Name:
Karl Henrik Johansson

Nationality:
Swedish

Born:
1967

Awarded Ph.D.:
1997

Works at:
Royal Institute of Technology

Title of project:
Embedded control systems in a network environment

A SOCCER REFEREE IN THE RESEARCH WORLD

The need to measure, monitor and control systems exists everywhere in society. When technical systems are connected together into networks, new methods and computer tools must be developed in order to ensure that all parts work. Functions must often take place in real time, i.e. without any time delays. When an airbag has to deploy in an accident it mustn't be delayed by other systems in the car.

Karl Henrik never really planned his education or his choice of career, he has always just done what he thought was most interesting. Gradually he has increasingly felt that he has found his way to the right field. Karl Henrik got his master's degree in Electrical Engineering at Lund University's Faculty of Engineering and had only taken the undergraduate course in control engineering before starting work on his Ph.D. in the field.

"I met Karl Johan Åström at the Department of Automatic Control in Lund, and he was very inspiring. There was such a positive atmosphere at the department, and I was convinced it was the right place to take my Ph.D.," says Karl Henrik.

What is control engineering?

Control engineering has to do with measuring and regulating a system so that it behaves in the way you want it to. A simple example of this is temperature control in a room. A thermometer measures the temperature in the room and a regulator adjusts the radiator so that the desired temperature is achieved. But the whole room doesn't reach the same temperature at once. First the area nearest the radiator is heated, and then the heat spreads. This means there is a delay in the system. When it comes to controlling the temperature in a room, some time lag may not matter so much. But imagine if it takes too long for the airbag in a car to deploy when the car crashes. The consequences then are much more dramatic.

The theories surrounding control engineering can be applied in a variety of areas: engineering, biology, economics, medicine, etc. Karl Henrik is working to develop general methods for network-based control engineering. The fact that it is network-based means that the system is connected to a network, e.g. the Internet, where information can be transferred. Interconnecting different information systems enables more functions to be utilised, but the complexity of the system leads to many difficulties. One example of a network is the Internet, another is a mobile phone network. They work relatively well by themselves, but when you connect the networks together, for example by connecting to a website via a mobile phone, problems sometimes arise. The networks are not designed to work well together. Karl Henrik is working to develop tools and methods to improve the technology of such interconnected systems.

After receiving his doctorate, Karl Henrik worked for two years at the University of California in Berkeley in the USA. He likes to compare Berkeley to Lund.

"Berkeley is a small university town located on the eastern side of San Francisco Bay. South of Berkeley is the industrial city of Oakland, just as Malmö is located south of Lund. And on weekends you cross the bay into San Francisco, just like you cross the Sound to Copenhagen if you live in Lund," says Karl Henrik.

Since 2000 he has had a position as an associate professor at the Department

With digital maps and a GPS navigator, the truck engine is prepared to climb a hill. This can reduce fuel consumption. (Photo: Scania)

Karl Henrik Johansson

of Signals, Sensors and Systems at the Royal Institute of Technology. Karl Henrik and his wife Liselott love to travel and visit friends all over the world together with their two sons, Kasper and Felix.

Predicting hills

Vehicles equipped with networks have been manufactured for the past 15 years or so. They have, for example, a sensor on the wheel to measure speed, radar to see if something is approaching, temperature sensors, and of course lock and alarm systems. These are examples of automotive functions that are connected to a network. Today, safety considerations preclude certain functions, such as the airbag, from being connected to the network. The reason is that if anything in the network breaks down, other functions can be disabled. Karl Henrik's research is aimed at improving these systems. If the functions could be prevented from being disabled, the vehicle would be safer. The information obtained from the vehicle's network of sensors and measurement transducers could be used to avoid a collision if, for example, a deer should run out onto the road.

"My research is a little like a good soccer referee. It should do its job but not be noticed," says Karl Henrik. "It can be described as a hidden technology. You build technology that no one notices as long as it works," he continues.

Karl Henrik and his research group are collaborating with the automotive industry to reduce fuel consumption in trucks. By using digital maps and GPS, the topography of the route can be predicted. When the truck approaches a steep hill, the engine can be prepared automatically so that the climb is managed with less fuel consumption. The truck can also be connected to a traffic information network. If the intensity of traffic on a section is known in advance, the truck can be prepared for this. The driver can even get alternative route suggestions.

International cooperation

Karl Henrik and his research group are running the project in cooperation with several companies. In this way they know they are working on problems of relevance to Swedish industry. A project is particularly successful when the group not only solves a company's particular problems, but the theories can be applied to other systems as well. The solutions lead to tools that make it possible for researchers and engineers to develop functions and applications within other areas as well.

"There are fundamental issues within control engineering and network design that are independent of the application. These are the issues I want to address in my research," says Karl Henrik.

There is extensive international cooperation within network-based systems. Karl Henrik is particularly involved in two EU projects, RUNES and HYCON. These projects engage both industry and academic researchers all over Europe to collaborate on problems in networks and infrastructure. Network-based systems are found everywhere: in industrial production, transportation systems, energy distribution and communication systems. Karl Henrik's goal is to establish a research laboratory to strengthen Sweden's role in this rapidly growing field. • LW