

# TJHSST Computer Systems Lab Senior Research Project Image Deblurring 2007-2008

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November 2, 2007

## **Abstract**

Either for recreation or for work, everyone has taken pictures before; inevitably with taking photographs, everyone's had blurry images. Whether, the target of the image moved, the camera itself moved, or the lens was simply out of focus, blurry images are often useless. The common misconception is that it is impossible to "deblur" a blurry image. In reality, if you know a little information about how the image was blurred, or can predict how the image was blurred, it is possible do some repair on the image. The restoration of blurred images can be applied to everything from vacation files to photographs taken by law enforcement in order to identify a license plate or even a face. A program that can adequately restore these images would be invaluable.

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

## **1 Introduction**

### **1.1 Scope of Study**

The image de-blurring process is relatively simple, but extremely difficult to perform correctly. Although there are many variables involved when doing the deblurring process, the most important is how the original image was blurred. Questions such as what type of blurring the image is suffering from

whether it's motion blur or not properly focused, and what direction or directions the blur is in, must be answered adequately in order to perform the process correctly. These issues can either be addressed by the program automatically in an extremely difficult process known as Automatic Deconvolution or by the user. Due to the complexity of Automatic Deconvolution and the time constraints on this project, I will not attempt an in-depth automatic deconvolution, but rather have such variables chosen by the user.

The final product will load any popular type of image, and after prompting the user for certain variables questioning how the image was originally blurred, attempt to de-blur the photograph. I only expect the program to handle simple types of motion blur where the object has moved opposed to the camera, not unfocused images or any others of that sort. Perhaps, the final application will be able to handle complex types of motion blur, but such estimates are difficult to make at this stage of the process. My first goal is to develop the software necessary to evaluate and manipulate the image in the Frequency domain, opposed to the spatial domain that we see in a conventionally displayed photograph. To move the image into the Frequency domain, I will need to code the Fast Fourier Transformation process that will perform the Fourier Transformation in a relatively quick fashion when compared to the Discrete Fourier Transformation. Once I can move the images in-between the Spatial and Frequency domains, I will start to perform the basic operations of the de-blurring process. These operations consist of a sort of division performed by another image representing how the photograph was blurred (ex: a motion blur five pixels to the right will require the Fourier Transform of the image to be divided by the Fourier Transform of a five pixel bar). I will be able to break the process up further once I am deeper into my research.

## **1.2 Expected results**

The benefits of an advanced image de-blurring application are nearly endless. The current technology can function part of the time in only a handful of select situations. Although the results of this project may not significantly increase the knowledge of the field immediately, I hope that some of my research can serve as an introduction to others planning on experimenting in image analysis.

Once my program is able to do simple image de-blurring, I wish to investigate new techniques in automatic image deconvolution, the process that

determines how the image was originally blurred. Any advances in this area of the process or simply an inspiration to others to improve the current state of automatic image deconvolution would be seen as a great success.

### **1.3 Type of research**

This project hopes to improve the understanding of the field, but with a primary motivation towards use. There are many large and extremely complex papers written on the topic, especially those that cover the field of Fourier transformations, but few of which actually produce an application for the average person apply to their own personal set of photographs.

## **2 Background and review of current literature and research**

Many others have attempted to create a general purpose image de-blurring application, but most have been relative failures. On the contrary, those who targeted a specific type of blur in a specific scenario have been able to produce fascinating results. An application built by the Mitsubishi Electric Research Lab (MERL) was designed for objects moving in one dimension. The MERL project further enhanced the general process for image deblurring by modifying the camera to take many photographs in a short period of time. The software then compares the photographs to get a much better estimate of how the image was blurred, and therefore a much cleaner de-blurred image. Other projects have attempted automatic deconvolution. M.D. Cahill has released his personal attempt at automatic deconvolution with some very successful de-blurs in certain cases, but it should be noted that in my informal tests of his program I got adequate results at best. Since automatic deconvolution involves a full university course to completely understand, it may be best to avoid such a subject. Even attempting to understand the code of other researchers such as Cahill, may prove frivolous.

## **3 Procedures and Methodology**

I have already completed the initial research and now have a basic understanding of the process. First, I need to improve my ability to convert an

image into the frequency domain through a Fourier transform. My current implementation is simply too slow, and I will need to utilize a Fast Fourier Transformation opposed to the discrete Fourier transformation. Next, I will need to correctly reverse the process in order to render an output image. Afterwards I can start attempting simply de-blurring. I plan to do all of the code in Java, making the application multiplatform and developer friendly. I am also currently implementing the JScience library in order to perform the advanced complex operations involved in the Fourier transformation.

The project, being in the field of image processing, revolves almost entirely visual data. Unlike other projects that may have to generate images that represent data, the data in my project is a collection of images.

Another interesting aspect of this project is that the results are largely subjective. It is extremely difficult to illustrate definitively the difference between a slightly blurred image and a relatively crisp one. On the other hand, it is quite obvious in the frequency domain when errors have been committed. There are a wealth of resources, and textbooks, dedicated to Fourier transformations; it will be very easy to compare my output with that of other applications.

It is essentially impossible to allow my application to accurately and reliably self-verify its output. But, it is possible, with the implementation of small de-blurring scripts written by others in the open-source community to have to program generate sample data and perform the de-blurring algorithm. Based on the speed of current applications, I am estimating that the process for a medium size image will take as much as five to ten minutes, and inevitably, someone will have to check that the program is outputting the proper data. Testing will be a very difficult stage of the process, but I look forward to the challenge.

My application will take an inputted blurred image of relatively small dimensions and with the user specifying how the image was blurred attempt to output a de-blurred version. The program will perform multiple Fourier transformations and run in an understandable amount of time, no greater than twenty minutes on a medium size image. If there is time remaining before the end of the course, I also hope to explore the possible of automatic deconvolution and perhaps attempt some sort of implementation.

## 4 Expected Results

The goal of this project is not only to reinforce our currently understanding of image deblurring algorithms and Fourier transformations, but also to create an accessible program for users without any formal training in computer science to deblur images. The most appropriate way to display outputs will be in the form of before and after pictures in conjunction with interval Fourier transforms found in order to render the output.

Assuming that I am able to complete the basic image deblurring, future researchers could expand upon my work by investigating and implementing automatic deconvolution thus freeing my program from the bounds of correct user input on how the image was blurred.