

1 Zoom and Enhance, Hollywood Style

Many of us have been awed by the amazing technologies portrayed in the Hollywood productions, in both television shows and movies, which allow the good guys to catch the bad guys. Although entertaining, it's amazing how many people assume these capabilities are real without any hesitation. I personally find it fun to explore these capabilities a little deeper to ascertain if the necessary technology is real, fantasy, or somewhere in between. Of particular interest to me are the incredible imaging systems and image processing methods we see in the Hollywood productions. A great example is the incredible ability of investigators to “zoom and enhance” images to obtain finer and finer details until they have the critical piece of evidence necessary to put the bad guy away.

When we wish to see better details in an image, our first attempt is usually to zoom in on the area of interest by magnifying the image to a larger scale. We may also enhance the contrast and even use a sharpening filter to see the details better in the image. This seems pretty straightforward, but Hollywood productions lead us to believe that our experience is different from the experiences in crime labs or secret research facilities. The television shows and movies seem to indicate that there is really more information in the image than simple folks like us can pull out. As a matter of fact, it seems that the technicians working on the image seem to forget that they have this amazing capability until the star of the show suggests it to them. I'm waiting for the time a technician says “Seriously? I wouldn't be good at my job if I hadn't already thought of that!” So can investigators really zoom and enhance these images to the incredible level of detail we see in the Hollywood productions? My haircutter certainly believes so.

Questioning the amazing results we see from the zoom and enhance process portrayed in the Hollywood productions gives us a great opportunity to delve into a tutorial on the image resolution that a digital camera and image processing can really provide. The specific example that we will explore is the depicted capability of crime scene investigators to zoom and enhance on the reflection of an eye in an image to reveal the identity of an assailant (Fig. 1).

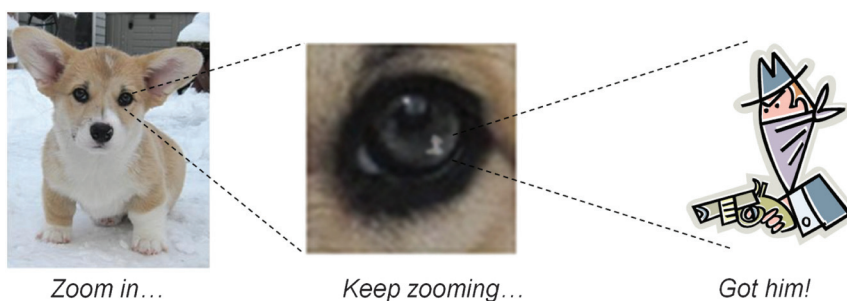


Figure 1 If we believe what we see in Hollywood movies and television shows then catching a criminal is as easy as zooming and enhancing on the reflection of a witness' eye.

1.1 Modeling camera capabilities

The image quality produced by a camera can be accurately predicted by modeling the step-by-step process that creates the final image we view. This process is called the imaging chain, which begins with a light source and ends with an interpretation of the image (Fig. 2).

Modeling the imaging chain will mathematically replicate the physical steps that create the final image and allow us to understand the key elements that drive the final image quality. Most importantly, the imaging chain will tell us the limitations of the final image quality that a camera can produce, i.e., the imaging chain will tell us what a camera can and cannot do.

First, let's look at whether or not it is possible to identify somebody from the reflection on an eye in a photograph. The answer is a simple "yes" and we don't need to model the imaging chain to answer the question when we can simply take a photograph to see it. Figure 3 shows an example of an actual photograph captured with a 12 megapixel consumer camera that clearly shows my face in the reflection of the dog's eye. (Note that I held the camera to the side of my face so that the camera would not obscure my face as I took the picture.)

OK, but this is not quite the scenario that we see on the crime investigation shows. For this photograph, the camera was approximately 10 cm from the dog's eye when the picture was taken and the lighting conditions were just right to catch my reflection. The scenarios that we see in the Hollywood productions typically have the camera several meters away from the individual's eye, so to address these scenarios let's see what resolution capabilities the imaging chain has to offer. First, we will look at the camera's capability to capture the necessary resolution then we will look at the capability of current processing schemes to enhance the image resolution.

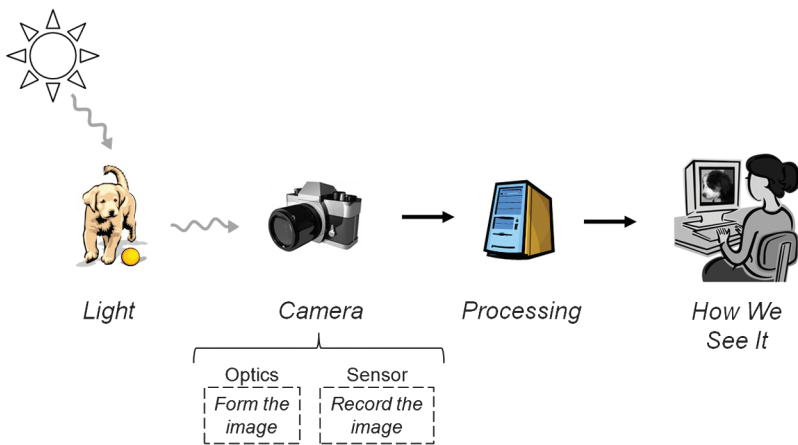


Figure 2 The fundamental links of an imaging chain.