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# Automatic Detection and Removal of Facial Wrinkles and Reconstruction Using Inpainting

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**Abstract—***Modifying defects in photographs is largely used in media and also in entertainment industry. In this digital era we were very much familiar about many facial retouching software. Some are even included in smartphones available at industries. Commonly such kinds of software were used by youngsters and social media maniacs to make their photographs attractive to other people and also they are used to reconstruct those images that lost their clarity due to ageing. But most of these software like Adobe Photoshop need experienced users to handle with. The user friendly applications available in smartphones does not distinguish between skin imperfections and other skin features. Some of them will diminish or blur the wrinkles or imperfections instead of removing them completely. Here the paper goes for an approach that automatically detects the wrinkles especially in forehead region automatically, removes them completely and reconstructs to give a natural look*

## 1. INTRODUCTION

Inpainting or more clearly digital image inpainting finds a number of applications in the area of image processing like reconstructing the lost part of image which are distorted due to ageing or mishandling. This technique is even used to remove scratches in paintings in museums which have historical values. Actually digital image inpainting is a process of closing gaps created in an image due to the removal of imperfect or unwanted regions. This technique is also used to remove large objects from an image which gives it a false look which may be interpreted as original.

Digital image inpainting, which is also known as image interpolation, image completion or image restoration, possess the aim of removing corrupted areas without much attention from the viewers. A survey on various digital inpainting techniques can be seen in [11]

In the proposed paper the inpainting technique plays a huge role as it used to reconstruct the image after all the processing. Photo editing or retouching tools available now a days requires an experienced user for handling it. But as a contradiction to it there are many user friendly applications like Visage Lab, Beautify etc., are incorporated in smart phones available in industries. These application will not target a specific region of image instead it will retouch image as a whole and will not distinguish between normal skin and skin imperfections

In current scenario, there is a method of detection and inpainting of facial wrinkles using skin features as input with the help of markov random field modelling and texture orientation fields proposed by Batool and Chellappa[14]. Here skin features of normal skin and skin with wrinkles are classified using Gabor filter responses and orientation fields as skin features. But the method won't isolate those regions for removing wrinkles or imperfections. In other words the method is not at all automatic. Here it is needed to manually isolate those regions which is needed to be checked for the presence of wrinkles or imperfections.

Another approach used for removing wrinkles is image painting method proposed by Georgiev [15]. This application make use of widely available poisson image editing tool. This method also works in the background of Adobe Photoshop. This method deals with including a small region in image like a screen, where source and destination should be provided by the user.

The observations that lead to the motivation of this work is listed below:

1. All professional software like Adobe Photoshop requires a minimum level of experience for the user.
2. User friendly applications won't distinguish between normal skin and wrinkles.
3. Since wrinkles won't appear as boundaries or edges, we cannot apply structural inpainting and cannot apply structural inpainting as they do not have any regular patterns.
4. Latest methods or wrinkle removal requires user to manually isolate all defected regions.

Main contribution of this paper is automatic detection of wrinkles on face, especially on forehead portion without any user interaction followed by their removal and reconstruction by inpainting.

In a glance the paper is organized as; in section II the reader will get an idea about all the related works for the proposed system. In section 3 the approach used in our works and all related computations are illustrated. Results of the work and its analysis is presents in section 4 and work is concluded in 5

## 2. RELATED WORKS

Image inpainting methods aims on one or both of the structure and texture of an image. Since image attributes of structure and texture of an image varies both requires different inpainting methods. A detailed survey of image inpainting methods can be found in [11], [3], and [2]. Most texture inpainting methods require user input or some masking function to emphasis the occlusion to be filled (e.g. the experiment by Criminisi [5]). Some examples of automatic filling of scratches, rectangular voids or random noise can be found in [1], [3], and [1]. Shi and Chang introduced a patch-based multi-resolution/multi-layer method to reconstruct the originality of paintings damaged by red scratches [3]. Their approach involved a mechanism to detect the destructed regions at first where the change in the color of a patch at a particular resolution was used to determine if a patch had retorted pixels. In contrast, the inpainting methods in [1] and [7] do not consider any explicit identification of gaps needed to be filled. These methods are based on the analysis of different layers containing low frequency against high frequency details.

The low frequency layer decides the piecewise clean regions of the image and the high frequency layer decides the texture. The reconstruction of these layers ultimately fills the gaps without detecting explicitly. In case where there are multiple texture surrounding the gap, sophisticated techniques are used for fusing different textures [5], [8]. Once a suitable combination of different textures has been found, the gap is filled by existing texture generating techniques. As an example, Grossauer [8] used the exemplar-based texture synthesis technique given in Criminisi et al. [5] used a generating method just like in [2].

The particular application of wrinkle removal is entirely different from other image processing applications as wrinkles are not unique objects that can be easily isolated. Wrinkles are very close to skin and are traceable only due to their irregularities in nature with respect to surrounding skin pattern. In recent times, the identification of wrinkles as repetitions of line segments or curves was shown by Batool and Chellappa ([14]). However, this method cannot be made practical here due to two reasons. First, wrinkles are found to be localized as curves and the surrounding folds of a skin region. Second, the method reported in [1] is completely based on line segments and cannot be used to identify other oval like skin imperfections.

