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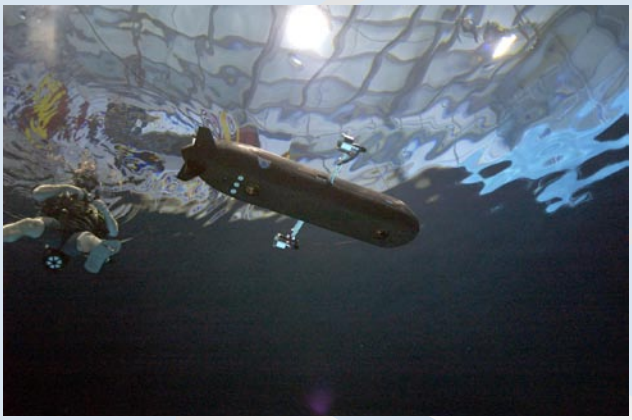
Multi-core processor technology extends reliability of Autonomous Underwater Vehicles

Into the Sea



Autonomous Underwater Vehicles (AUVs) enable researchers and scientists to explore hitherto unreachable depths. They also have commercial applications with oil and gas companies using them to obtain detailed maps of the seabed for laying pipelines cost effectively and with minimum disruption to the environment. Another typical life saving application is mapping an area of the ocean to determine the presence of mines.

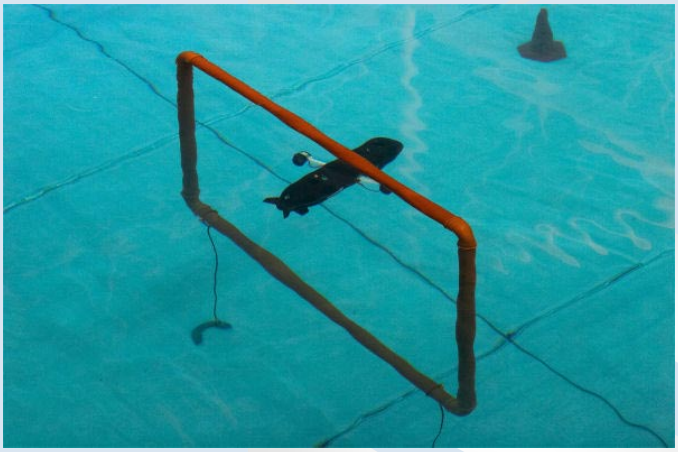
In order to accelerate the continued development of AUV technology, the Research Acquisition Organisation (RAO) launched the Student Autonomous Underwater Challenge - Europe (SAUC-E), a competition that encourages young engineers to think about the future possibilities of underwater technology. This year's winners - the team of students from the University of Southampton - used the latest dual-core processor technology to design the winning AUV.

The challenge – staying cool under tough conditions

Teams from six universities competed in a series of missions designed to test the capabilities of their AUVs. The missions were a series of tasks that ranged from passing through a submerged validation gate without touching any part of its structure to locating submerged objects and producing a 2-D map of the features in the competition tank.

All vehicles had to be fully autonomous which meant that no external communication of any type was allowed. The vehicles had to be powered by batteries and designed with an emphasis on safe and reliable operation. For example, the electrical drives, the batteries and the electronic processors used in the AUV generate a significant amount of heat and there is danger of overheating unless the internal temperature is maintained within safe limits. Another critical consideration is that computationally intensive processes should not interfere with the vehicle's essential real-time control processes. For example, the AUV from Southampton is equipped with three waterproof video cameras for locating and identifying objects in the test tank. Cameras were chosen over other detection systems, e.g. sonar, since they provide optimal target recognition under the given test conditions. Navigation

is accomplished by means of a pressure sensor, a compass and an inertial measurement unit that provide the information used to control the submarine's pitch, depth and roll with the aid of thrusters attached to the AUV's hull. The challenge was to find a computing system that was powerful enough to process the three continuous 640 x 480 pixel video streams without interfering with the real-time control of the submarine's navigation – you don't want the AUV to drift off course because it is spending too much time processing Megabytes of information from the cameras instead of concentrating on where it is heading.



The AUV from the University of Southampton entering the validation gate (picture courtesy of dstl)

The solution – multi-core processor technology

Faced with fierce competition, the team from Southampton knew that they needed an innovative software and hardware solution if they were to have a chance of winning the SAUC-E. In order to meet the demands on operational reliability, the team developed a software control module consisting of independent "software agents" (SA) that run parallel and asynchronously on a dual-core MiniITX computer provided by the competition sponsors, Kontron. The 986LCD-M/mITX was chosen for its parallel processing power, small form factor, numerous interfaces and excellent thermal design power. All of the SAs were written in the Matlab scripting language which is operating system independent. Communication between the SAs takes place via asynchronous requests using UDP (User Datagram Protocol) signalling.

