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Surgically Altered Face Image Detection Using Genetic Algorithm – A Comprehensive Study

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Abstract—In recent years, plastic surgery has become popular worldwide. People take facial plastic surgery to correct feature defects or improve attractiveness and confidence. It has been observed that many face recognition algorithms fail to recognize faces after plastic surgery, which thus poses a new challenge to automatic face recognition. Increasing popularity of plastic surgery and its effect on automatic face recognition has attracted attention from the research community. Apart from cosmetic reasons, plastic surgery procedures are beneficial for patients suffering from several kinds of disorders caused due to excessive structural growth of facial features or skin tissues. These procedures amend the facial features and skin texture thereby providing a makeover in the appearance of face. This survey presents five papers that describe various methods used for surgically altered face image detection. Also discussed about the advantages and disadvantages of the papers.

Keywords—Face recognition, Genetic Algorithm, Skin texture, Sparse Representation, Granulation

I. INTRODUCTION

A facial recognition system is a computer application for automatically verifying or identifying a person from a digital image or a video frame from a video source. It isoften used in security systems. There are many difficulties during face recognition such as changes in illumination, head rotation, age-related changes and others. However, due to advances in technology, there are new emerging challenges for which the performance of face recognition systems degrades and plastic/cosmetic surgery is one of them.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.

The nonlinear variations introduced by plastic surgery remain difficult to be modelled by existing face recognition systems. Transmuting facial geometry and texture increases the intraclass variability between the pre-surgery and post-surgery images of the same individual. Therefore, matching post-surgery images with pre-surgery images becomes an arduous task for automatic face recognition algorithms. The feature extraction methods used in the research paper [1] has strong robustness and stability, which can be applied in many bad conditions to achieve high recognition rate. However, it also contains redundant information, which makes the

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calculation amount of following matching increase.Theobjective of this research is to analyse various methods for surgically altered face image recognition. And analyses the advantages and disadvantages of those methods in various conditions. Also find better method for feature extraction to enhance the performance of feature extraction methods used in [1].

II. Related Works

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. 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. These procedures amend the facial features and skin texture thereby providing a makeover in the appearance of face.

In the presence of variations such as pose, expression, illumination, and disguise, it is observed that local facial regions are more resilient and can therefore be used for efficient face. Most of the existing face recognition algorithms have predominantly focused on mitigating the effects of pose, illumination and expression, while the challenges of face recognition due to aging and disguise still remains. The proposed algorithm yields high identification accuracy as compared to existing algorithms and a commercial face recognition system.Himanshu*et al.* [1] proposed method, presents a multiobjective evolutionary granular computing based algorithm for recognizing faces altered due to plastic surgery procedures.However, the nonlinear variations introduced by plastic surgery remain difficult to be modelled by existing face recognition systems. The proposed algorithm starts with generating non-disjoint face granules where each granule represents different information at different size and resolution. Further, two feature extractors, namely Extended Uniform Circular Local Binary Pattern (EUCLBP) and Scale Invariant Feature Transform (SIFT), are used for extracting discriminating information from face granules. Finally, different responses are unified in an evolutionary manner using a multiobjective genetic approach for improved performance. The proposed algorithm yields high identification accuracy as compared to existing algorithms and a commercial face recognition system.

The system includes four main components:

- Face Image Granulation.
- Facial Feature Extraction.
- Multiobjective Evolutionary Algorithm For Feature Extractor and Weight Optimization.
- Combining Face Granules with Evolutionary Learning for recognition.