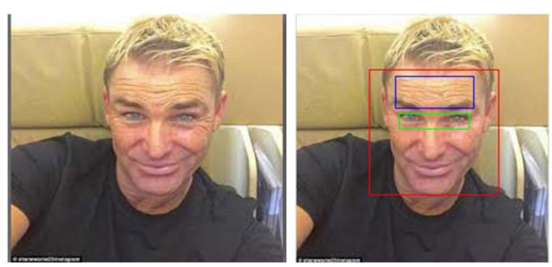
## 3. APPROACH

The main title (on the first page) should begin 1-3/8 inches (3.49 cm) from the top edge of the page, centered, and in Times 14-point, boldface type. The approach used here has basically five steps, (a) detecting the facial features from an input image, (b) detecting wrinkles and imperfections in detected areas, (c) converting the resulting image to binary, (d) removal of defected areas after labelling, (e) reconstruction of the image. Since here it is introducing the unsupervised image inpainting method, an extra step is needed to identify wrinkles automatically. The phenomenon of wrinkling creates deep holes and causes curves in the surrounding skin. The resulting skin features causes particular intensity differences in skin images which seems like irregularities in the nearby skin textures. An efficient inpainting of wrinkles will require both the wrinkle folds and the surrounding curved skin to be taken off. In image inpainting specified above, we select skin portions close to the detected wrinkles. This is because of the fact that the skin texture can differ significantly inside a small region of face.

The skin patches very near to the wrinkles have the closest look to skin texture. For steps (b) and (c), we can use an exemplar-based texture synthesis technique based on the experiments of Efros and Freeman [13]. The details of the texture synthesis method used here are presented in Section 3.2.

## 4. DETECTING FACIAL FEATURES

The facial features supposed to be detecting here are the face as a whole, the forehead region and the eye region. The detection is done by creating a cascade detector object available. By default a cascade detector object will detect the face as a whole, for detecting eye region we have to specify it like CascadeObjectDetector('eye pair small'). We can specify eye pair either as small or large depending on the situation. Then detected regions are labelled with colored boxes for the easy identification. The Fig. 1 (a) shows the original image and the Fig. 1 (b) shows the image after detection.



**(a) (b)**

**Fig. 1: Detecting facial features**

## 5. WRINKLE DETECTION

The texture orientation field proposed by Rao [10] and responses of Gabor filters are used here for wrinkle detection.

The significance of using texture orientation field are they will mark the irregularities in normal skin texture which can be identified as wrinkles. At same time Gabor filters gives the indication on discontinuities in pixel intensity. To get a perfect output we need to fuse all these features. This can be done using Gaussian mixture models. It is obvious that the filter here is used for detecting the orientation features. There are many filters available with these facilities like Gaussian second derivative filters, Gabor filters and line operators. From a comparative study done by [12] F. J. Ayres and R. M. Rangayyan the Gabor filters are found to be best among them. A Gabor filter kernel is denoted by the equation:

$$g(x_1, x_2) = \frac{1}{2\pi\sigma_{x1}\sigma_{x2}} exp\left[\frac{-1}{2}\left(\frac{{x_1}'^2}{{\sigma_{x1}}^2} + \frac{{x_2}'^2}{{\sigma_{x2}}^2}\right)\right] cos(2\pi f {x_1}')$$

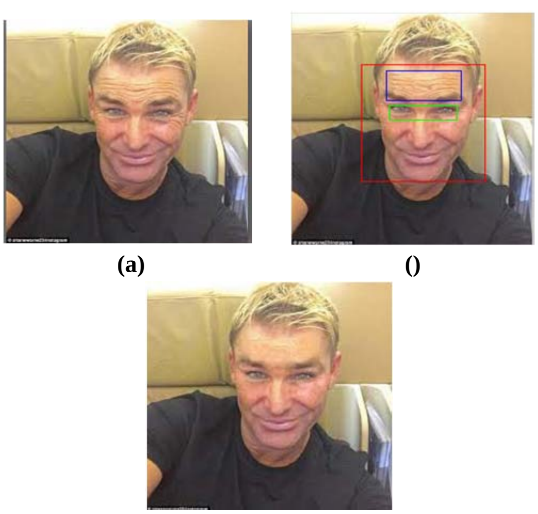
Where,

$$\begin{bmatrix} {x_1}' \\ {x_2}' \end{bmatrix} = \begin{bmatrix} cos \propto & sin \propto \\ -sin \propto & cos \propto \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

The variables f and α represents frequency corresponding to sinusoidal factor and orientation angle respectively and the corresponding standard deviation is represented as $\{\sigma_{x1}, \sigma_{x2}\}$ of Gaussian shield in 2D plane.