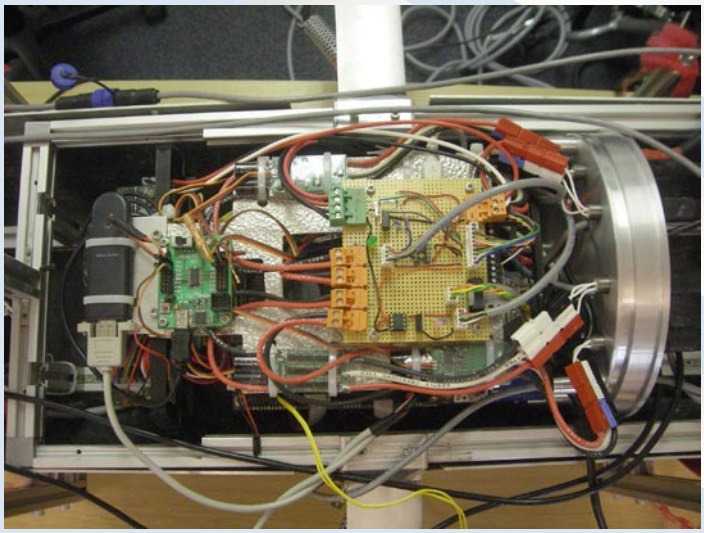
By using a control system based on small, multiple and autonomous SAs instead of a single, monolithic and therefore time consuming software process, the team from Southampton were able to take full advantage of the parallel processing afforded by the Kontron multi-core MiniITX computer. As mentioned above, the AUV is equipped with three USB video cameras that continuously provide graphic information on the submarine's environment. This information is used to locate and identify objects in the AUV's vicinity and to direct the AUV either towards or away from the objects. More specifically, the agentMissionCntr module that is responsible for the high-level control of the AUV takes the data provided by the agentFrontCam and agentDownCam modules as its input and sends the high-level commands to the agentMotionCntr module as its output. This latter module is responsible for the low level control of the AUV's depth, pitch and roll. The low level module was configured to run with high priority while the other three modules were configured to run with normal priority. The dual-core technology is crucial since it allows at least two processes to be executed simultaneously. In other words, the high priority delay-sensitive thruster tasks are continuously executed on the dedicated first processor core, while all other lower-priority tasks are scheduled for execution on the second core. This means that graphic image processing, which is computationally intensive, runs in the background and does not interfere with the essential low-level control of the AUV's pitch, depth and roll so that it always stays on course.

The dual-core processor board selected for the AUV was the Kontron 986LCD-M/mITX motherboard with a 2GHz Intel® Core™ Duo processor and 2GB of RAM (the 986LCD-M/mITX can accommodate up to 3GB of RAM, if desired). Despite the small form factor (17cm x 17cm) the board is equipped with 4 serial ports and 8 USB ports so there was no need for an additional USB hub or a USB to serial converter for connecting the AUV's three cameras (USB), pressure sensor (USB), compass (serial), inertial measurement unit (serial), thruster controller (USB) and other system components. As well as powerful parallel processing capacities, the thermal design of the board was also a decisive factor. Since the thrusters are located outside the vehicle, most of the heat within the vehicle comes from the main processor and the chipsets. Indeed, one of the teams participating in this year's SAUC-E was forced out of the competition after burning the internals of their sub while running it for just a bit too long out of the water. In contrast, the Southampton team could test their vehicle out of the water for extensive periods of time without any danger of overheating. Among the things contributing to the markedly lower thermal dissipation of the Kontron board is Intel's Core Duo processor technology with a thermal design power of only 31 watts that makes it ideal for temperature critical applications.

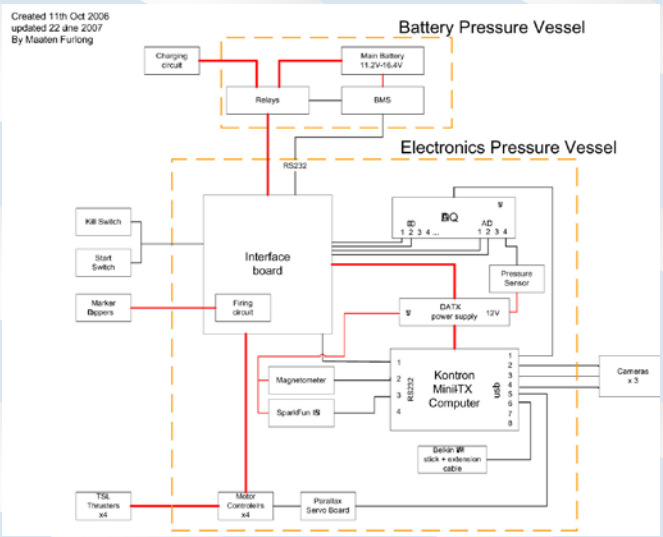
Size matters

With strict limits on the maximum size of the AUV, every means of saving space within the vehicle was welcome. At only 17cm x 17cm, the size of the Kontron 986LCD-M/mITX was also an important factor. As Jos Akhtman, the electronics specialist on the Southampton team explains "The 986LCD-M/mITX board was perfectly suited for our needs in terms of performance, form factor, power consumption and interfaces. Moreover, the dual-core technology allowed us to fully exploit the potential of our Software Agents. We would like to thank Kontron for donating the powerful Mini-ITX system."

