Enhancement of Edges of Images

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***Abstract*—Edge enhancement is an image processing filter that enhances the edge contrast of an image or video in an attempt to improve its acutance (apparent sharpness).**

The filter works by identifying sharp edge boundaries in the image, such as the edge between a subject and a background of a contrasting color, and increasing the image contrast in the area immediately around the edge. This has the effect of creating subtle bright and dark highlights on either side of any edges in the image, called overshoot and undershoot, leading the edge to look more defined when viewed from a typical viewing distance.

The process is prevalent in the video field, appearing to some degree in the majority of TV broadcasts and DVDs. A modern television set's "sharpness" control is an example of edge enhancement. It is also widely used in computer printers especially for font or/and graphics to get a better printing quality. Most digital cameras also perform some edge enhancement, which in some cases cannot be adjusted.

Edge enhancement can be either an analog or a digital process. Analog edge enhancement may be used, for example, in all-analog video equipment such as modern CRT televisions.

I. INTRODUCTION

In edge enhancement, there are a lot of already existing techniques used for this purpose. But it should always be kept in mind that, we cannot in any way increase the detail in the image. But, we can make the image appear sharper by increasing the acutance. Any of the classical techniques used have a tradeoff associated with them. There exists a tradeoff between edge-enhancement and noise-enhancement. Basically, we have tried to use the already existing techniques with some optimizations to impove the enhancement of edges and to reduce the noise enhancement.

II. EASE OF USE

A. INPUT

The application just takes an image as an input. The user can manually select the amount of blur and contrast stretching applied to the image using a GUI interface provided.

B. OUTPUT

The output image is an enhanced version of the input image where the edges seem sharper. All the adjustments made to the level of blur and contrast stretching applied will be reflected in the output image.

III. TECHNOQUES USED

Let us first begin by describing the classical techniques used for enhancement of edges.

Then we will move on to how we have used them to achieve our goal and how we minimize the tradeoff.

A. Laplacian Operators

In mathematics, the discrete Laplace operator is an analog of the continuous Laplace operator, defined so that it has meaning on a graph or a discrete grid. For the case of a finite-dimensional graph (having a finite number of edges and vertices), the discrete Laplace operator is more commonly called the Laplacian matrix.

Discrete Laplace operator is often used in image processing e.g. in edge detection and motion estimation applications. The discrete Laplacian is defined as the sum of the second derivatives Laplace operator and calculated as sum of differences over the nearest neighbours of the central pixel.

In image processing, we are using a 2-D laplacian matrix to detect the edges.

$$\mathbf{D}^2_{xy} = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

B. Unsharp Masking

Edge enhancement applied to an image can vary according to a number of properties; the most common algorithm is unsharp masking, which has the following parameters:

- Amount. This controls the extent to which contrast in the edge detected area is enhanced.
- Radius or aperture. This affects the size of the edges to be detected or enhanced, and the size of the area surrounding the edge that will be altered by the enhancement. A smaller radius will result in enhancement being applied only to sharper, finer edges, and the

enhancement being confined to a smaller area around the edge.

- Threshold. Where available, this adjusts the sensitivity of the edge detection mechanism. A lower threshold results in more subtle boundaries of colour being identified as edges. A threshold that is too low may result in some small parts of surface textures, film grain or noise being incorrectly identified as being an edge.

In some cases, edge enhancement can be applied in the horizontal or vertical direction only, or to both directions in different amounts. This may be useful, for example, when applying edge enhancement to images that were originally sourced from analog video.

C. *Contrast Stretching*

Contrast stretching (often called normalization) is a simple image enhancement technique that attempts to improve the contrast in an image by `stretching' the range of intensity values it contains to span a desired range of values, e.g. the the full range of pixel values that the image type concerned allows. It differs from the more sophisticated histogram equalization in that it can only apply a linear scaling function to the image pixel values. As a result the `enhancement' is less harsh. (Most implementations accept a graylevel image as input and produce another graylevel image as output.)

D. *Gaussian Blur*

A Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen, distinctly different from the bokeh effect produced by an out-of-focus lens or the shadow of an object under usual illumination. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales—see scale space representation and scale space implementation.

E. *Median Filter*

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal. The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.

F. *Minimizing the Tradeoff*

- We are basically using unsharp masking. But in unsharp masking, we are also detecting a photographic grain which may exixt in images.
- For managing the photographic grain which may be enhanced by the unsharp mask we first apply a gaussian blur to the image which wil reduce the photographic grain in the image and then we will apply the unsharp mask. Now, the likelihood that noise will get enhanced in the final image gets reduced
- The amount of gaussian blur required for an image to achieve the optimal result may be varying from image to image. So, in the interface which we have provided, the user can actually choose how mych blur to apply and check for which values is the result better than others.
- After we apply the unsharp mask, we use contrast stretching to balance out or normalize the varying intensities in the image. Now, the amount of contrast stretching required for each image may be different. So, we have provided an interface where the user can chose how much stretching to actually apply.
- Finally, as our method is not perfect, there may be visible noise which might have been enhanced by our method, so we apply a median filter to reduce the noise. In this case too, the user can choose whether to apply the noise reduction filter or not.

IV. RESULTS

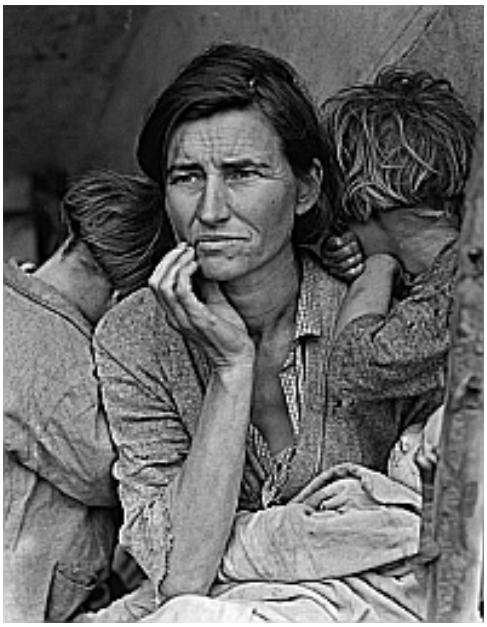
Let us describe a sample case where we test our approach. Al l the steps which have been used in our technique will be shown with the state of the image after each step.

A. *Input Image*

We took a sample grayscale image which is very popular in the image processing field. It would help in comparing the results with various other techniques.

B. Applying a Gaussian Blur

C. Apply Unsharp Masking with Contrast Stretchng



D. Applying Noise Removal

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