

## PC-Based Three-Dimensional Volumetric Imaging

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**The Challenge:** Searching for a quick, easy, and inexpensive way to interpret three-dimensional data.

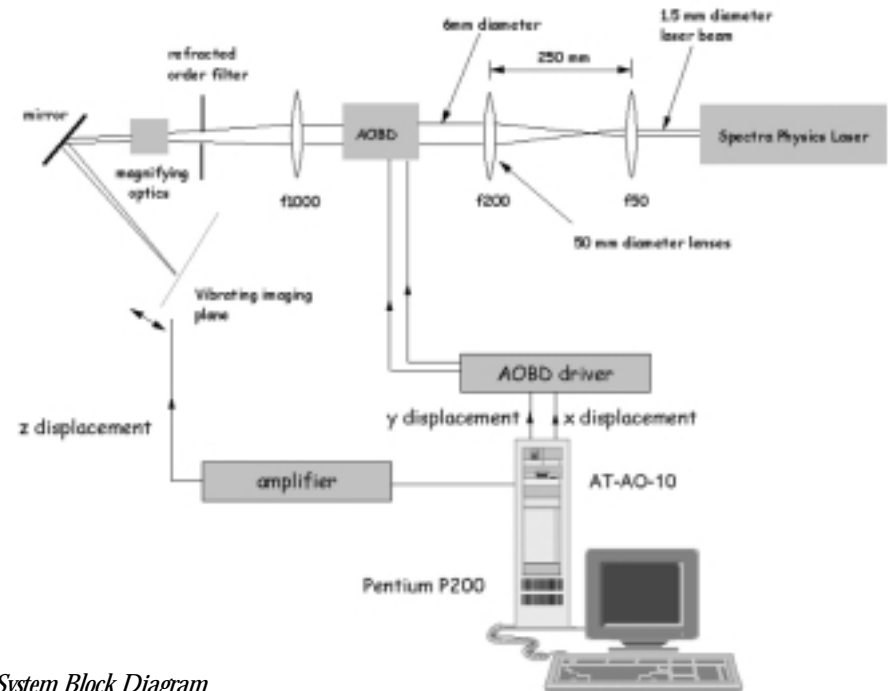
**The Solution:** Creating a PC-based three-dimensional imaging system from an off-the-shelf reasonably priced argon laser, acousto-optic beam deflectors, and a National Instruments AT-AO-10 board.

### Introduction

Engineers and scientists have always relied on their own imagination for interpreting three-dimensional (3D) data by its representation as a two-dimensional (2D) image. In the past, this was usually acceptable because most calculations and data were in a 2D domain. However, with the advent of powerful computer-aided engineering packages and 3D flow-measuring techniques, the amount of data in a 3D domain has increased significantly.

Today, it is not uncommon for engineers and scientists to carry out computational analysis of 3D transient, structural, and fluid-flow problems. To complement this, experimental techniques in fluid mechanics have advanced so that it is now possible to measure velocity vectors in three dimensions. It is evident that the amount of 3D information produced is expanding rapidly and the possibility of useful interpretation is lagging behind. If it were possible to develop a computer-generated, 3D image of this data, then engineers and scientists could efficiently arrive at an accurate interpretation of the information contained within the data.

*We selected the AT-AO-10 board because of its low-cost, multiple-output channels, excellent dynamic characteristics, and FIFO buffer.*



*System Block Diagram*

To fill this market need, we developed a 3D imaging system known as planar contour imaging so that engineers and scientists can more accurately interpret 3D data. We used an imaging system consisting of an argon ion laser that draws two-dimensional shapes on a translating plane. We steer the path of the laser beam quickly to generate a 3D image. We steer the beam in the XY plane with two A.A. acousto-optic beam deflectors (AOBDs) and the translating plane generates the third direction, Z. In this way, we can draw a point of light, known as a voxel (volumetric pixel), in three-dimensional space.

### System Hardware

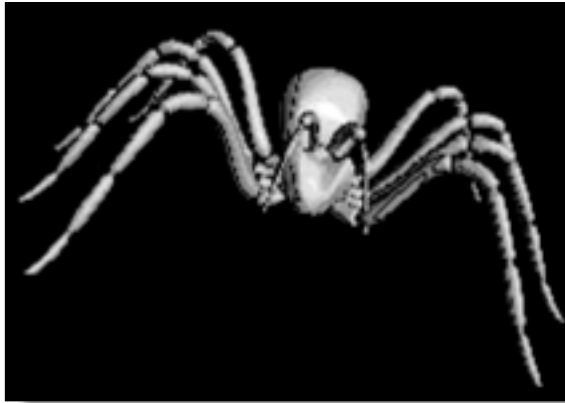
The planar contour imaging system consists of a Spectra Physics laser that produces a beam approximately 1.5 mm in diameter. The beam passes through two lenses, of 50 mm and 200 mm focal length, separated by 250 mm to produce a 6 mm diameter collimated beam, which then passes through the optical cavity of an A.A. DTS.XY.400 AOBD. Through an adjustable iris, we pass a single refracted, first-order beam onto a

f1000 lens, which focuses the scanning laser beam into magnification optics. The system then focuses the magnified images onto a translating plane assembly. You can see a schematic of the optical setup in the figure. The volumetric imaging system is controlled by a 200 MHz Pentium PC fitted with a National Instruments AT-AO-10, an ISA plug-in analog output board, that controls the AOBD. We selected the AT-AO-10 DAQ board because of its low-cost, multiple output channels (the color imaging system needs seven analog outputs), excellent dynamic characteristics, and first in first out (FIFO) buffer. We controlled the board with NI-DAQ driver software, programmed in Microsoft Visual Basic.

### System Block Diagram

To create the high-data rate required, we used the waveform generation properties of the AT-AO-10 DAQ board. We downloaded voxel location data to the FIFO buffer on the DAQ board. After we fed the data to the board, it was theoretically possible to output data at the rate of 300,000 kHz maximum.

We controlled the AT-AO-10 with code written in Microsoft Visual Basic, which offered a user-friendly interface for manipulating the data and controlling the image-generation process. We found that the AT-AO-10 could write error-free data at rates up to only 110 kHz because of the large amounts of data and the limitations of the ISA bus. Even though this rate was not the highest possible with the board, we could create volumetric images with 1500 voxels at 25 Hz or 7,500 voxels at 5 Hz.



Image



3D Image

## Results

The figure shows a photograph of the three-dimensional image generated from a stereo lithography file created by a CAD package by Delcam. The data set was from a file named boris.stl, hence the spider is often referred to as Boris. On the left is a 2D screen shot of Boris. A photograph of the 3D image of Boris, containing 8,000 voxels, is shown on the right. The photograph of Boris is a fully 3D object that you can view through 360 degrees of azimuth and 180 degrees of elevation. We have also applied this apparatus and technique to the

presentation of scientific data. We can visualize velocity vectors measured experimentally around a bubble growing from an orifice in three dimensions. We created an interface with a commercial computational fluid dynamics (CFD) program for presenting the CFD velocity vectors in three dimensions.

*The system has a wide range of uses in the scientific, engineering, design, and entertainment industries and has been used to visualize such things as automotive, aircraft, and human figures.*

## Conclusion

We have successfully developed a 3D imaging system capable of creating computer-generated images of data from CAD packages, CFD simulations, and experimental data sets. The system uses only components that you can buy off the shelf. This system, which has a wide range of uses in the scientific, engineering, design, and entertainment industries, has also been used to visualize things such as automotive, aircraft, and human figures. ▽

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