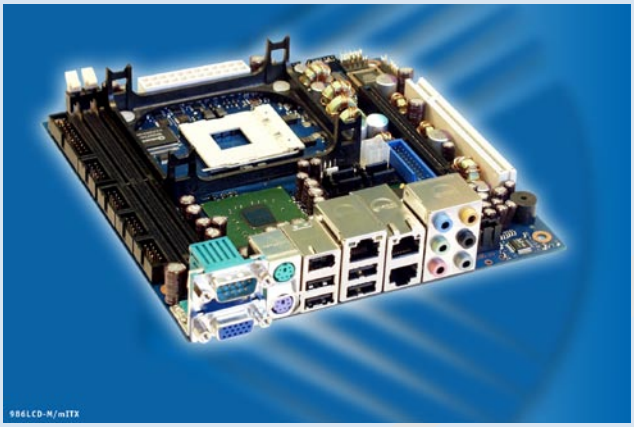
As a world leader in embedded computer technology, Kontron supports programs like the SAUC-E that push the boundaries of innovation. The AUV from the University of Southampton demonstrates the benefits and potential of dual-core technology, not only for AUVs but also for similar applications. It is one of the first industrial multi-core applications with asynchronous multiprocessing that clearly demonstrates one of the many other advantages of multiprocessing in addition to performance, i.e. extended reliability.



The interior of the Soton AUV



SotonAUV Electrical Systems Overview



The 986LCD-M/mITX motherboard from Kontron

Mini-ITX is the smallest ATX-compatible motherboard standard that has quickly gained great acceptance from professional users. With the advancing integration of chipsets and functions MiniITX boards house a variety of interfaces and functions at a mere 17 cm x 17 cm: 1x PCI slot, 1x ATA100, 4x SATA with RAID 0/1/5/10 support, 8x USB2.0, 4x RS232C, 2x IEEE1394(400a), 3x GbE LAN, LPT, 1x mini PCI-Express socket, compact flash socket, 7.1ch HDA sound and GPIOs. The Mini-ITX is ideal for use in very compact housings and systems. Kontron's 986LCD-M/mITX supports the latest dual core processors from Intel, including the new Intel® Core™ 2 Duo Mobile as well as the Intel® Core™ Duo, Intel® Core™ Solo and Celeron® M low power processors. The Core™ 2 Duo Mobile and Core™ Duo processors provide extreme performance for embedded applications with low power consumption.

All Mini-ITX boards from Kontron are specially designed for use in embedded systems, and are therefore built to be robust and available in the long-term with more than five years of product availability.

About Kontron

Kontron designs and manufactures standard-based and custom embedded and communication solutions for OEMs, systems integrators, and application providers in a variety of markets. Kontron engineering and manufacturing facilities, located throughout Europe, North America, and Asia-Pacific, work together with streamlined global sales and support services to help customers reduce their time-to-market and gain a competitive advantage. Kontron's diverse product portfolio includes: Computer-on-Modules, SBCs/blades, open-modular platforms and systems, HMIs, and custom capabilities. Kontron is a Premier member of the Intel® Communications Alliance and was awarded 2006 Intel Member of the Year. The company is a recent three-time VDC Platinum vendor for Embedded Computer Boards. Kontron is listed on the German TecDAX stock exchange under the symbol „KBC". For more information, please visit: www.kontron.com.

Author

Tim Jensen, Product Manager Motherboards, Kontron AG
tim.jensen@kontron.com

Corporate Offices

Europe, Middle East & Africa
Oskar-von-Miller-Strasse 1
85386 Eching/Munich Germany

Tel.: +49 (0)8165/ 77-777
Fax: +49 (0)8165/ 77-279

sales@kontron.com

North America
14118 Stowe Dr
Poway, CA 92064-7147

Tel.: +1 (888) 294-4558
Fax: +1 (858) 677-0898

sales@us.kontron.com

Asia Pacific
17 Building,Block #1,ABP.
188 Southern West 4th Ring Road
Beijing 100070,P.R.China
Tel.: + 86 10 63751188
Fax: + 86 10 83682438

kcn@kontron.cn

Kontron Technology A/S
Dr. Neergaards Vej 5D
2970 Hørsholm, Denmark

Tel.: +45 4576 1016
Fax: +45 4576 1017

sales@kontron.com

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