Generally face recognition algorithms either use facial information in a holistic way or extract features and process them in parts. On the other hand, cognitive neuroscientists have observed that humans solve problem using perception and knowledge represented at different levels of information granularity. Face granules are generated pertaining to three different levels of granularity. The first level of granularity provides global information at multiple levels of resolution.This is analogous to a human mind processing

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holistic informationfor face recognition at varying resolutions. At the second level of granularity, different inner and outer facial information are extracted. Local facial features play an important role in face recognition; therefore, at the third level of granularity features from the local facial fragments are extracted. Each face granule is used to extract facial features. In this research, Extended Uniform Circular Local Binary Patterns and Scale invariant feature vector are used for facial feature extraction because these are fast, discriminating, rotation invariant and robust to changes in gray level intensities due to illumination.The problem of finding optimal feature extractor and weight for each granule involves searching very large space and finding several suboptimal solutions. Genetic algorithms (GA) are well proven in searching very large spaces to quickly converge to the near optimal solution. Therefore, a multiobjective genetic algorithm is proposed to incorporate feature selection and weight optimization for each face granule.

Plastic surgery is now established as new and challenging covariate of face recognition alongsideaging and disguise. Singh *et al.* [2] analyzed several types oflocal and global plastic surgery procedures and their effect on different face recognition algorithms.Advancement and affordability is leading to the popularity of plastic surgery procedures. Facial plastic surgery can be reconstructive to correct facial feature anomalies or cosmetic to improve the appearance. Both corrective as well as cosmetic surgeries alter the original facial information to a large extent thereby posing a great challenge for face recognition algorithms. The contribution of this research is 1) preparing a face database of 900 individuals for plastic surgery, and 2) providing an analytical and experimental underpinning of the effect of plastic surgery on face recognition algorithms.

The results on the plastic surgery database suggest that it is an arduous research challenge and the current state-of-art face recognition algorithms areunable to provide acceptable levels of identification performance. Therefore, it is imperative to initiate a research effort so that future face recognition systems will be able to address this important problem. The main aim of this paper is to add a new dimension to face recognition by discussing this challenge and systematically evaluating the performance of existing face recognition algorithmson a database that contains face images before and after surgery.In plastic surgery, facial features are reconstructed eitherglobally or locally. Therefore, in general, plastic surgery can be classified into two distinct categories.

A. Disease correcting local plastic surgery (Local surgery):

This is a kind of surgery in which an individual undergoes local plastic surgery for correcting defects, anomalies, or improving skin texture. Local plastic surgery techniques can be applied for possibly three different purposes: 1) to correct by-birth anomalies, 2) to correct the defects that are result of some accident, and 3) to correct the anomalies that have developed over the years. This type of local surgery leads to varying amount of changes in the geometric distance between facial features but the overall texture and appearance may look similar to the original face.As facial plastic surgery procedures become more and more prevalent, face recognition systems will be challenged to recognize individuals after plastic surgery has been performed. This research investigates different aspects related to plastic surgery and face recognition. Specifically, a plastic surgery face database is prepared and the performance of six face recognition algorithms is evaluated. Plastic surgery has been an unexplored area in the face recognition domain and it poses

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ethical, social, and engineering challenges. Because it is related to the medical history of an individual which is secure under law, invasion of privacy is an important constraint in this research. In some cases, facial plastic surgery is performed due to medical reasons and sometimes it is the individual's choice (i.e., cosmetic/aesthetic surgery). In both cases, even though individuals undergoing facial plastic surgery cannot be bound under any legal and social obligations, it is ethical responsibility of the person to get the face image/template updated in the database.

B. Plastic surgery for reconstructing complete facial structure (Global surgery):

Apart from local surgery, plastic surgery can be performed to completely change the facial structure which is known as a full face lift. Global plastic surgery is recommended for cases where functional damage has to be cured such as patients with fatal burns. Note that global plastic surgery is primarily aimed at reconstructing the features to cure some functional damage rather than to improve the aesthetics. In this type of surgery, the appearance, texture, and facial features of an individual are reconstructed to resemble the normal human face but are usually not the same as the original face. The study shows that appearance, feature, and texture-based algorithms are unable to effectively mitigate the variations caused by plastic surgery procedures. Based on the results. It has to be noticed that the results of this work would inspire further research in this important area. One possible future research direction would be to use thermal-infrared imagery and compute the thermal differences between pre-surgery and post-surgery images. However, such an approach first requires creating a large face database that contains pre-operative and post-operative thermal infrared images.

