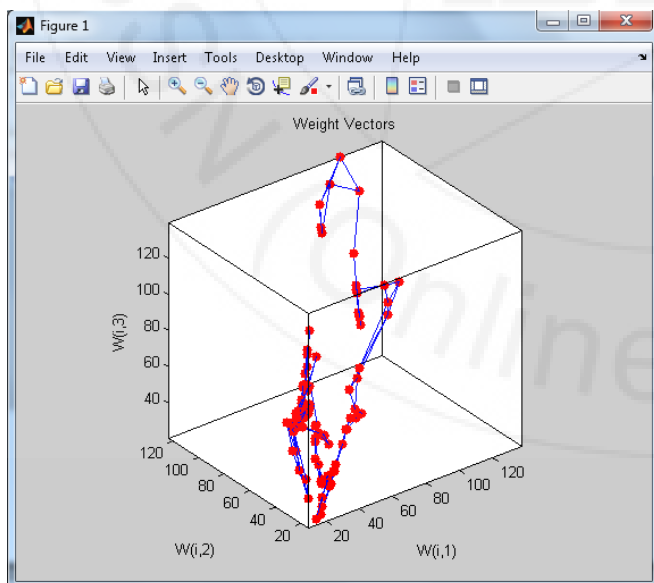


Figure 15: Weight Vectors of SOM

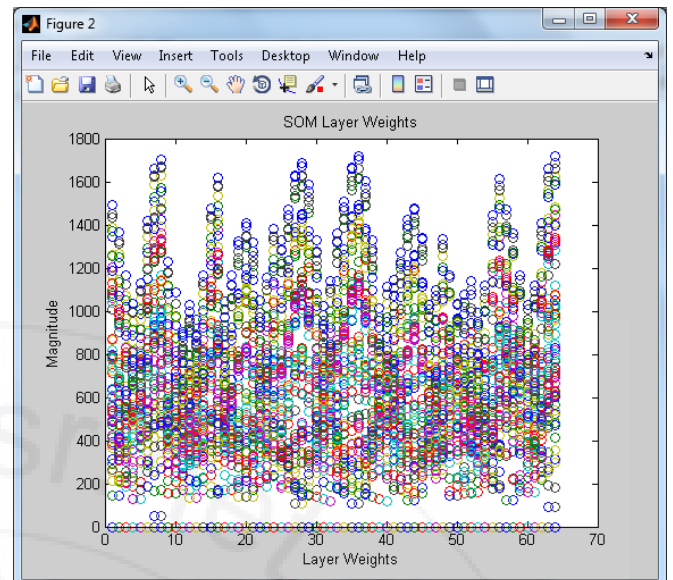


Figure 16: Euclidean Distance Weights

4. Conclusion

In this paper we have discussed about the concept of plastic surgery along with the type of various plastic surgery approaches. Also, we explain how the concept of plastic surgery approach is considered as a great challenge in the recent advanced face recognition technique. There are many different types of face recognition techniques, which is used to consider the new challenges, but in this paper we have discussed only two of them, which are PCA and SOM. In future we can develop new method by combining these two techniques.

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