Face Recognition and Plastic Surgery: Social, Ethical and Engineering Challenges

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Abstract. Face recognition systems has engrossed much attention and has been applied in various domains, primarily for surveillance, security, access control and law enforcement. In recent years much advancement have been made in face recognition techniques to cater to the challenges such as pose, expression, illumination, aging and disguise. 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. In this paper we comment on the effect of plastic surgery on face recognition algorithms and various social, ethical and engineering challenges associated with it.

1 Introduction

Face recognition systems have the ability to recognize humans based on facial features such as geometry and texture. These system are primarily used for ID cards, e-passports, e-borders, border security and law enforcement. *Face* has the benefit of being non-invasive as a biometric when compared to other biometrics such as fingerprint or iris. Though human beings use face for recognition very effectively, automated systems that use face as a biometric have just begun to establish their reliability in real world applications. However, performance of face recognition systems are affected by well establish covariates such as amount and direction of light on the face (illumination), pose, expression, and image quality (e.g. noise and blur). Researchers have also worked to develop face recognition systems that are resilient to aging and disguises.

In our previous research, we introduced plastic surgery as one of the most challenging covariate in face recognition [1]. A recent incident in China accentuates the intricacies of this covariate. At Hongqiao International airport's customs, a group of women were stopped as all of them had undergone plastic surgery and had become so unrecognizable that customs officers couldn't use their existing passport pictures to recognize them [2]. We can, therefore, assert that plastic surgery is a new and equally serious covariate that has sprung from our evolving cultures. It is also entwined with many ethical dilemmas in their use in biometric technology.

During the last decade, there has been a tremendous growth in the number of plastic surgery procedures worldwide. According to the 2008 statistics provided

by The American Society for Aesthetic Plastic Surgery [3], in USA alone there has been an increase of about 162% in total number of plastic surgeries from 1997. Liposuction (341,144 procedures), eyelid surgery (195,104), Rhinoplasty (152,434), Chemical peel (591,808) and Laser skin resurfacing (570,880) are the most common plastic surgery procedures for faces. If we look at the plastic surgery distribution by age, 0-18 years contribute 2% of total procedures whereas 19-34 years contribute around 22%, 35-50 years contribute around 45%, 51-64 years contribute around 26% and 65 above contribute 6% of total plastic surgery procedures. Moreover, 20% of all the plastic surgeries are performed on individuals belonging to racial and ethnic minorities. The statistics clearly indicate the popularity of plastic surgery among all age groups, ethnicity and gender. Thus there is a great need for the future face recognition systems to confront the challenges posed by facial plastic surgery.

In our preliminary study [1], we analyzed the effect of facial plastic surgery procedures on different face recognition systems widely used in the literature. Using pre and post surgery images of around 500 individuals, performance of six face recognition algorithms namely Principal Component Analysis, Fisher Discriminant Analysis, Geometric Features, Local Feature Analysis, Local Binary Pattern, and Neural Network Architecture based 2D Log Polar Gabor Transform were evaluated. The results indicate that facial plastic surgery is one of the most challenging covariate for current face recognition algorithms and more research is required in this direction. Along with performance issues there are several other challenges associated with the problem of facial plastic surgery. Due to the increased dependence on face recognition systems for law enforcement, security and surveillance at crucial places it is required that face recognition systems should learn to tackle such future challenges. In this paper, we discuss social, ethical and engineering challenges to face recognition posed by facial plastic surgery procedures.

2 Plastic Surgery

Facial plastic surgery is generally used for correcting facial feature anomalies or improving facial appearance, for example, removing birth marks, moles, scars and correcting disfiguring defects. These surgical procedures prove beneficial for the patients suffering from structural or functional impairment of facial features, but such procedures can also be misused by individuals to conceal their identities with the intent to commit fraud or evade law enforcement. These surgical procedures may allow anti-social elements to freely move around without any fear of being identified by any face recognition or surveillance system. Facial plastic surgery results being long-lasting or even permanent provide an easy and robust way to dupe law and security mechanism. Face recognition after plastic surgery can lead to rejection of genuine users or acceptance of impostors. Moreover, because these procedures modify the shape or texture of facial features to varying degree, it is difficult to find correlation between pre and post surgery facial geometry.