Heisele*et al.*[3] proposed a component based face recognition approach using different facial components to provide robustness to pose.This work presents a novel approach to pose and illumination invariant face recognition that combines two recent advances in the computer vision field: component-based recognition and 3D morphable models. First, a 3D morphable model is used to generate 3D face models from three input images from each person in the training database. The 3D models are rendered under varying pose and illumination conditions to build a large set of synthetic images. These images are then used to train a component-based face recognition system. In this paper, the system is further developed through the addition of a 3D morphable face model to the training stage of the classier. Based on only three images of a person's face, the morphable model allows the computation of a 3D face model using an analysis by synthesis method. Once the 3D face models of all the subjects in the training database are computed, Then generate arbitrary synthetic face images under varying pose and illumination to train the component-based recognition system.

The component-based face detector was applied to each synthetic face image in the training set to detect the components and thereby the facial region. Histogram equalization was then preformed on the bounding box around the components. The gray pixel values of each component were then taken from the histogram equalized image and combined into a single feature vector. Feature vectors were constructed for each person, and corresponding classifiers were trained. The experiments shows that, the component-based system consistently outperformed global face recognition systems in which classification was based on the whole face pattern. A major drawback of the system was the

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need of a large number of training images taken from different viewpoints and under different lighting conditions. These images are often unavailable in real-world applications.

Advantages:

- Component-based recognition is more robust against pose changes.
- Component-based recognition only used face parts as input features for the classifier while the input features to the global system occasionally contained distracting background parts.

Disadvantages:

- Component based system less performed for global face recognition system.
- Requires large no. of training images taken from different viewpoints and under different lightening condition.
- Unavailable for real-world applications.

Himanshu et al. proposed a new method for surgically altered face recognition [4]. This paper presents an evolutionary granular approach for matching face images that have been altered by plastic surgery procedures. The algorithm extracts discriminating information from non-disjoint face granules obtained at different levels of granularity. At the first level of granularity, both pre and post-surgery face images are processed by Gaussian and Laplacian operators to obtain face granules at varying resolutions. The second level of granularity divides face image into horizontal and vertical face granules of varying size and information content. At the third level of granularity, face image is tessellated into non-overlapping local facial regions.

An evolutionary approach is proposed using genetic algorithm to simultaneously optimize the selection of feature extractor for each face granule along with finding optimal weights corresponding to each face granule for matching. The algorithm starts with generating non-disjoint face granules with each face granule having different information at varying size and resolution. Further, two feature extractors, namely Uniform Circular Local Binary Pattern (UCLBP) and Speeded Up Robust Features (SURF) are used for extracting discriminating information from face granules. Finally, different responses are unified in an evolutionary manner using genetic algorithm for improved performance. Experiments are performed on plastic surgery and non-plastic surgery face databases and results show an improvement of at least 15% over existing algorithms. The proposed granulation technique is used to generate 40 non-disjoint face granules from a face image of size 196 X 224. Here, would like to mention that the technique is based on fixed structure and no local feature based approach is used for generating granules from frontal face images.

Advantage:

- Two feature extractors (SURF and UCLBP) that help in encoding discriminating information conforming to the content of each face granule.

Recently, Aggarwal*et al.* [5]proposed sparse representation approach on local facial fragments to match surgically altered face images. Though recent results suggest that the algorithms are improving towards addressing the challenge, there is a significant scope for further improvement. Plastic surgery procedures can significantly alter facial appearance, thereby posing a serious challenge even to the state-of-the-art face matching algorithms. In this

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paper,here propose a novel approach to address the challenges involved in automatic matching of faces across plastic surgery variations. In the proposed formulation, part wise facial characterization is combined with the recently popular sparse representation approach to address these challenges. The sparse representation approach requires several images per subject in the gallery to function effectively which is often not available in several use-cases, as in the problem addressed in this work. The proposed formulation utilizes images from sequestered non-gallery subjects with similar local facial characteristics to fulfil this requirement.

Consists of the following steps:

- Localization of face and primary facial features.
- Generation of training Matrix (for each facial part).
- Sparse Recognition (for each facial part).

