Case Study

Unnamed Vehicles

Kontron Supports Computing Autonomy

Kontron Lends Its Embedded Computing Expertise by Sponsoring Autonomous Underwater Vehicle Team

JREX-PM

JFLEX

ETX®

Computer-On Modules | Blades & Mezzanines | CPU Boards | Systems | Custom Solutions

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Executive Summary

A fantastic four-day underwater adventure took place in July 2007 in San Diego, California. There, students from North America, Asia, and Europe competed in the Tenth Annual Autonomous Underwater Vehicle Competition hosted by the Association for Unmanned Vehicle Systems International (AUVSI) and ONR. Just as the name of the competition implies, unmanned vehicles were put to the test in a 40-foot deep Transducer Evaluation Center pool at the Space and Naval Warfare Systems Center. The vehicles were required to go through a series of maneuvers that include following pipelines, dropping markers in bins, locating and bumping two illuminated buoys, recovering a cross-shaped object, and surfacing above one of two acoustic beacons. All of this was to be accomplished within a fifteen minute time frame during which the vehicle must have maintained stability. As each team watched the vessels move through the course, it was important to note that the controls were completely unmanned. All participating vehicles remained in operation without any remote controls throughout the competition.

The fate of each vehicle was entrusted to an onboard embedded computer, responsible for processing physical data from numerous instruments, processing camera inputs for machine vision and running the complex software that enables autonomous operation. As a leader in embedded computing, Kontron sponsored a team of participating students from Canada's third largest engineering university, École de Technologie Supérieure. Kontron's role was to provide the team with its advanced embedded computing platform and expertise, providing the essential computing "brain" to power the team's unique vehicle, named "Système d'Opération Nautique Intelligent et Autonome" (SONIA).

From 2003-2007, the SONIA Autonomous Underwater Vehicle (AUV) design team has taken full advantage of its modest budget and of corporate sponsorship opportunities to achieve remarkable second and third place standings in competition, consistently outperforming top universities from the United States and Canada. The SONIA AUV design team has demonstrated talent and effective teamwork in its implementation of mission software on the Java platform. Sun Microsystems recognized the skillful use of Java in robotics applications and presented the team with a Duke's Choice Award, an award celebrating extreme innovation in the world of Java technology and granted to the best and most innovative projects using the Java platform. The goal of the team is to optimize its design for the AUVSI challenge course.

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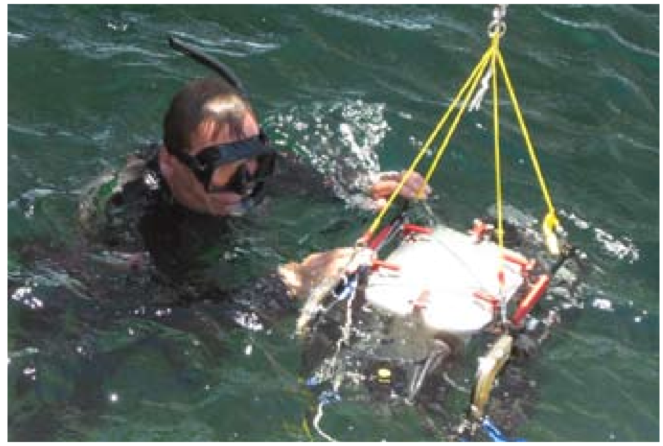
By Christine Van De Graaf
Product Marketing Manager, Kontron

AUV Competition Challenges

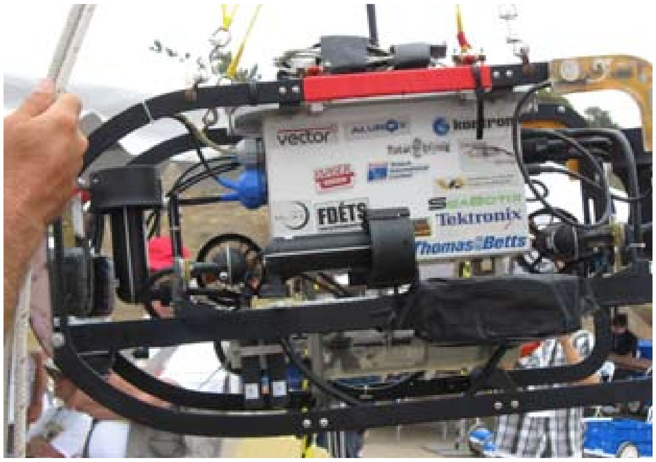
An autonomous underwater vehicle has specific embedded computing requirements beyond the obligatory small form factor. The vehicle's operation is dependent on data and telemetry from various instruments and sensors, each of which requires an independent interface to the processing board. Mission software in Java and machine vision software in C++ are executed unceasingly under a Linux environment to keep the vehicle in autonomous operation. Lacking trained expertise in embedded computing, the team is thoroughly challenged with fulfilling design requirements and learning by trial throughout the process.