After detection, the output image is converted to binary, so that the defected regions can be easily isolated as binary images easily reflects the irregularities in normal skin texture. Most probably these regions are identified as black. But for thresholding we don't take value=0 which corresponds to black, instead NAN (not a number) is chosen. Otherwise eye brows and hair is also taken as unperfected region

## 6. RESULTS AND ANALYSIS



**(a)** **()**

**(c)**

**Fig. 2: Detection and inpainting**

Here we can explain the system in short; first of all an input image should be given whose wrinkles or similar imperfections that needed to be removed. The next step is feature detection, where eye and mouth regions are detected. Then forehead and remaining regions are isolated which are prone to most wrinkles and imperfections. The very next step is the detection of these wrinkles and imperfections. As soon as these regions are detected they should be removed instead of blurring or diminishing. The gaps created due to this removal can be filled or reconstructed without losing the visual quality of the image by using digital inpainting. The Fig. 2(a) denotes the original input image. Then using cascade detector object features like face as a whole, eyes and forehead portions are detected, which is shown in Fig. 2(b). After detection of wrinkles by the help of Gabor filter responses and orientation fields as image features, they were completely removed instead of blurring and reconstructed using inpainting which is shown in Fig. 2(c)

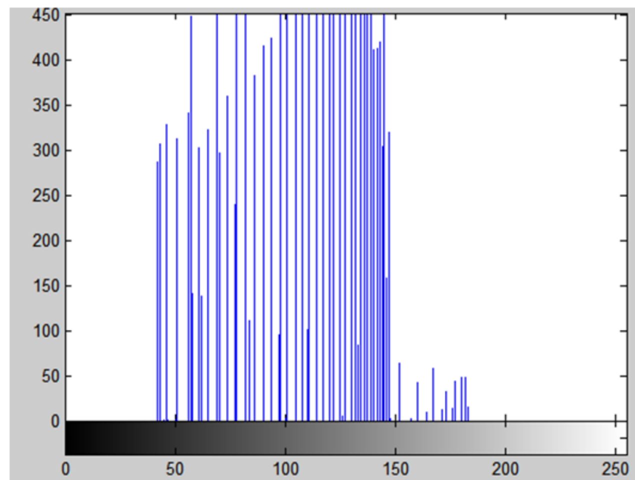



**Fig. 3: Histogram before inpainting**

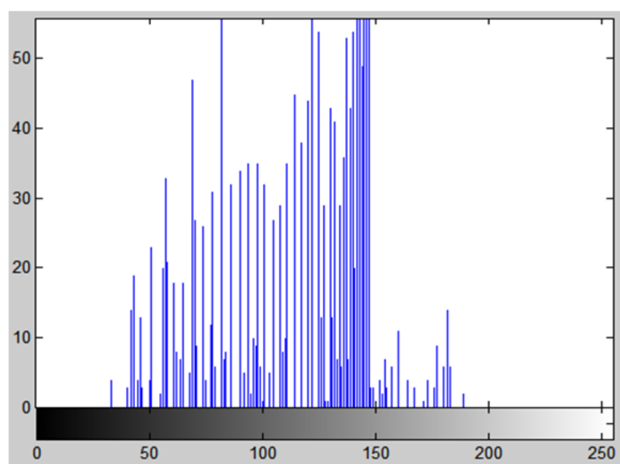



**Fig. 4: Histogram after inpainting**

To have a classification we need to plot histograms before and after inpainting. Another method for quantitative analysis is by plotting Bhattacharya distances between pixels before and after inpainting. Bhattacharya distance between the pixel will be get reduced if inpainting has occurred perfectly. The Fig. 5: shows the plotting of Bhattacharya distance (Bd) between pixels before and after inpainting. From the plot it is clear the Bd of two samples taken got reduced after inpainting than that of before inpainting. It is seen that Bd of one sample is two and other is close to 3.5 before inpainting and after inpainting it reduced to a value close to 0.011 and 0.02 respectively.

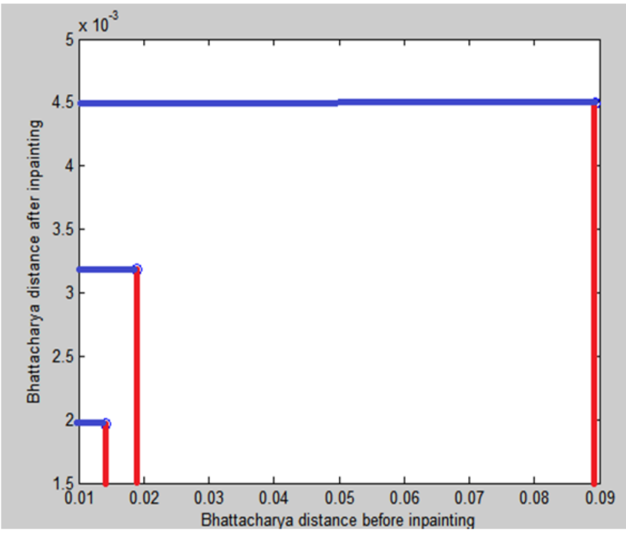



**Fig. 5: Bhattacharya distances before and after inpainting**

## 7. CONCLUSION

Through this paper we had gone through several limitations of all the available facial retouching software available in industry. The paper proposed a method of detecting and removal of all facial wrinkles and afterwards reconstruction without any user interaction. The work can be extended towards removal of high intensity wrinkles caused due to severe ageing and also to detect and remove artifacts created due to repeated inpainting.

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