The proposed framework exploits the advantages of part-wise analysis with the recently popular sparse recognition approach to deal with the challenges posed by plastic surgery variations. The proposed formulation relies on training images from sequestered non-gallery subjects to fulfil the multiple image requirement of sparse recognition method.

The use of sparse representation for face recognition wasintroduced by Aggarwal [5]. Given a set of labeled training samples from k distinct classes, the task is to determine the class to which a new unseen test sample belongs. Let Ai = $[v_{i,1}, v_{i,2}, \dots, v_{i,n_i}]$ be a $m\ X\ n_i$ matrix of training images from the i^{th} class in which the n_i training samples are arranged as columns.Each column $v_{i,j}$ in matrix Ai can be the vectored intensity imageor some suitable characterization of the intensity image. One of the main requirements of the sparse representation based approaches is the availability of multiple samples for each class in matrix A. The plastic surgery dataset consists of only one pre-surgery and one post-surgery image for each subject in the dataset. To this end, this work uses sequestered training data with no identity overlap to fulfil the requirement.

The faces in plastic surgery images do not look similar to the training face images in any way since those identities are not present in the training data, but the images show much higher similarity when considered at a more local level.For example, eyes of a person may resemble those of some other person. This intuition forms the basis of the proposed training approach. For each gallery identity,populate matrix A with the images with most similar facial characteristics from the sequestered training data. This is done in a part-wise manner. The proposed algorithm significantly bridges the performance gap earlier observed whenmatching faces across plastic surgeries, compared to matching normal face images. As supported by the experimental evaluations, the good performance of the proposed approach is attributed to both part-wise analysis and sparse recognition technique.

Advantage:

- Exploits the advantages of part-wise analysis with the recently popular sparse recognition approach.

Disadvantages

- Requires multiple samples of data.
- Less identification accuracy (about 21.5% - 40%).
- Outperforms for the identification of 6 facial regions.

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Marko*et al*. [6] proposes a novel interest region descriptor called CS-LBP which combines the strengths of the well-known SIFT descriptor and the LBP texture operator.Local feature detection and description have gained a lot of interest in recent years since photometric descriptors computed for interest regions have proven to be very successful in many applications. In this work, propose a novel interest region descriptor which combines the strengths of the well-known SIFT descriptor and the LBP texture operator. It is called the center-symmetric local binary pattern (CS-LBP) descriptor. This new descriptor has several advantages such as tolerance to illumination changes, robustness on flat image areas, and computational efficiency. A good region descriptor can tolerate illumination changes, image noise, image blur, image compression, and small perspective distortions, while preserving distinctiveness. In a recent comparative study the best results were reported for the SIFT-based descriptors. The local binary pattern (LBP) texture operator, on the other hand, has been highly successful for various problems, but it has so far not been used for describing interest regions.

The gradient features used by SIFT are replaced with features extracted by a center symmetric local binary pattern (CS-LBP) operator similar to the LBP operator. The CS-LBP descriptor performs significantly better than SIFT for structured scenes, while the difference for textured scenes is smaller.The CS-LBP descriptor was evaluated against the SIFT descriptor using a recently presented test framework. This descriptor performed clearly better than SIFT for most of the test cases and about equally for the remaining ones. Especially, the tolerance of our descriptor to illumination changes is clearly demonstrated. Furthermore, these features are more robust on flat image areas, since the gray level differences are allowed to vary close to zero without affecting the threshold results. It should be also noted that the CS-LBP descriptor is computationally simpler than the SIFT descriptor.

Advantages:

- Method is tolerant to illumination changes.
- Robustness on flat image areas.
- Computational simplicity.

III. Conclusions

This research evaluated various methods for recognize surgically altered face images and to find a suitable method for feature extraction with better accuracy and consistency.About different feature extraction methods are analyzed during the research ,among them a simpler and accurate feature extractor was selected for feature selection purpose.From that a separate feature extraction module is taken to incorporate feature selection process specified in the method [1].Instead of H.S Bhatt and R.Singh evolutionary granular approach for plastic surgery detection [4],M.Heikkil and M. Pietik Description of Interest Regions with Center-Symmetric Local Binary Patterns [6] is being used in a new face recognition system.

