

# COMPUTER VISION

## Inside The Human Body

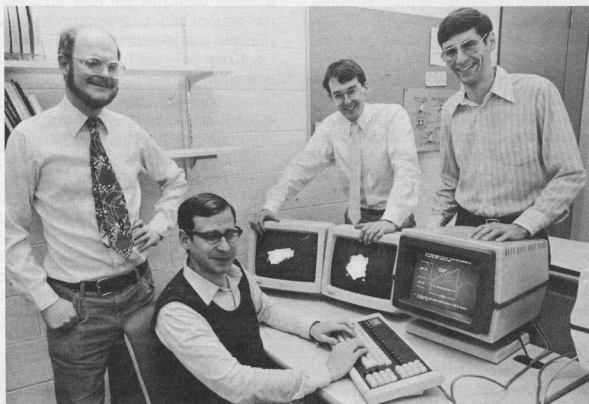
The University of Pennsylvania has developed a prototype 3-D imager and will soon produce 4-D images. Success depends on venture funds.

by Marc Nichols

**A** robotics research project and a class assignment to formulate a hypothetical business plan have led to the establishment of a new company, Dynamic Digital Displays, Inc. (3D, Inc.) of Bala-Cynwyd, Pennsylvania. This company is committed to the development and commercialization of ultra high performance three-dimensional computer imaging workstations for a variety of applications including medicine, manufacturing, oil exploration, and even art — anything where interactive display of high resolution 3-D images are useful.

The project began at the University of Pennsylvania's School of Engineering and Applied Science, where basic research is underway on intelligent robots — machines which can sense, manipulate, and understand their environment. This work is directed at understanding the basic problems that need to be overcome before the industrial and household robots of the future can be developed and commercialized.

While intelligent robots at Penn and elsewhere are at least 15 years away from realization as practical machines, another aspect of this effort is at the point where it can be moved from the research lab to commercial development. The Penn researchers have developed sophisticated computer hardware and software that is capable of displaying realistic three-dimensional (3-D) images from data obtained from modern medical imaging systems such as Computer Tomography (CT), Magnetic Resonance (MR), and Positron Emission Tomography (PET). These displays are fully interactive — the images can be rotated in any direction, sliced open, and



3D, Inc. founders around their prototype imager.

segmented into bone or soft tissue — and all operations happen instantaneously.

According to Dr. Samuel Goldwasser, assistant professor of computer and information science and co-director of the General Robotics and Active Sensory Perception (GRASP) Laboratory, a series of two dimensional slices obtained from a standard CT, MR, or PET examination can be stacked to form a 3-D image that a diagnostician, surgeon, or medical researcher can manipulate interactively. A physician's workstation incorporating a small scale prototype of a machine based on this research has been implemented.

For example, CT scans of a patient's head can be displayed on a computer screen, and using a trackball or other graphics input device, the skull can be rotated instantaneously in any direction to view

the data from any direction. The skull may be sliced open electronically to view internal structures such as the sinuses, optic nerve or lens of the eye, or brain.

Since the various tissues of the body show up in different shades of gray on the CT or MR scans, the computer can isolate such structures as bone, soft tissue, or tumors. These can be manipulated to show their relationship to surrounding tissue.

"This kind of capability has just become feasible" says Professor Goldwasser, who developed the computer technology on which the system is based. "Three-dimensional display of medical data is being used experimentally. Our system, called the Voxel Processor, is fully interactive and manipulates images in true real-time. This means that the user never has to wait for the system to

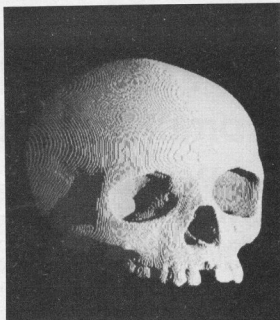
T. BURNS

respond—any new view requires less than one-fifteenth of a second to be generated. The trackball moves the 3-D image as though it were directly connected to it.

"The Voxel Processor is based on technology that is approximately 1000 times faster than the fastest known software based systems and 20 times faster than the fastest known hardware based systems available commercially or under development elsewhere."

In other systems, there may be a delay of 30 seconds or more between the time a move instruction is given to the computer until a new view appears on the computer screen. This delay makes precise manipulation virtually impossible and extremely frustrating.

"The advantage of true real-time motion is that it provides important depth cues which greatly enhance 3-D perception. Furthermore, you can adjust the orientation until the precise structures of interest come into view. For example, an image of the spinal column may be rotated until the interior of the spinal canal becomes visible, to reveal an abnor-



*A high resolution 3-D computer image of a human skull.*

mal internal bone growth. This type of precise adjustment would be extremely difficult with a 30 second delay. The difference between even a one second delay and a true real-time is the difference between a slide show and a movie," says Goldwasser.

There are certain limitations to the prototype, however, which was constructed on a small budget

by three students for academic credit. Goldwasser and his colleagues can produce extremely high resolution detailed images — some of the best available — but these cannot be manipulated in real-time.

The prototype hardware can handle small sections of full datasets or display reduced resolution images of full datasets. But by using advanced parallel processing techniques new systems are being designed that will support full size medical datasets without any loss in real-time performance.

In addition to developing the basic hardware and software, interactive techniques are being investigated to permit non-computer scientists to use the system. The physician's workstation is designed to be usable by diagnosticians, surgeons, or other end users.

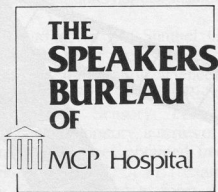
The idea of actually pursuing the commercial development of the technology occurred after Dave Talton, a Penn student completing a joint degree in engineering and business, entered the picture.

He had to create a detailed busi-

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