Hybrid systems get strengthened through diversity

January 11 2010

(PhysOrg.com) -- Our everyday work and home lives are becoming increasingly dependent on complex computerised networks with built-in control systems. European researchers are working to make the controls more autonomous and intelligent.

The controls can be as commonplace as those on a modern, thermostat-controlled central heating system or as complex as those needed for an air traffic control system. If they malfunction the results can range from the mildly annoying, in the case of a room heating thermostat, to the catastrophic in the case of an air traffic control system.

What the systems have in common though is that they are digital controllers of physical processes, and they interface with other computerised systems as well as with human users and supervisors. They

are, in scientific terms, hybrid systems where physical processes interact with computational processes.

Mathematical models can be produced to describe hybrid systems, and to help them work efficiently. But until recently all the different disciplines necessary to provide the most efficient way of digitally controlling systems embedded in networks had not been properly brought together.

Multidisciplinary super project

This was addressed in late 2004 when an EU-funded super project, the Hycon Network of Excellence, brought together 27 full partners and 12 associates from 14 countries in fields including maths, physics, computational science and several industries.

The partners were tasked with “concentrating on the use of advanced automatic control methods to make networked embedded systems fulfil their promise.”

“Networked embedded systems are rapidly becoming a ubiquitous technology that defines our everyday lives,” notes project coordinator Francoise Lamnabhi-Lagarrigue of Laboratoire des Signaux et Systemes. “They are based on smart digital devices that can sense, communicate, adapt and act on their environment. These devices are present in ever-greater numbers all around us, in our homes, hospitals, workplaces, and vehicles.”

Intelligent control systems

They promise to reshape the way we think of healthcare, transportation, personal spaces, and environmental problems, she adds.

“Today, their use is mostly in monitoring but their capability goes beyond this relatively simple function: they can also assume control functionality, react to signals and act on their environment to prevent catastrophic events and improve the operation of complex systems.”

Working together with the industrial partners, the researchers in the network first developed a series of novel ideas in the area of automatic control and then deployed them in real situations to solve a number of challenging problems in diverse application areas.

One such test bed was in a supermarket, controlling a refrigeration system. The challenge was to maintain a steady temperature in the freezers right through the day and night as conditions and external temperatures varied.

There were 10 different freezer display cases powered by six compressors and all of these had to be continually monitored to measure such variables as changes in the number and mass of frozen goods during shopping hours, the sudden drop in the energy load during the day/night transition and a variety of others.

Mathematical model helps optimisation

Working with the supermarket staff and experts from other disciplines, the mathematics researchers were able to come up with a mathematical model to describe exactly what was going on, and this model was used by the computer scientists to optimise the set up and running of the system.

Other test beds were established in a solar air conditioning plant, a sugar processing plant, a mining and smelting company, and a power station with the end result being a new set of methodologies and sophisticated software tools for controlling complex hybrid industrial processes.

The knowledge gathered and created in the project, which ended in 2009, has been widely disseminated to both academic institutions and industries throughout the EU as a key part of the project. There were several pubic presentations of the results and a special website has been created where anybody who is interested is able to download the software tools created by the project partners.

Worldwide focal point for research

A book, 'The Hycon Handbook of Hybrid Systems Control: Theory, Tools, Applications' has also been published.

The groundwork has been laid for a European Embedded Control Institute (EECI), which will become a worldwide focal point for hybrid systems research. A key part of the project was to organise international training courses for graduate students each year, something new in the field and which has not been done elsewhere in the world.

Partners in the project are also keen to carry on with their work on engineering technologies for large-scale, distributed and cooperating systems for monitoring and control, including wireless sensor networks.

More information: Hycon network: www.ist-hycon.org/

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