Facial plastic surgery procedures can be classified as (1) *disease correcting local plastic surgery* in which an individual undergoes local plastic surgery for correcting defects, anomalies, or improving skin texture, and (2) *global plastic surgery* in which complete face structure is altered (e.g. face lift). Local plastic surgery is primarily aimed at reshaping and restructuring facial features to improve appearance. Measurable quantities such as geometric distance between facial features are altered, nonlinearly, as a result of such procedures, but other aspects like texture of skin and overall appearance remains same. In global surgery, complete facial structure can be reconstructed. This type of facial plastic surgery is aimed at reconstructing the features to cure some functional damage as well as to improve appearance. Global plastic surgery entirely changes face appearance, texture of skin and other face geometries making it arduous for any face recognition system to recognize faces before and after surgery. Global plastic surgery may be exploited by perpetrators to dupe the law and security mechanism posing a great threat to the society despite all the security mechanism in-place and him being a cooperative user.

2.1 Facial Plastic Surgery Procedures

This section discusses some of the popular facial plastic surgery procedures and how they affect facial features during recognition. Most popular facial plastic surgery is Rhinoplasty i.e. nasal surgery. It is used to re-enact the nose in cases involving birth defects, accidents where nose bones are dented and also to cure breathing problems caused due to the nasal structure. Blepharoplasty (eyelid surgery) is used to remodel eyelids when over-growth of skin tissues on the eyelid causes vision problem. Fig. 1 illustrates the effect of Rhinoplasty and Blepharoplasty. Brow lifts (forehead surgery) is generally recommended to patients who suffer from flagging eyebrows (because of aging) which obstruct vision. Mentoplasty (chin surgery) is used to reshape the chin, including smooth rounding of the chin and reducing or augmenting chin bones. Cheek implants are used to improve the facial appearance. This is done by Malar augmentation, in which a solid implant is inserted over the cheek bone or Sub-Malar augmentation where implants are fitted in areas of the cheeks which have a dug in or hollow look. Otoplasty (ear surgery) brings the ears closer to the face, reduces the size of ears and prunes some structural ear elements. Liposhaving (facial sculpturing) removes excess fat attached to the skin surface on the face (chin, jaws). Skin resurfacing (skin peeling) is used to treat wrinkles, stretch marks, acne and other skin damages caused due to aging and sun burnt. Rhytidectomy (face lift) treats patients with severe burns on face and neck or to get a younger look by tightening the face skin and thus minimizing wrinkles. Lip augmentation involves proper shaping and enhancement of lips with injectable filler substances. Craniofacial surgeries are employed to treat by-birth anomalies such as clift lip and palate (a gap in the roof of mouth), microtia (small outer ear) and other congenital defects of jaws and bones. Dermabrasion is used to give a smooth finish to the face skin by correcting the skin damaged by sun burns or scars (developed as a post surgery effect), dark irregular patches (melasma) that grow over the face

skin and mole removal. Among all the techniques listed above Rhinoplasty, Blepharoplasty, Forehead surgery, Otoplasty, Lip augmentation, and Craniofacial are purely local plastic surgery. Rhytidectomy (face lift) is purely global plastic surgery whereas Liposhaving, skin resurfacing, Dermabrasion can be local as well as global plastic surgery.

Fig. 1. Pre and post facial plastic surgery images. First sample illustrates the effect of Rhinoplasty and second sample shows the effect of Blepharoplasty.

In our previous research, we observed that current face recognition systems cannot handle variations due to global plastic surgery procedures and their performance deteriorates to an unacceptable level. Local plastic surgery procedures alter the geometry of fudicial points and appearance of local features only. Therefore, face recognition algorithms yield better accuracy for images with local surgery as compared to images with global surgery. Moreover, the surgical procedures that modify key fudicial points such as nose, forehead, chin, eyelid, eyebrows, mouth and lips have a much pronounce effect on face recognition systems than the techniques which deal with ears, mole removal, and dermabrasion. This is because most face recognition systems do not embrace ear region and moles for recognition. Brows lift (forehead surgery) and chin surgery (mentoplasty) also have a major affect on the performance of face recognition system because these features are used to normalize face and estimate the pose variations.

