Image Retouching by Blemish and Red-eye removal

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1. Introduction

Digital Image Processing refers to modifying the image by means of a digital computer. The processing techniques include enhancing the image in the spatial domain as well as in the frequency domain, image segmentations using point, line and edge detection and various image transformations.

The major factor that we are concerned with is image enhancement. Image enhancement basically deals with highlighting certain areas of the image to improve the quality of the image for a *specific* application. The project deals with removal of blemishes from darker images and detection and correction of red eye from images.

Blemishes are nothing but spots on the images (e.g. acne on the face and other birth marks that stay on the skin). They can be treated as sudden changes in the intensity of the pixels in the image. Blemishes that exist on brighter skins can be easily removed, but the ones on darker skins are the ones that are difficult to get rid of. The focus of this project will be on non-red blemishes. These blemishes will be removed using advanced filtering techniques

The second part of the project is on red eye removal. Red eye is basically reflection of light from the retina of the eye. During image acquisition, the light from the capturing device goes through the iris and hits the retina from which it is reflected back to the capturing device. This reflection can be seen in the digital image as red-eye. The basic process of red eye removal consists of two steps: detection and correction. The detection can either be automatic or manual and will require some user input.

The Graphical User Interface (GUI) is a computer interface that works on graphics rather than plain text with active participation from the user. A GUI is designed for the project using MATLAB. This GUI allows the user to open images to be modified and saved the image after retouching algorithms are preformed.

2. Image Blemish Removal

Blemishes

Blemishes for the purposes of this project are considered imperfections that mar or impair various regions within an image. More specifically, focus is given to imperfect regions found on the subject within the photograph. In the past, famous artists painted portraits reflecting not how the subjects really are, but rather as how they imagined themselves to appear. Thus, historic artists served as a medium for image filtering, emphasizing certain distinguishing aspects while removing unwanted blemishes. With the advancement of technology, the modern world has adopted the use of digital cameras and digital imagery; personal portraits today directly reflect the subject, including all physical imperfections.

There exist many aftermarket image enhancement tools to modify and improve upon digital images. These tools implement a wide range of image processing algorithms mainly exploiting digital extrapolation techniques. An example of digital extrapolation can be seen in the method used by a previous study conducted by Reed, Stamm and Rangarajam. In that study blemishes were determined to be sudden changes in intensity of the pixel values within a region of the given image. In order to remove blemishes a filtering technique was implemented exploiting these intensity changes. This technique was proven effective for light colored skin types, as there exists extreme intensity changes between blemishes and light skin. This same technique when applied to darker skin types proved to be a failure, the filtering of intensity values negatively affected overall image coloration.

Operation of the Human Eye

In order to accommodate for dark skin blemish removal image enhancement, consideration was given to human perception. The human eye is often compared to a camera. In order for human to visually perceive, an image must be sent to an area at the back of the eye called the retina and for the image to be perceptibly acute, it must be focused. The human eye performs automatic focusing of a subject independent of the brain, this process known as accommodation. Once focused, light-sensing information is collected and processed through two types of cells, rods and cones. The eye operates like a digital device; continuous light sensing information is discretized and processed at an ostensible sampling rate. Thus, when quickly turning one's head or simply staring out the window of a moving car, a blurring of color occurs. In movies, the wheels of a moving car may sometimes appear stationary to the human eye, this process is termed the strobe affect. The strobe affect occurs when relative changing frequencies differ significantly. When the human eye is unable to keep up with incoming visual data, interpolation is preformed. This interpolation is what results in the blend of color.

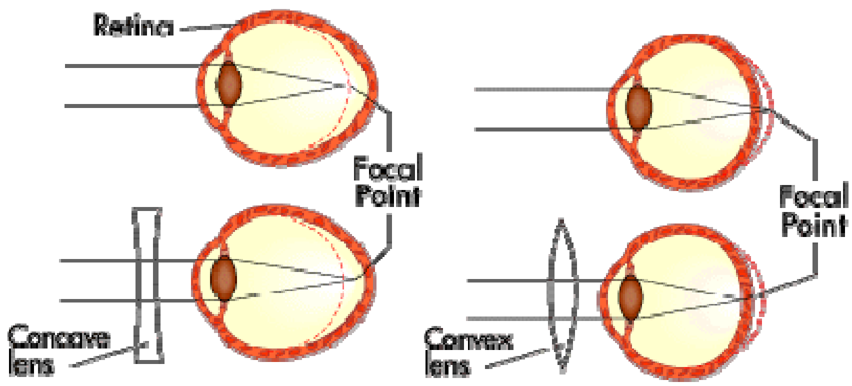

Figure 1: Image Focusing by the Human Eye

From understanding of the human eye, a parallel can be drawn for image enhancement. Similar to how the human eye performs accommodation independent of the brain, selection of blemish regions requires user identification independent of data interpretation. The information is then processed in a discrete manner. In order to remove blemishes a novel technique is developed based upon the blurring seen through human eye latency. It is proposed that convolution techniques are used since the blurring of colors in a moving pinwheel is resultant from mixing of color at a point X with the following color at point Y.

