VLITE NODE – NEW SENSOR TECHNOLOGY FOR PRECISION FARMING

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ABSTRACT

In past years in world an extensive research and development work is being done to ensure information technology use in agriculture; long range wireless sensor network (WSN) creation for specific agricultural use. Existing WSN solutions are in experimental development phase; their implementations is not possible without the specific WSN technology developers' assistance and they have a short working range (ability to guarantee communication between sensors only at a range of several tens of meters); therefore their implementation in large area is very expensive. Realistic WSN implementation is unthinkable without specific WSN technology that includes physical nodes, sensors, operating system, application programming environment, competence centre support. The paper describes new long distance RFID based technology implementation - VLIT NODE.

Keywords: Wireless Sensor Network, Precision Agriculture, RFID

INTRODUCTION

The importance of meteorology in agriculture has been increasing during last decades due to emerging need to access appropriate information as consequence of the increased rapid weather conditions changes. Although the quality of weather forecast has been improved constantly and, at large, agriculture is benefiting from this achieved capability, in many European regions, the currently available meteorological data are not sufficient for crop production, as a lot of additional local scale data are needed to be integrated in the specific agro-meteorological models and to take the correct decision in any farm management system. To meet the farmers ambitions, especially in areas where parcels are relatively small involving the growth of “expensive” cultivars (as for the production of wine), there is the need of establishing networks of local sensors and meteorological stations. The ongoing significant advancements in sensors technologies and in_situ sensing are expected to support also the development of more systematic capabilities for assimilating all sort of in_situ measurements in agro-meteorological models, at relevant scales, to generate immediately (in real time) useful information for the farmer’s decision. At the same time, the fusion of meteorological sensors data with existing agro-production database and implementation of new online agro-meteorological models for farms could open new possibilities for farmers to increase quality of their production, to be more competitive on the market and in this way also to increase they sustainability and profit.

Agro meteorological parameters have strong influence on crop growth and development, but also on the dynamics of other important biological elements, such as plant diseases and pests. The monitoring of agro-meteorological variables on the territory together with the application of simulation models, represent the basis for a correct management of cultivation methods and sanitary treatments. For the realization of such a monitoring, the development of a reference detail climatologically study of the area is required, in order to assess the climatic conditions and to identify the most representative sites where the meteorological stations for the measurements of the interested variables have to be placed. Once the strategic sites are monitored by stations, data can be collected for further processes, such as spatial interpolations and application of agro-meteorological simulation models.

1. SENSORS

A **sensor** is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. There exist many kinds of sensors for surveillance and intrusion detection, such as infrared, other optical, microwave-based, or other types. They, for example, video cameras, can be effectively used to support manned surveillance. There are also video-based systems that sense changes in the image and will trigger an alert. Since every sensor used for this kind of applications can be characterised by its location coordinates (changeable) and a time component, the spatial extension and near-real-time availability of sensor-originated information layers in geospatial applications create a great potential.

Sensors are most commonly used to make quantifiable measurements, as opposed to qualitative detection or presence sensing. For the sensor selection there are four criteria:

- What we need to measure, this influenced type of sensors, sensors could measure almost anything, but every phenomena need different type of sensors

- In which environment we will measure, there are different need on outdoor and indoor sensors, and also there are specific needs on sensors working in extreme conditions
- What is required accuracy of measurement
- The question, if the whole system is calibrated or certified

These four aspects could have influence on selection of sensors, but also on the cost of sensors.

Every sensor is described by next characteristics:

- Transfer Function - the functional relationship between physical input signal and electrical output signal
- Sensitivity - relationship between input physical signal and output electrical signal
- Span or Dynamic Range - range of input physical signals that may be converted to electrical signals by the sensor
- Accuracy or Uncertainty - largest expected error between actual and ideal output signals
- Hysteresis - width of the expected error in terms of the measured quantity
- Nonlinearity - maximum deviation from a linear transfer function over the specified dynamic range
- Noise - sensors produce some output noise in addition to the output signal
- Resolution - minimum detectable signal fluctuation
- Bandwidth - response times to an instantaneous change in physical signal

When we are speaking about sensors, we usually consider both part of sensors and transducer, a *sensor* is a device that receives a signal or stimulus and responds with an electrical signal, while a *transducer* is a converter of one type of energy into another. From a signal conditioning viewpoint it is useful to classify sensors as either active or passive. An active sensor requires an external source of excitation. A passive (or self-generating) sensor generates their own electrical output signal without requiring external voltages or currents.