At any time, the SONIA AUV system must be capable of supporting an upgraded or outdated instrument or board. All boards sit on a single backplane and must maintain pin compatibility with the 2004-2006 design. An ARM7 processor collects real time telemetry and then relays it to the main onboard computer from navigation systems including: MicroStrain 3DM-GX1 Inertial Measurement Unit; Tritech Micron Echo Sounder altimeter; MEMS gyroscope; internal temperature and humidity sensors; relative pressure depth sensor; power monitoring sensors; and a remote I/O module link. Many of these instruments use RS-232 and RS-485, so the system requires a large number of serial ports. A separate system based on a DSP is also present on the backplane to process signals from acoustic transducers (hydrophones). This system allows for the detection of acoustic beacons. Additional interfaces include FireWire, which is used by the cameras, and standard PC peripherals. A CAN bus local network is the main bus used to communicate with the navigation hub, hydrophones, and thrusters, but LIN bus local network support is necessary for backward compatibility with older thrusters. This assortment of interfaces quickly becomes difficult to integrate in a small package and manage efficiently.

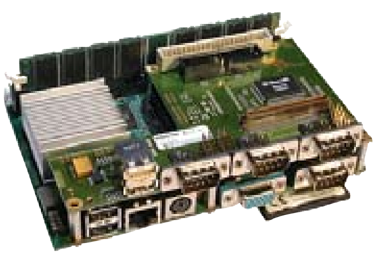
The complexity of the software algorithms demands that the processor be capable of reliable and continuous program execution. This implies a higher consumption of power and greater thermal footprint due to reduced idle time of the processor. However, thermal considerations must not be ignored in SONIA's unique operating environment. A typical embedded system takes advantage of outside air circulating through the chassis to aid in cooling its components, which is not possible when the system is sealed in an airtight box underwater. Thermal management options are limited, thus it is essential that the onboard computer processor sets an example of power consciousness, robustness and efficient system operation to minimize the thermal impact of the embedded system.

In addition to ever-present technical challenges, unique features of the current SONIA design team membership included inconsistent schedules, unpredictable productivity, and additional commitments with higher priority. Comprised solely of undergraduate students on a volunteer basis, the interdisciplinary team concentrated on effective communication and spreading knowledge so that all members were able to contribute to whichever subsystem of SONIA held top priority during the time each student was allotted to work. Another constraint of the SONIA AUV design team was its small budget, in terms of both money and time, and the varied backgrounds of team members. The expense, lead time, attention to detail, and testing that would be necessary with a fully-customized embedded computing solution would not be feasible for this team. Any hardware used in the system needed to be readily available in case of necessary replacement, and pricing needed to allow for a backup to be purchased at any time.



The Kontron SBC Solution

Kontron provides commercial off-the-shelf solutions in a variety of form factors for embedded computing applications. To meet the needs of the SONIA AUV team, a Kontron JRex-PM single board computer (SBC) was selected. Upgraded from 2006, this SBC features a 1.8GHz Intel Pentium M processor with a 400 MHz front side bus and Intel Extreme Graphics 2 on chip. Standard Kontron JRex embedded SBC interfaces include a DDR-RAM-DIMM, Type 1 CompactFlash, a single RS-232 and single TTL COM ports, two USB 2.0 ports, a low power integrated LAN controller with 10/100 Base-T interface, and support for standard peripherals, all of which were used in the SONIA vehicle. This product line simplifies the expansion of a CPU board to enable usage with a range of power supplies.



Kontron JRex systems are plug-and-play enabled to integrate Kontron JFLEX extension cards in the system effortlessly without the need for cables. In the SONIA AUV design, Kontron JFLEX expansion cards were used to provide all of the I/O not found on the CPU board. These commercial off-the-shelf boards provide one FireWire™ port and two JFLEX boards (one for additional USB and FireWire, and another for RS-232, GPIO and CAN). The SONIA AUV design team uses these ports for direct instrument connection and troubleshooting. Kontron JFLEX expansion cards stacking connections with pull-up resistors, which simply can be left unconnected when not in use or connected at any time without reconfiguring hardware.