Region of Interest

One emphasis of this project is region of interest (ROI) programming used for blemish removal. By visual inspection a human user is capable of determining blemishes within an image. This determination allows for filtering of specific regions while leaving others untouched. A combination of Matlab functions found in the image processing toolbox enables user input in selection of a polygonal region of interest. The getline function obtains coordinates from user mouse clicks while roipoly computes the polygon region of interest. Upon completion of this process, filtering is preformed and recompiled with the original image.

2-Dimensional Filtering

After obtaining a ROI, filtering is preformed upon the selected data. Within the Matlab imaging toolbox there exists many tools to assist in filtering. Asides from common high/lowpass finite impulse response filtering techniques, well known two-dimensional filters such as gaussian, sobel, prewitt, laplacian, log, average, motion, and unsharp are defined. These filter types produce differing results when implemented upon an image. For purposes of blurring the image in the same way as one would find inherently within the human eye, gaussian and motion filters were experimented upon.

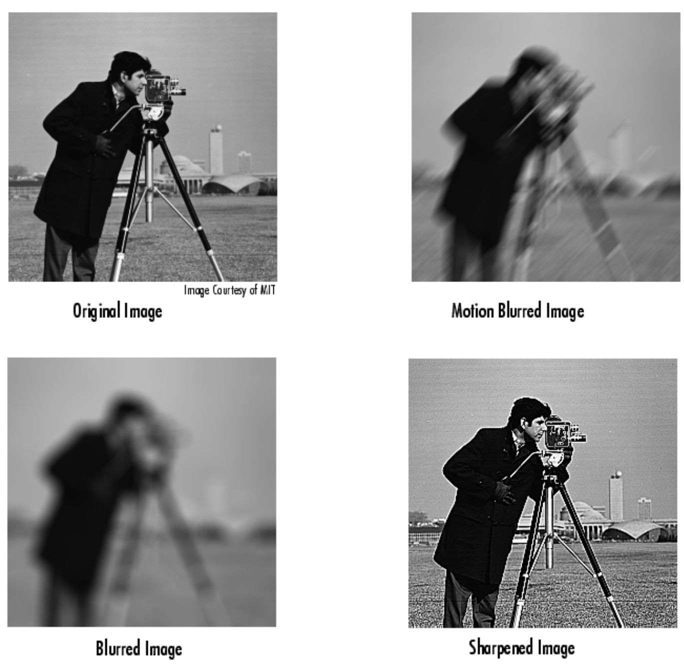

Figure 2: Matlab Image Processing Techniques

These two filters are computed differently. The gaussian filter is computed using a rotationally symmetric lowpass filter determined below.

$$h_g(n_1, n_2) = e^{-(n_1^2 + n_2^2)/(2\sigma^2)}$$

$$h(n_1, n_2) = \frac{h_g(n_1, n_2)}{\sum_{n_1}\sum_{n_2} h_g}$$

When applied this method is expected to remove detail and noise from an image. In the case of blemish removal, it was found that alterations by a gaussian filter to the intensity values of a picture are indeed capable of reducing blemish through blurring. Difficulties to this method arises however in discoloration of darker pixel values as an inherent problem exists to the relative equivalence between dark skin types and values of lowpass filtering characteristics.

The motion filter is unique as it was written using autocorrelation, the image within the region is convolved with a shifted version of itself. This filter operates by convolving specified pixels in horizontal and angled directions (2-dimensional) in order to approximate blurring. Thus, in the time domain, one can consider the frame of reference to be moving linearly with relation to the image and thereby mimicking blurring of images found through sampling latency. For implementation in the project, we will consider horizontal convolution as it was experimentally determined that the angle will have minimal effect upon image processing of small ROI.

Blemish Removal Results

Through the implementation of a motion filter instead of a gaussian lowpass filter, it was determined that removal of blemishes of dark skin is possible without discoloration. The motion filter essentially averages pixel values with relation to surrounding pixels. In this manner the motion filter is more robust than a basic lowpass FIR filter. This method of blemish removal still contains several problems, filtering is only capable of blurring the image and blending the blemish with surrounding pixel values. Large blemishes in this manner remain to a degree even after image enhancement. Additionally filter techniques must be applied to luminance and chrominance domains as blemishes may be of any color. Application in the red-green-blue image domain is practical only when emphasizing the removal (blurring) of a specific colored blemish type.