TITLE SLIDE - AG

Hello, we are Gloria Diederich, Alyson Grassi, and Molly Nichols.

We have chosen to discuss image deblurring and its relationship to matrix theory as well as its practical applications. In particular, we will focus on a topic of interest in real-world applications known as blind image deconvolution.

OUTLINE SLIDE - AG

We’ll first walk through a quick introduction to the problem and why it is significant, along with introducing some relevant terminology. We’ll then move into more details about the model of the problem. Finally, we’ll show some results using Matlab.

WHAT IS IMAGE DEBLURRING SLIDE - MN

First we ask – what is image deblurring? Essentially, it is what it sounds like. Given some degraded or blurred image, we would like to recover as much information as possible about the source image and restore that quality to it.

Images have become ubiquitous, for personal, public, and scientific purposes. Images are extremely useful for things like security footage, medical screening, remote sensing and astronomical exploration. Of course, we’d like the highest possible quality images for these applications, but there are numerous issues that could occur, such as motion blur, incorrect system calibration, unexpected environmental effects, transmission errors, and many more. Ultimately clarity in images can define the results in certain fields of research. Image deblurring can help us achieve the necessary image quality for serious applications like these.

As demonstrated earlier in this course, matrices can represent images and therefore the theory behind matrices is inherently present in this application.

WHAT IS BLIND DECONVOLUTION SLIDE - MN

If we think of the blurred image as a convolution of two sources (the image of desired quality and the blur), we can begin to develop a mathematical process of acquiring the ideal image. This is more straightforward when we know how the image was degraded – we could use the convolution and the degradation to find the ideal image, basically reversing the blur’s affects. A more prevalent problem in real world applications is when there is no precise prior knowledge of the image degradation. This is a harder, but very relevant, problem, since the convolution of the two sources can be observed, but neither the blur nor the ideal image is known. This makes acquiring the ideal image more difficult. The separation of the blur and the image, is called “deconvolution”, and achieving this without knowledge of the sources is known as blind deconvolution. The solution to this problem generally involves some sort of iterative process or algorithm to find the maximum likelihood estimate of the two sources.

MODEL TERMINOLOGY - GD

In order to construct our model, we define g as the convoluted signal of the ideal image and blur, f as the image source or ideal image, h as the Point Spread Function, a mathematical expression used to define the effects of the blur, and n as additional noise. The basis of our model is shown in the first equation. The bottom graphic shows how g is created. Our goal is to go backwards to find both h and f ultimately. These functions have 3 dimensions, x, y, for pixel location and a z for the image data in that pixel.

MODEL ALGORITHMS – GD

On the right is a graphical display of a general algorithm used to achieve blind deconvolution. In general, we start with a guess, and use a variation of Fourier transforms, imposing plane constraints, forming new estimates and taking inverse Fourier transforms. The Richardson-Lucy algorithm is the process we will examine specifically.

The collected image data has a likelihood of being produced by a particular source because of the random nature of quantum photon emissions. The Maximum likelihood estimation is a method of creating best estimates of data effected by random noise by finding the estimate of f, the source, from the convolution equation that is most likely to have given rise to the data collected.

This is achieved by creating a ``logarithmic-likelihood function'' representative of the likelihood that a certain level of noise is measured in the collection of data. This functional, a function of f(), h() and g(), is solved iteratively to calculate its maximum value. A reconstructed image, f(), and reconstructed Point Spread Function, h(), are found using an iterative search. A more detailed look on this algorithm, called the expectation- maximization (EM) algorithm, is given in Holmes.

Matlab uses the Richardson-Lucy algorithm in its software for blind deconvolution. This algorithm operates under the assumption that the original image was degraded due to any of the aforementioned causes and these can be represented with a Point Spread Function. The Richardson-Lucy algorithm employs the expectation-maximization algorithm in order to determine a restored image with the best quality. Thus, this algorithm assumes that the degraded image was formed through a Poisson process meaning the degraded image has signal-dependent noise corruption.

MATLAB IMPLEMENTATION - AG

In order to show the significance of deblurring, we investigated Matlab’s function deconvblind and have prepared some results from using it. With a small amount of code, you can restore an image to a more ideal form. The key to using the algorithm is a good initial guess of the blur and a weight array determined from the edges of the image. Otherwise, it’s hard to restore the image. On this slide is an example from one of the papers we’ve referenced. On the left is the source image. Next to that is the blurred image using a known point spread function. The weight array photo shows the results of edge detection to help clear up the necessary focal points of the image. Finally, on the right is our deblurred image that took into account the size of the Point Spread function and the weight array.

CONLCUSION - AG

By thinking of a blurred image as a convolution of the blur and the clear image, we use algorithms that find the maximum likelihood estimates for image and blur from initial guesses. Image deblurring is essential in specific fields of research and matrix theory is a crucial aspect of it. With matrix theory we are able to construct the image data and use the algorithms to enhance or restore images. With the availability of built-in functions within Matlab or other software packages, researchers can get the needed clarity to adequately categorize their findings. Blurred images negatively affect many fields including astronomy, security, biology, and history, and Image deblurring through blind deconvolution is a critical component of gathering data and information in each.