Alan Pierce
pierceaj@optontine.net

Refocusing Photography

Photography is all about catching a moment in time so it can be shared with others. In film photography, light, hardware and chemistry play Specific roles that lead to production of the final photographic print. The only memory involved in the film photography process is the one sparked when you relive the original experience as you view the photograph.

In digital photography, the camera's charge-coupled device (CCD) chip has millions of photo diode pixels. Each pixel cell converts the light that strikes it into an electricaicharge.Individualanalog charges are converted to digital format so they can be saved in the camera's memory as a data file. A computer program converts the data file's string of 1s and 0s into *a* photograph.

Digital photographs are actually software-rendered images created by piecing together the digital information stored in data files. If you can increase the amount of information stored in a file, you can increase the photographic possibilities when the file is later converted into a picture,

Ren Ng, a Ph.D. candidate in computer science at Stanford University, envisioned a more powerful digital camera, and he developed a research project to test his camera theory He now leads the Stanford University research project that might eventually alter the picture-taking properties of future digital cameras. Ng's team has developed the hardware and software needed to enhance the information-gathering abilities of the photo diode pixels in a digital camera. The resulting enhanced digital file allows a photographer to refocus completed photographs to change a picture's depth of field. The photos shown in this column were created from the same photograph by manipulating the enhanced data that the experimental camera gathered when a single picture was taken.

Refocused photos show **changes in a picture's depth** of field.

Photos courtesy of Ren Ng

The research camera that the Stanford team designed gives a photographer the ability to separate camera sections to alter or enhance camera components. To enhance digital information, researchers placed a microlens array over the camera's CCD chip. If you look carefully at the back section of the research camera on the next page you can see the microlens array fastened over the camera's CCD chip.

The goal was to have each microlens of the array enhance the information-gathering abilities of the pixels that they covered. Each microlens caused the pixels under it to capture a slightly different image of the same scene.

You can best understand the technology if you think of the microlens array as an artificial compound insect eye. The pixels of the camera record multiple images with multiple points of focus. The image's text file holds all the information for the separate pictures, and software sorts it out, giving the photographer the ability to create pictures with different points of focus.

The compound characteristics of each microlens allows the pixels to measure the light intensity that they receive, as well as the specific path the light ray took through the microlens to the sensor. The software that Ng's team has developed allows a photographer to refocus photographs by separating the multiple images to create the desired point of focus. The software can also be used to create synthetic photographs by combining different points of focus, as if the viewer sees the image through the compound eye of an insect.

I asked Ng what he considers the main obstacle to overcome to allow this technology to find its way into consumer products. "The main problem is that we need sensors

---

Alan Pierce. Ed.D., CSIT, is a technology education consultant, technical writer, and public speaker on technology issues.

Research camera used to develop the new technology

with higher resolution than we currently see on the market," Ng replied. These much larger CCD sensors are needed because a camera with a microlens array splits its pixels so they are simultaneously recording different pictures.

The other members of the team from Stanford University are professors Marc Levoy, Pat Hanrahan, and Mark Horowitz and graduate student Mathieu Brédif. The team also includes Gene Duval from Duval Design. To learn more about this technology, start your Internet research at http://cs.stanford.edu. Also view the Stanford **Tech** Report CTSR 2005-02 at http://graphics. stanford.edu/papers/lfcamera.

Recalling the Facts

1. Film and digital photographs can look alike. Describe significant differences.

2. How does the microlens array affect the individual pixels that fall under each microlens?

3. Do you think consumers would want to own a camera that could change a photograph's focus long after pictures were taken? Why? ©