2. Wireless Sensors networks (WSN)

The future utilization of sensors technologies will be mainly based on Wireless Sensors Network which is an emerging technology made up from tiny, wireless sensors or “motes.” Eventually, these devices will be smart enough to talk with other sensors yet small enough to fit on the head of a pin. Each mote is a tiny computer with a power supply, one or more sensors, and a communication system. One is the network independent module Smart Transducer Interface Module (STIM) that contains the transducers, its signal conditioning circuitry and a standard interface. The other is a network specific module Network Capable Application Processor (NCAP) that implements the interface to the desired control network and also implements the standard interface of the transducer module. Sensor networks are receiving a significant attention because of their many potential civilian and military applications. The design of sensor networks faces a number of challenges resulting from very demanding requirements on one side, such as high reliability of the decision taken by the network and robustness to node failure, and very limited resources on the other side, such as energy, bandwidth, and node complexity.

Sensor Network Systems provide a novel paradigm for managing, modelling and supporting complex systems requiring massive data gathering, with pervasive and persistent detection/monitoring capabilities. It is not therefore surprising that in recent years, a growing emphasis has been steered toward the employment of sensor networks in various technological fields: e.g. aerospace, environment monitoring, homeland security, smart buildings. A significant amount of resources has been allocated for national (USA, France, Germany) and international (e.g. European Commission) research programs targeted at developing innovative methodologies and emerging technologies in different application fields of wireless sensor network. The main features that a sensor network should have are:

- each node should have a very low power consumption, the capability of recharging its battery or scavenging energy from the environment, and very limited processing capabilities;
- each node should be allowed to go in stand-by mode (to save as much battery as possible) without severely degrading the connectivity of the whole network and without requiring complicated re-routing strategies;
- the estimation/measurement capabilities of the system as a whole should significantly outperform the capabilities of each sensor and the performance should improve as the number of sensors increases, with no mandatory requirement on the transmission of the data of each single sensor toward a centralised control/processing unit; in other words, the network must be scalable and self-organising, i.e. capable of maintaining its functionality (although modifying the performance) when the number of sensor is increased1;
- a sensor network is ultimately an event-driven system, so that what it is really necessary to guarantee is that the information about events of interest reach the appropriate control nodes, possibly through the simplest propagation mechanism, not necessarily bounded to the common OSI protocol stack layer;
- congestion around the sink nodes should be avoided by introducing some form of distributed processing;
- the information should flow through the network in the simplest possible way, not necessarily relying on sophisticated modulation or multiplexing techniques.

Summarising, the fundamental requirements of a sensor network are:

- Very low complexity elementary sensors, associated with a low power consumption and low-cost;
- High reliability of the decision/estimation/measurement of the network as a whole;
- Long network life-time for low maintenance and stand-alone operation;

- High scalability;

The resilience to congestion problems in traffic peak conditions.

3. WINSOC approach

WINSOC developed very innovative concept of sensor network that represents a significant departure from current proposals. Whole network is achieved by introducing a suitable coupling among adjacent, low cost, sensors, enabling a global distributed detection or estimation more accurate than that achievable by each single sensor, without the need for sending all the data to a fusion centre. The whole network is hierarchical and composed of two layers: a lower level, composed of the low cost sensors described above, responsible for gathering information from the environment and producing locally reliable decisions, and an upper level, composed of more sophisticated nodes, whose goal is to convey the information to the control centres. The key point is the interaction among the low cost sensors that increases the overall reliability, also insuring scalability and tolerance against failure and/or stand-by of some sensors, (e.g. battery recharge and energy saving). The goal was, on one side, to develop a general purpose innovative sensor network having the distributed processing capabilities described above and, on the other side, to test applications on environmental risk management where heterogeneous networks, composed of nodes having various degree of complexity and capabilities, are made to work under realistic scenarios. More specifically, the project will address applications to small landslides detection and large scale temperature field detection and monitoring. Scrutinising the state of the art of the paradigms typically employed in sensor networks, it is possible to recognise a common critical factor: the current paradigms greatly reflect (although scaled and adapted) a well known and consolidated methodological approach borrowed from TLC networks, which however has been developed to cope with totally different requirements and constraints, with respect to a sensor network. The most typical solutions try to adapt classical telecommunication protocols, except for a much greater emphasis on energy-efficient design (see, e.g., ZigBee). However, they still require rather sophisticated network protocols and management overheads in applications where the bit rate required by the sensor network is relatively small and what is really necessary is only to bring the event of interest from the source to the right control node. Typically, the congestion around the sink nodes is only alleviated, but not avoided and the network is not scalable. In WINSOC, it was envisage the development of a very innovative concept of sensor network that represents a significant departure from current proposals. The network is organized in two hierarchical levels. At the low level, there are very simple nodes that gather relevant information and interact with each other to achieve a consensus about the locally observed phenomenon. The interaction occurs through a very simple mechanism that does not require complicated modulation, MAC, or routing strategies. This interaction among the sensors is the key feature, as it improves the reliability of the local decisions and, at the same time, it yields fault tolerance and scalability. The decisions taken locally are then communicated to the upper level nodes that take care of forwarding them to the appropriate control centres.