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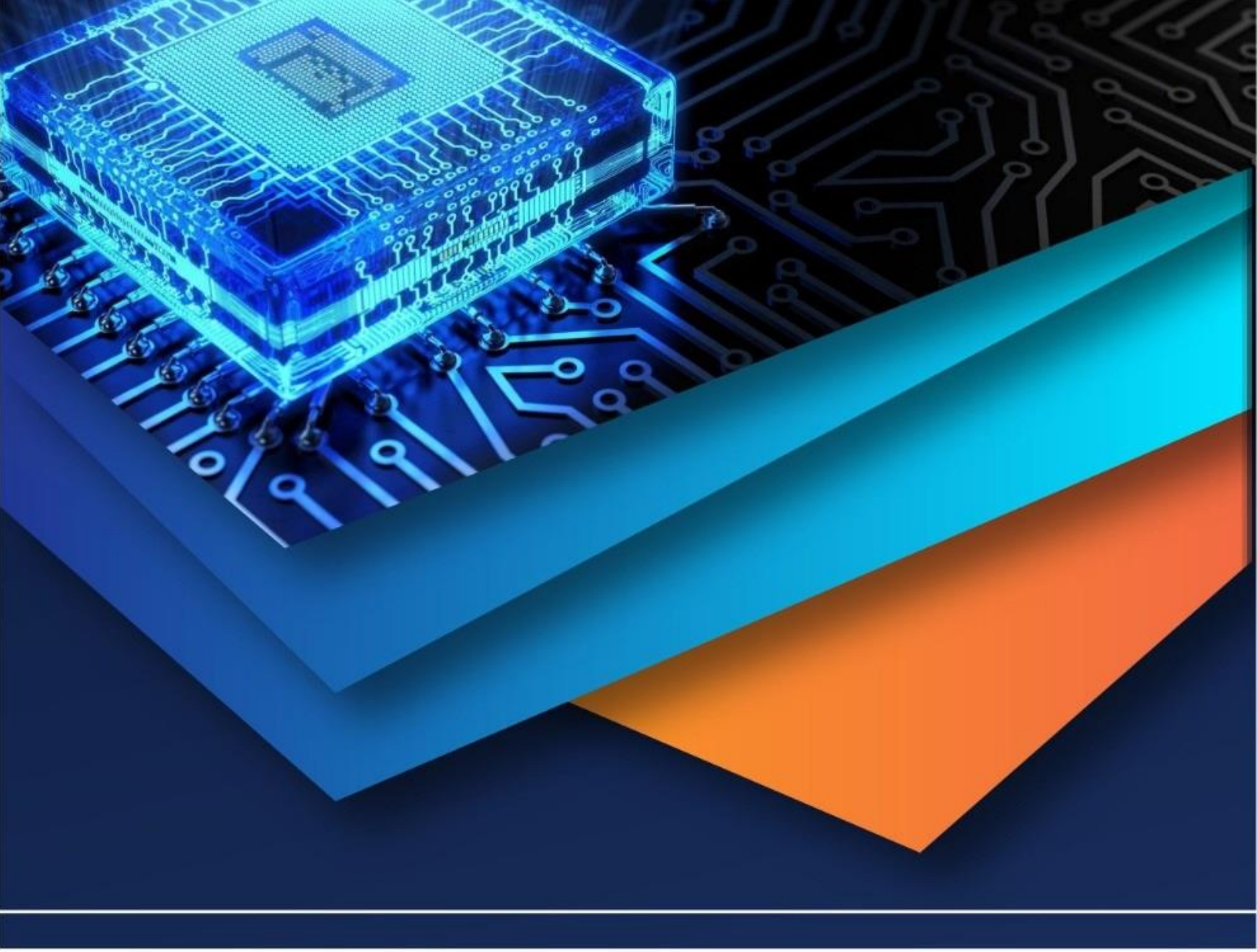
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