Making Blurry Images
A Thing of the Past

My family loves to take pictures. We see stars on Christmas Eve, not from the twinkling night sky, but from the hundreds of flashes coming from my mom’s and aunt’s 35 mm cameras. When asked why they take so many pictures, they always respond, “Just in case some of them don’t turn out.”

Nowadays, the convenience of digital cameras allows us to immediately see our picture and take another if we are unsatisfied. But what if it costs $5,000 to take one picture? Would you pay another $5,000 if the picture was blurry or contaminated with specks of dust? Instead, I think you would try to fix the image you already have. With the help of advanced mathematics and high-performance computers, researchers are finding new ways to take the blur out of images.

You may be wondering what kind of picture costs $5,000. One example is a medical image from a device called a PET scan. This particular camera can scan for cancer, detect Alzheimer’s disease and diagnose heart disease. But the image will be blurred if the subject fidgets. Performing the scan again is costly, not to mention possibly detrimental to the patient’s health. The radiologist, which is just a fancy name for a doctor who interprets medical images, must now face a blurred, degraded image of, say, your heart. She has no hope of a clearer image.

The goal of my research is to take that blurry image and work backwards to “undo” the blur. The reconstruction must be done using a computer. As a computational scientist, I work to develop sophisticated algorithms or instructions for the computer.

Now, a good detective knows that prior to starting any major operation, we need the proper tools and research. That is, we need some knowledge about our problem. The first line of investigation is determining what caused the blur. There could be many culprits; one example is motion blur. If you take a picture of a fast-moving car, you may see lines and streaks in the image. Many photographers desire this artistic effect, but medical doctors and radiologists want to eliminate it. To alleviate the smearing effects, the radiologist will ask you to lie still during the test. No matter how hard you try, you will breathe, itch, sneeze and/or twitch, thereby causing motion blur in the image.

Once we know the kinds of blur contaminating our image, the next step is to arm ourselves with the tools needed to do the reconstruction. We start with the basics. A digital image is a picture sitting inside a computer. Each image consists of pixels that snap together in a grid-like formation. Each pixel has an associated value, like each tile of a mosaic has its own color. A typical medical image has a grid of 256 pixels by 256 pixels, giving a total of 65,536 pixels in the image. That’s equivalent to the seating capacity of a large football stadium. Now imagine we line up all the players and fans into one single-file line and assign each person a number. This is similar to how images are stored in the computer. We organize them by putting all 65,536 pixel values into a very long list, making it easier to access each value individually. Remember that our goal is to “undo” the blur in the image. Thus, it is important to understand what happens during the blur process. We do this through mathematical modeling, which is just a fancy expression for using math to explain real-life phenomena. For example, suppose we want to model

Motion blur makes it difficult for radiologists to image the heart and surrounding organs. The heart beat and natural blood flow could be the culprits, but patient fidgeting also contributes to the problem.
Medical images often are blurry. This one is significantly degraded by motion blur.

motion blur. Imagine a scenario in which we paint red, yellow and blue stripes side-by-side on the wall. While the paint is still wet, a child runs his fingers straight through all the colors. The mixture of paints causes a rainbow of colors to appear. In the same way that the motion of the kid’s hand causes the colors to mix along the wall, motion in an image causes an average (or smearing) of neighboring pixel values. Mathematically, this phenomenon is characterized by a formula we learned in elementary school: to compute an average, sum up the values and divide by the total number of items. Since a typical image has 65,536 pixels, we have to do this “averaging” 65,536 times! That’s a lot of values to manage, so computational scientists conveniently store the information in a large table. This is where computers are helpful and important. Not only do we have to store all of these numbers, but massive computing power also is required to execute instructions that work with these huge tables.

So far, we seem to have everything needed to perform the reconstruction, but we have overlooked the most notorious villain of all: the “specks of dust” on the image, which scientists call noise. Looking at an image degraded by noise is like trying to see an image behind the black and white static in a bad TV transmission. Due to the random or accidental nature of noise, the chance of us ever getting back to the exact original image now is like finding a pin in a haystack the size of China. I and many other researchers are trying to solve this problem. No definitive answer has been found, but we will NOT give up.

Even though we cannot reconstruct the original image, many computational mathematicians and researchers are investigating ways to get a good approximation. With the advent of novel mathematical techniques and the help of modern computer technologies, we are getting closer and closer to finding a reliable and automated way to “undo” the blur in any image. Clearing up blurry images is important to many aspects of life, whether to clear up the motion blur in your $5,000 PET scan or to avoid taking yet another family photograph. With my research, maybe one day I will be able to convince my family that one picture is enough.