4. Problems of current technologies

…..In past years in world an extensive research and development work is being done to ensure information technology use in agriculture; long range wireless sensor network creation for specific agricultural use, would ensure a PA technological leap, would solve pressing problems for agriculture and would make PA widely available for farmers, even for low scale use (cranberry fields, fruit gardens, bee-gardens etc.). However for existing solutions these problems remain:

- Existing WSN solutions are in experimental development phase; their implementation is not possible without the specific WSN technology developers' assistance.
- Existing WSNs have a short working range (ability to guarantee communication between sensors only at a range of several tens of meters); therefore their implementation in large area is very expensive.
- Existing WSN technology application programming is not possible without deep WSN operating system (open source Tiny OS, commercial ZigBee etc.) knowledge, that is possible only in specialized development centers;
- Presently known WSN physical node technologies with several hundred meters working range don't support available Operating Systems;
- Existing WSNs are not suited for climatic and geographical factors, as well as production manufacturing problems;
- Realistic WSN implementation is unthinkable without specific WSN technology that includes physical nodes, sensors, operating system, application programming environment, competence centre support.

So it is clear, that new development is necessary. Development would include:

- Principally new sensor nodes with communication ranges of 200-800m depending on environment, weather conditions and sensor location, that are suited for use in most of European countries;
- Development of operating system programming that would collect data from sensor nodes and transport them via wireless network to base computer, such communication protocol configuration that would comply with respective usage target environment, as well as specific usage application programming development in to the utmost simplified environment (in language C with possibly minimal specific knowledge about operating system and WSN physical realization), that would ensure sensor control and communication between sensor nodes;
- Development of network architecture,

5. VLIT technology

Currently, there are many technologies for building wireless sensor networks. They are implemented on different platforms, but their common drawback is that they are able to guarantee the communication between sensors at a distance of only tens of meters. This is the first limited range of networks, while these networks are unaffordable.
Cominfo Corp. developing RFID technology with unique properties, whereby you can build a sensor networks with long-range communication, and affordable costs. Technology is internally known as VLIT. It is characterized by 868 MHz working frequency and by protocol that supports communication mode Point-To-Point, Point-To-Multipoint and the relay station of long distance over several devices. In combination with the mobile unit and the software interface being developed by The Ceske Centrum pro Vedu and Spolecnost (CCSS) presents VLIT NODE completely new and unique solution for building mobile sensor networks.

Technical specifications

- The operating frequency of 868 MHz, divided into several sub bands
- Bi-directional communication protocol of anti-collision
- Communication distance of 200 to 800 meters depending on the environment, weather and location sensors
- Different communication modes: challenge, selective call, communications event management
- Support for communication Point-to-point, Point-to-multipoint, multi - hopping
- Memory integration
- Each tag contains a unique number (physical address)
- The calculation of simple operations
- Easy connectivity measuring sensors
- Very low power consumption
- Lifetime 6 months - 5 years (depending on battery size and type of communication)
- Implementation of wireless sensor networks for collecting and transmission of data
- The ability to connect to the existing mobile solutions that ensure the collection of measurement and its transmission to the Internet environment
- Integration into the Web environment, storing data in standardized formats

CONCLUSION

Currently were developed 200 prototypes of sensors nodes and started deployment and filed testing. Intensive filed testing is provided in Czech Republic and Latvia. It is also expected testing in Italy during this season.

The research leading to these results received following funding:

WINSOC - the solution was achieved with financial co-funding by the European Commission within the Sixth Framework Programme (2002-2006) with registration number 033914 and name “Wireless Sensor Networks with Self-Organization Capabilities for Critical and Emergency Applications”.

VLIT NODE - the solution was achieved with financial support from state resources provided by the Ministry of Industry and Trade of the Czech Republic for support of project of the program “TIP-2009” with registration number FR—TI1/523.

enviroGRIDS @ Black Sea Catchment -the solution was achieved with financial co-funding by the European Commission within the Seventh Framework Programme with registration number 226740 and name “Building Capacity for a Black Sea Catchment Observation and Assessment System supporting Sustainable Development”

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