

Implementation of Image Deblurring Techniques in Java

Peter Chapman

Thomas Jefferson High School for Science and Technology
Alexandria, Virginia

November 2, 2007

Abstract

A countless number of photographs are taken every day, and inevitably many of those suffer from some sort of blurring. A program that would be able to take a blurred image and restore the photograph back to its original, deblurred form would be invaluable. Anyone from law enforcement trying to read a blurred license plate on a getaway car to a family attempting to refine their grandfather's smile would find such a piece of software useful. In my implementation I attempt to deblur images suffering from simple types of motion blur using the alternate domains granted by the use of Fourier transformations and a basic understanding of image deconvolution.

Keywords: Fourier Transformations, Spatial Domain, Frequency Domain, Phase Domain, Deconvolution, Fast Fourier Transformation, Cooley-Turkey Fast Fourier Transformation Algorithm, Discrete Fourier Transformation

1 Introduction

Photographs are utilized in many different fields with a seemingly infinite number of uses. Whether in scientific experiments, law enforcement, or simply recreation, a blurred image is often a useless one. A program that could reverse the damages created by the motion blur or any other type of blur would be extremely useful. Such functionality may be prove to be so valuable

that it could be bundled into the software of cameras and performed automatically after each shot, or even built into the photo software that comes standard on many computers today. Due to the complexities involved in the image deblurring process my research assumes that the as part of the input the application is given a general overview of how the image was blurred. In addition, to further simplify the project, I will only deal with motion blurred images.



Figure 1: Photograph from a taxi suffering from motion blur (Raskar, Agrawal and Tumblin).

2 Background

Due to the value of a program that can deblur images, many have tried to create an all purpose deblurring program, but few have found much success with a general approach. The tendency in the field is to focus on motion blur and narrow the application of the program in order to get a more effective program for a smaller range of tasks. In one project, the researchers decided to consider only motion deblurring using a modified camera that allowed the researchers to extract extra data from a series of photographs (Raskar, Agrawal and Tumblin). The results were phenomenal (Figures 1 and 2). But, it is possible to have some success with more general applications, such as that found in the work of M. D. Cahill. His program, called Unshake, attempts to reverse the motion blur on nearly any image. Although it works

relatively small motion blurs, such as those less than ten pixels, it simple cannot handle blurs as severe as more specialized programs can.



Figure 2: Deblurred photograph (Raskar, Agrawal and Tumblin).

In order to reverse the blurring process it is necessary to consider the subject area in a mathematical context. Therefore, if the blurring process is considered a mathematical function, it must be reversed; to do so, it is necessary to understand how the image was blurred: direction, type (motion, out of focus image, etc.), magnitude. In order to accomplish this, it is necessary to visualize the image in a different domain. Normally we only view images in the spatial domain, but if the image is converted into a series of sin functions through a mathematical technique known as a Fourier transformation (Figure 3) it is possible to view the image in the frequency domain (Gonzalez and Wintuz). Once in the frequency domain, it is possible to analyze the image in a more advanced and perform operations in a more generalized way. It is understood that the Fourier transformation of the original image multiplied by the Fourier transformation of the blur (a five pixel horizontal line corresponds to a five pixel blur) produces the Fourier transformation of the blurred image (Figure 4). Thus, the blurred image divided by the blur factor should produce the deblurred image (Cahill). The most difficult part of this process is determining what the "blur factor" was when the picture was taken. In theory, if one can determine how the image was blurred, it is possible to blur the image. This entire process is known as deconvolution (Cahill).

$$F(u, v) = \frac{1}{NM} \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} f(x, y) e^{-2\pi i \left(\frac{xu}{N} + \frac{yv}{M} \right)}$$

Figure 3: Equation for a 2D Descrete Fourier transformation (Bracewell).

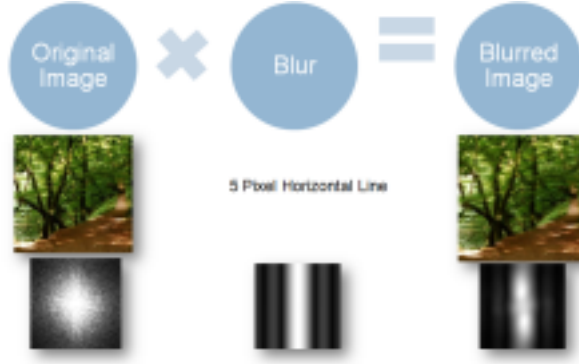


Figure 4: The blurring process with images taken from Cahill.

3 Rendering the Fourier Transformation

The first step in the deconvolution process is to render the blurred image in the frequency domain using the Fourier transformation. The general formula for a Fourier transformation requires a continuous function. Since an image can seldom be represented as a continuous function, it is necessary to treat the image as a set of values in a limited domain. Using the formula for the discrete Fourier transformation (Figure 3) it is possible render the Fourier transformation of the image. A 2D discrete Fourier transformation requires every single point to perform a calculation on every other point, resulting in an extremely slow $O(N^3)$. As a result it is necessary to use a faster implementation of the Fourier transformation. The Fast Fourier transformation (FFT) is a process that allows one dimensional data sets to be rendered in the frequency domain in $O(N \log N)$ time. Since the sum in the discrete Fourier

transformation can be separated, a two dimensional Fourier transformation can be rendered quickly by applying an FFT to the rows and then to the columns.

References

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