Intel Technology Helps Robotics Students Create Cutting-Edge 3-D Vision System

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Executive Summary

The award-winning robotics team at Carl Hayden Community High School is a group of engineers in the making — students who tackle the tough stuff with ingenuity, technology and determination. The team recently took on an especially tricky problem: How to provide the navigator of a remotely operated vehicle (ROV) with a realistic view of what the robot sees.

The project couples an innovative design with cutting-edge hardware and software, including a powerful Intel® Core™2 Quad Processor.

To overcome the limitations of flat screens and two-dimensional images, team members built a real-time 3-D stereoscopic vision system that mimics the workings of the human eye. Their project couples an innovative design with cutting-edge hardware and software, including a powerful Intel® Core™2 Quad Processor at the heart of the machine that the students dubbed “the beast.”

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The Challenge

Carl Hayden High School in Phoenix, Ariz., first gained notoriety for its Falcon Robotics team in 2004, when members bested MIT and other universities in a national underwater robotics competition. In 2008, the team won the International Chairman’s award from FIRST (For Inspiration and Recognition of Science and Technology), an organization that encourages students to excel in engineering and technology.

Such honors aren’t awarded for anything less than bold ideas and unbridled ambition, and neither is in short supply on the Falcon robotics team. So when the current crop of aspiring engineers kept encountering a fundamental flaw in their robot operating method, they decided to engineer a solution. The problem? “We were driving with one eye,” explains 17-year-old senior Jonathan Harris, leader of the 3-D robotics team. “We had no depth perception.”

Typically, the operator of a remotely controlled robot uses a flat screen that projects a two-dimensional image, giving him a less-than-realistic view of what the robot “sees.” For example, when the students piloted an underwater robot, the lack of depth of field made it hard to tell whether they could grab or manipulate objects. They sought to equip their robot with an ability that humans use every day: 3-D stereoscopic vision.

The students knew that stereoscopic systems work by providing one eye with an image slightly offset from the other, but they had never seen such systems used in real time and with a live video feed. After considering several options for duplicating this offset, they decided to model their design on a method called the Vizard* 3-D viewing system. In a Vizard system, two LCD monitors are positioned with their tops forming a 90-degree angle. A 50 percent mirror is placed between the two monitors with the reflection side up, bisecting the angle of the monitors. The rear monitor’s image penetrates the mirror with its polarity unchanged, and the top monitor’s image is bounced off the mirror, which rotates the polarity 90 degrees. This creates two images with perpendicular polarity. The operator wears polarizing 3-D glasses that cause his eyes to see separate images. The brain does the rest of the work, separating the images as if the user’s eyes were cameras, and creating a realistic 3-D effect.
Robotics Students Create Cutting-Edge 3-D Vision System

The Solution

Working after school over about six months, the students had a prototype built in January 2009. It worked well enough to prove the concept of a 3-D vision system, Harris says, but not well enough to handle the workload because it was designed around an outdated computer. Its processor was so slow that even on standard-definition pre-recorded videos, the picture shuddered and the video signals to the two monitors refused to stay synchronized. To build a real-time 3-D vision system, the students needed a more powerful computing platform.

To help the students achieve their goal, Intel provided them with an Intel® Core™2 Quad Processor running at 3.0 GHz. The processor enabled true multitasking, with the platform simultaneously running video feeds, video recording and system processes.

“This processor is very efficient,” Harris says. “And, it comes with advanced performance features like Intel Advanced Digital Media Boost and Intel HD Boost, which make video encoding and multimedia effortless. It has worked flawlessly for us.”

The students mounted the Intel Quad processor on an ATX motherboard that supports Intel Architecture. Availability of I/O ports was critical for their application since the platform had to process multiple incoming video streams while simultaneously displaying them out. The board is equipped with two PCI Express 2.0 slots, three PCI Express slots and two PCI slots, which enable the students to use two FireWire PCI Express cards for interfacing with the system’s two Canopus* ADVC-110 analog-to-digital converters. The motherboard layout also accommodates an external video card with dual Digital Video Interface (DVI) outputs that are essential to making a functional 3-D stereoscopic vision system.

“On the Falcon Robotics team, we like to expose the team members to all the latest technologies so they can be better prepared to take on the challenges the world will throw their way,” says Faridodin “Fredi” Lajvardi, a teacher at Carl Hayden and the highly regarded mentor for the robotics team. “This platform helped the team push the envelope of tele-operated robotics by giving the operator depth perception with a 3-D vision system, and at the heart of that system is an Intel processor.”

The system is housed in transparent 3/8-inch acrylic, chosen primarily for its strength but also to expose the system’s inner workings. Other key components included a mouse and keyboard for system input; a 50 percent (teleprompter-style) mirror; two Samsung T260* LCD monitors; and a 14-fan cooling system. On the software side, the students chose 3dtv.at* Stereoscopic Player and Stereoscopic Multiplexer, which provide video playback and real-time video encoding capabilities.
Results

In June 2009, the Intel-enabled 3-D viewing system was deemed a success. Here’s how it works: As an operator navigates an underwater robot equipped with two cameras, two video signals are sent up a tether to the surface. The video data is fed into the system, where it’s processed and displayed in real time so that an operator wearing special glasses can see what the robot sees in 3-D stereoscopic vision. This enhanced vision allows for more finely tuned piloting, which is especially important for exacting tasks. The system also excels at playing pre-recorded 3-D video.

“With all this new hardware, we can play 1920 x 1080 high-definition videos effortlessly,” Harris says. “Nothing bogs down this beast.”

Along with accomplishing the goal of building a 3-D vision system, the project exposed some key points about the differences between human vision and cameras, Harris adds. Namely, the human eye has the ability to change its focal length, while the typical camera’s focal length is fixed. This can cause disorienting problems with double-imaging.

To address this challenge, the students may try refitting their robot in the future with more complex cameras that have an adjustable depth of field. They also hope to upgrade their standard-definition cameras to high-definition cameras at some point to more closely resemble the mechanics of the human eye and achieve a 3-D effect that’s even more lifelike.

To view a video on the Carl Hayden High School Falcon Robotics team, go to http://tinyurl.com/yz2ofn9

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