Power management has remained an ongoing challenge for the design team, since SONIA runs entirely on battery power. JRex-PM is compatible with a variety of power supplies, including ATX, for flexibility in meeting the needs of its application environments. In order to increase the duration of autonomous operation, the design team selected a 21-cell NiMH rechargeable battery pack for a 25.2 V power system, reducing current draw, connector and conductor size, and thermal dissipation. The Kontron JRex-PM embedded SBC installed in SONIA uses a 5V power supply with a wide input range of 9Vto 36V to power its components. The 2006 iteration of SONIA used the ATX version of the JRex-PM with a wide-input PicoPSU plug-in ATX supply to accomplish the same task. The navigation and acoustics boards are supplied by an efficient 12V DC-DC converter. Redesigns such as inclusion of this combination of battery pack, power supply, and converter increased vehicle operation by 30-60 minutes over last year's system.

The modularity of stack and individual boards was quite attractive to the SONIA AUV design team. This is one of the major reasons the team selected a Kontron JRex embedded SBC, as it allowed them to mix, match and add different combinations of I/O. Standard desktop computer memory, for example, makes it easy to upgrade the capacity and speed of the system memory at any time. It is always readily available, competitively priced, and requires no rework or soldering on the board. An added cost and reliability benefit was the absence of cables to connect the CPU board and the extension boards. This simplicity allowed every SONIA AUV design team member to understand the complicated embedded system interfaces without having a background in electrical or computer engineering.

Conclusion

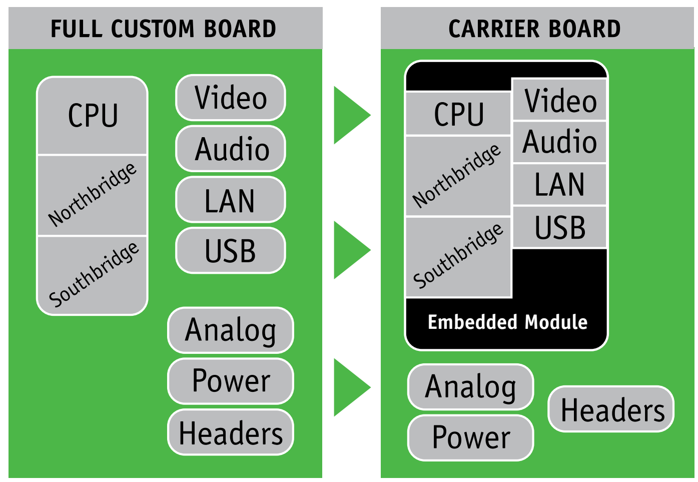
Once again, Kontron has demonstrated leadership in embedded computing by providing an aggressive solution for this unique application. The SONIA team may rely on future expansion or fall back on previous systems at any time, and Kontron provides the flexibility for both cases with its JRex product line and JFLEX expansion options. The Kontron JRex-PM embedded SBC provides the processing power necessary for collecting telemetry from the instruments and elegantly executing the AUV software and vision processing without causing a thermal management dilemma. In addition, the use of Kontron JFLEX standard expansion cards allows for future upgrades in the same form factor offering pin compatibility with the older systems.

The Kontron JRex embedded SBC form factor has proven to be a great advantage to the SONIA AUV design team. The ability to plug in up to three expansion slots provides greater freedom to incorporate instruments with different interfaces or to modify the overall architecture of the system without an electrical or mechanical redesign penalty. In addition, the team has not suffered a single thermal shutdown working at 100 percent CPU load in a hostile thermal environment since switching to the Kontron platform. The SONIA AUV design team's members also are assured of future scalability and flexibility with Kontron JRex as the SONIA AUV moves toward its next generation design.

In its continued support of the SONIA team, Kontron may propose that future AUV designs migrate to a Kontron full-featured Embedded Technology eXtended (ETX) module. What makes Kontron ETX modules a good solution moving forward for the team is that they are very compact (95mm x 114mm, 12mm thick), highly integrated Computer-on Modules which would solve the team's need for high processing power in a small form factor. Since all ETX modules feature a standardized form factor and a standardized connector layout that carry a specific set of signals, the SONIA design team could create a single-system baseboard (off-the-shelf carrier boards also are available) that would accept present and future ETX modules as needed. The ability to build a system on a single baseboard using the computer as one plug-in component would eliminate cabling, and significantly reduce system-level cost for the team. Moving to a Kontron ETX solution can give the team the full range of functions and performance found in a desktop PC motherboard all in a cost-efficient compact package.

*FireWire is a trademark of Apple Computer, Inc.

Custom Motherboards vs. COMs



AUTHOR'S BIO

Christine Van De Graaf is the Product Marketing Manager of Kontron America's Embedded Modules Division that is located in Northern California's Silicon Valley. She has more than five years experience working in the embedded computing technology industry and holds a Masters of Business Administration, Marketing Management degree from California State University, East Bay (Hayward, CA). Van De Graaf has authored a number of technical articles published in various embedded computing technology trade publications and recently presented at the WindRiver Worldwide Users' Conference on the topic of COM Express and Linux based embedded solutions.

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