3 Challenges Due to Facial Plastic Surgery

This relatively unexplored research area, i.e. face recognition under variations due to plastic surgery poses several ethical, social and engineering challenges. We briefly explain these issues in the following subsections.

3.1 Ethical and Social Challenges

The most important ethical and social issue is *invasion of privacy*. The exact definition of what constitutes an individuals privacy and its infringement is a

debated topic and varies hugely in different parts of the world. In general, privacy issues in facial plastic surgery is related to medical information and, therefore, it is private and secure even under law. In some cases, these types of surgery depend on an individuals choice, they cannot be bound under any legal or social obligations. However, it should be the ethical responsibility of an individual to re-enroll himself after undergoing a facial plastic surgery procedure that has led to changes in facial features.

A deliberate identity theft in order to bear a resemblance to someone with the help of plastic surgery is another major social challenge. Face recognition systems must be able to distinguish between a genuine and stolen identity, for which system must include laws and other cross references apart from a recognition algorithm. In our opinion, as new complexities like facial plastic surgery emerge and gain popularity, we must constantly be a step ahead to ensure reliability and accountability of face recognition.

Another major challenge in this research is to collect images of patients before and after facial plastic surgery. There are several concerns in collecting the database as patients are hesitant to share their images. Apart from the issues of privacy invasion, many who have undergone a disease correcting facial surgery would also like to be discrete. Hence, there are no large databases available that can be used to train or test current face recognition algorithms or develop a new algorithm to match human face images before and after surgery.

3.2 Engineering Challenges

Apart from ethical and social issues, several engineering challenges are also important in developing algorithms to handle variations due to facial plastic surgery. First one is to have an algorithm that can classify whether the false acceptance or rejection is owed to facial plastic surgery or to some other covariate such as aging or disguise. Since some of the local plastic surgery preserves overall appearance and the texture of the face, this challenge may not be significant for some cases. However, in other cases including global plastic surgery or full face lift cases where the entire structure of the face is remodeled, it is of paramount interest to automatically differentiate among plastic surgery, aging, and disguise. In other words, face recognition algorithm must be able to single out the variations in face due to facial plastic surgery from the variations due to other covariates such as aging, disguise, illumination, expression and pose. Despite many advances in face recognition techniques, to the best of our knowledge, there exists no technique that can perform such classification.

Even if we somehow (e.g. manually) identify that a particular human face has undergone plastic surgery, it is still an arduous task for current face recognition algorithms to effectively match a post-surgery image with a pre-surgery face image. Therefore, an engineering challenge would be to design an algorithm to correlate facial features in pre and post surgery images. Local facial regions such as nose, chin, eyelids, cheek, lips and forehead have an imperative role in face recognition and small variations in any of these features carry a partial affect on the neighboring features. Further, a combination of local plastic surgery

procedures may result in a fairly distinct face from the original face. To develop an algorithm to assess such non-linear variations in pre and post facial plastic surgery images makes the engineering challenge fiercer. Finally, facial plastic surgery may also lead to identity theft. A deliberate identity theft in order to bear a resemblance to someone is a major social issue but identity theft can also be purely unintentional, where a person who has undergone plastic surgery now closely resembles another person. This situation is a good test for robust face recognition systems. It is our assertion that these challenges should receive immediate attention from the research community to develop efficient face recognition algorithms that can account for non-linear variations introduced by facial plastic surgery procedures.

4 Conclusion

In this paper we have discussed the significance of facial plastic surgery as a challenging covariate for face recognition algorithms. The popularity of facial plastic surgery is on the rise owing to advancement in medical technology and greater acceptance in society. Plastic surgery proves highly beneficial for patients with birth anomalies or some accidents or trauma, but poses such a big threat to the society as it can be exploited by criminals and terrorists to conceal their identity and evade law enforcement and security agencies. There is a lack of research efforts to confront this covariate. It may be because of the privacy issues involved in dealing with the pre and post surgery facial images or engineering complications involved in designing automated algorithms. The paper emphasizes the ethical, social and engineering challenges that need to be addressed by the research community so that future face recognition systems are capable of addressing challenges posed by facial plastic surgery.

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