Simulating a Wireless Soil Moisture Sensor Network using a Multi-agent Toolkit

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In this poster we present the simulation of the setup and operation of a wireless soil moisture sensor network for the purposes of controlling irrigation in orchards in South Tyrol. With current irrigation practices only 50% or less of the water used in irrigation arrives at the plant. Novel irrigation equipment requires a fine control of the water distribution in the soil. One solution would be to have sensors near the plants' roots control the water inflow depending on need. Such a dense soil-hydrological measuring network must ideally be composed of wireless microsensors, which are distributed in the soil, collect data of relevant parameters in the pedosphere at a high temporal resolution and transmit the information to a central logger-unit. Ideally, the sensors organize and calibrate themselves to optimize information transfer, minimize energy consumption, and to interpolate missing values if any sensors fail. In order to determine whether the proposed sensor network will work as expected or where we might have to expect problems, we simulate its setup and operation. Our validation data for the soil-hydrological model stems from measurements in an orchard in South Tyrol.

Bringing sensor networks into the soil for the purpose of irrigation control has in the past been an expensive venture and has only been practiced in setups such as greenhouses, where exogenous processes can be rigidly controlled. These sensor networks are usually hardwired sensor mats reporting to a central logging station that in turn controls the irrigation. However, the problem of precisely controlling irrigation using such sensors could not be applied to extensive outdoor cultures (such as apples or cherries) because of the costs involved and because exogenous factors such as rain, soil movement etc. would distort the placement of the sensor mat, thus damaging or even destroying the setup.

With the advent of small, relatively cheap wireless sensor units irrigation control for extensive outdoor cultures becomes feasible. However, once the sensors are in the soil, they cannot be moved or accessed easily for maintenance. This requires that the sensors be very robust, self-healing, self-organizing and self-calibrating in the sense of organic computing (Schmeck 2005). Many processes might change the sensor locations in the soil: new roots growing, the soil being changed over the course of time, too much water washing the sensors further down, mechanical processes pushing the sensors up or down, etc. When trying to interpret the measurement of the sensors, the soil type in which the sensor is located needs to be known for subsequent calculations. Due to the processes described above the soil type could change over time. The only way to detect this change is to compare measurements of one sensor with measurements of its local neighbours, track their measurements over time and use measurements only when they deviate within certain parameter intervals.

In many climatic regions, the availability of water in soils determines to a large extent their agricultural productiveness. The hydrologic balance in soils is the result of complex physical processes, which are influenced by diverse geo-parameters with enormous spatial-temporal variations. Therefore, the measurement and quantity-based monitoring of the soil moisture dynamics has always been at the centre of soil physics and soil ecology. Especially in irrigated agriculture, information about the actual soil water dynamics can deliver valuable data to optimize the irrigation practice with regard to volume and duration of irrigation. Not least because of the aspects of climate change, irrigation in agriculture will be confronted with big challenges in the future.

South Tyrol is a region where these questions are currently discussed. Intensive orcharding is practised within an area of about 18.000 hectares. Because of the local climatic situation irrigation is considered to be necessary and has been practised for a very long time. However, in many locations much more water is used for irrigation than the apple trees there actually need (Thalheimer 2005, Grashey-Jansen 2008). Because of decreasing water resources precision irrigation is being discussed as a potential solution, but robust sensors, their setup and operations as well as potential problems with the control loop need to be explored beforehand.

In this poster we will present our idea of providing the necessary information for controlling irrigation using a simulated wireless soil moisture sensor network (see Fig. 1). We introduce and discuss our database and the known parameters of simulation. We will report on the first simulations and their preliminary results.

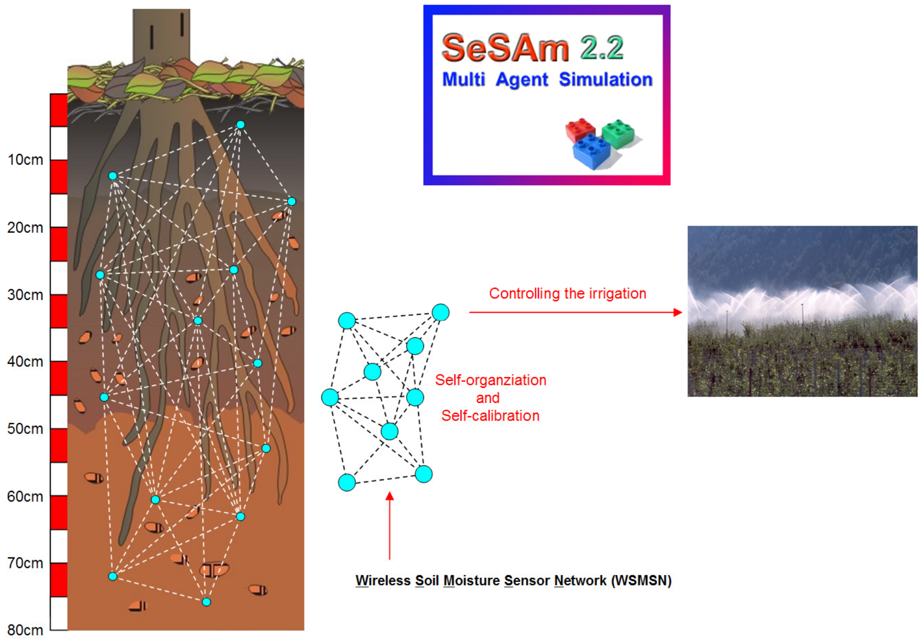

Figure 1: Physical construction of the wireless soil moisture sensor network.

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