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Content

This is the first NewsLetter dedicated different Ph.D. projects within the area of agricultural engineering – spanning a wide area from technology development of sensors, software systems, and robots to modelling and decision support systems.

The first Ph.D. project to be described is by Esmaeil S. Nadimi, and the final project plan finished last month.

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Modelling of Sensor Networks for Monitoring in Biological Processes

Smart environments represent the next development step in building, industry, transportation and agricultural sciences. The information needed by smart environments is provided by novel distributed wireless sensor networks, which are responsible for sensing as well as for the first stages of the processing hierarchy. In animal science applications, natural mobility and the animals' social interactions make wireless sensor networks extremely effective in order to aggregate the motion data. This may potentially benefit commercial farming by providing ways to ensure animal welfare while automating and optimizing the production process. Herd behavioural parameters such as herd motion data may serve as input to behavioural modelling, which will eventually allow control of the herd through automatic environmental changes.

Figure: Grazing cows equipped with sensors to monitor behaviour

For example, the knowledge about the herd behaviour (grazing time, position of the animals in the field, the animals' motion velocity while they are grazing) is useful for automatic control of fences in order to provide strips of new grass. The motion data such as velocity and position will in the project be estimated using accelerometer, magnetometer and signal strength data which are passed through a Kalman filter, aggregated based on IEEE 802.15.4 standard (ZigBee), processed and finally sent through the network to the infrastructure facilities. The behaviour of the animals while they are in the field will be mathematically modelled based on random walk mobility model or other related models. Finally the decision to make the fence move will be made based on different states of the animals' behaviour such as grazing state or searching grass state. The challenges include, establishing the wireless sensor network infrastructures on a group of animals, establishing a model of this biological process based on the aggregated information with the aim of performing active control of a herd for potential optimization of the production process and the welfare.

Project background

Smart environments need information about their surrounding as well as their internal working and this information is provided by novel distributed wireless sensor networks, which are responsible for sensing as well as for the first stages of the processing hierarchy. In animal science applications, herd natural mobility and the animals' social interactions make wireless sensor networks the perfect candidate for monitoring animal behaviour parameters. Such systems differ in many ways from engineered mobile systems because a herd of animals can move on their own due to complex natural behaviours as well as under the control of the environment (for example moving toward a food or water source). Different aspects of behavioural states such as stress, desire, hunger, grazing time, position in the field while they are grazing and the velocity of their movements can be mentioned. These are, however, only partially observable and only limited control over motion can be exerted. Motion velocity of dairy cows during different grazing time length has been registered and their position while they were in the field has been studied in other projects, but no model of the motion was provided. Motion data would potentially benefit commercial farming by providing ways to ensure animal welfare while automating and optimizing the production process. Motion data may serve as input to behavioural modelling, which will eventually allow control of the herd through automatic environmental changes such as automatic control of fences for providing strips of new grass.

Goal & Results

The final goal of the thesis is to monitor and model the behaviour of the animals and to provide strips of new grass based on automatic control of the moving fence in order to increase animal productivity and welfare.

The result is a framework that enables / supports the design of the autonomous system which will allow control of the behaviour of a herd of animals using environmental changes, increase animal productivity and welfare as well as a demonstration of the applicability of the developed framework on a herd of animals.

The developed framework is expected to enable and support a systematic design, analysis and verification of the system which will lead to establish a mathematical model describing the behaviour of a herd of animals when they are in the field. Using this model, the control effort

over environmental changes can be done in order to provide strips of new grass for animals to increase their productivity and welfare.

Ph.D. student

M.Sc.EE Esmaeil S. Nadimi is enrolled as a student at Aalborg University (Institute of Electronic Systems, Department of Control Engineering) with Thomas Bak/Roozbeh Izadi-Zamanabadi as advisors. He comes from a background in Iran as a Master of Electrical Engineering of the Sharif University of Technology in Tehran.

For more information contact Ph.D. student Esmaeil Nadimi - esmaeil.nadimi@agrsci.dk or take a look at the project description

Topics of coming newsletters

A Vietnamese-Danish science transfer project in sustainable, sanitary and efficient management of animal manure for plant nutrition
Portraits of PhD students in the area of agricultural engineering and technology
Navigation systems and IT in Denmark