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Wireless sensor networks that organise themselves

European and Indian researchers are working on the Wireless Sensor Networks with Self-Organisation Capabilities for Critical and Emergency Applications (WINSOC) project which aims to find new ways of organising sensor networks to make them robust against node failures and capable of being implemented on large scales.

The project is based on biological systems. The networks are made up of many individual sensors similar to living organisms that are made up from many individual cells.

“Living systems are intrinsically robust against cells dying or being damaged,” said Sergio Barbarossa of the University of Rome 'La Sapienza', scientific coordinator of WINSOC.

“The behaviour of most organs is an emerging feature, resulting from the interaction of many cells, where no cell is particularly robust or even aware of the whole behaviour.”

For example, the rhythm of the heart is controlled by the interaction of several pacemaker cells, each of which can be seen as a pulse oscillator. Even though individual oscillators are not particularly stable or reliable, the heart as a whole is extremely stable and can readily adapt to changing conditions.

“The starting point in WINSOC was to provide mathematical models of biological systems and translate them into algorithms to determine how the sensor nodes should interact with each other,” said Barbarossa.

A prototype sensor node is being developed, but the challenge is to make the network able to function even when several sensors fail. The answer is in self-organisation to make sensor nodes communicate with neighbouring sensors on what has been sensed. The network then finds the best path

through the available nodes to relay this information to the control centre.

This biological principle is being tested in the landslide detection system. A prototype network of geological sensors has been installed in the Idduki rainforest of Kerala, India, a region vulnerable to landslides in the monsoon season.

The networks can be used to warn nearby communities that a landslide is imminent.

Wireless devices are suitable for this system because the sensor nodes are small, simple, cheap and require no cabling to connect them together and to the control centre. But then disadvantages include: failure of sensors and communication links; the nodes rely on battery power; large networks can become congested with many sensors reporting at the same time to the same control centre.

However, what matters is not the reliability of the individual sensors but the reliability of the network as a whole.

“Our Indian partners have buried sensors in the terrain, with the capability of monitoring the humidity and porosity of the terrain and the acceleration forces,” Barbarossa said.

“The sensors are then linked to a satellite which gathers the data and conveys them to the control centre.”

The network includes 12 geological sensors connected to 15 wireless sensor nodes spread over three hectares.

The consortium is also developing a ‘Sensor Web’ to allow applications and services to access sensors of all types over the internet. This is a distributed sensing system in which information is globally shared and used by all networked platforms.

In the long term, the group expects two kinds of benefits to emerge from the project:

- Monitoring the earth with a system capable of autonomous decisions, which according to Barbarossa is important in remote areas where it is difficult to recharge batteries or replace defective nodes.
- Further progress in the design of self-organising systems with the cross-fertilisation of ideas from biology to engineering and vice versa to provide substantial benefits to both areas.

WINSOC is funded by the European Union’s Sixth Framework Programme for research and is due to be completed in February 2009.

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