In situ sensors and Prefarm system

Pavel Gnip\textsuperscript{1}, Karel Charvat \textsuperscript{1}, Maris Alberts\textsuperscript{2}, Marek Musil\textsuperscript{3}, Jan Jezek\textsuperscript{4}, Zbynek Krivanek\textsuperscript{5} and Luigi Fusco\textsuperscript{6}

\textsuperscript{1} WirelessInfo, Czech Republic, gnip@wirelessinfo.cz
\textsuperscript{2} Baltic Open Solutions Center, Latvia
\textsuperscript{3} Lesprojekt služby, Czech Republic
\textsuperscript{4} West Bohemia University, Czech Republic
\textsuperscript{5} Czech Centre for Science and Society, Czech Republic
\textsuperscript{6} European Space Agency, Italy

Abstract

Wireless Sensor Networks open new possibility for on line information access in precision farming. The presented paper describe new possibilities, how new sensors technology could increase of quality of agriculture decision. The paper is focused on description of integration of new sensors measurement with existing Web based system for precision farming. Paper conclude work of previous research projects, butt also experiences from current commercial solutions. The work in this area started in Czech Republic in past mainly in projects WIRELESSINFO, PREMATHMOD, and continued in projects VOICE, AMI4FÖR, NAVLOG and PREZEM.

Keywords: Sensors, Precision Farming, Communication, Spatial Data Infrastructure, Mobility

Introduction

The relationships between human society and the land have been progressively transformed as a result of dramatic changes in the course of the 20th century, particularly by increasing industrialization, the mechanization of agriculture, immediacy in global trade and communication, rapid increases in population size and densities, and the expanding use of biotechnology. National, regional and international perspectives on agriculture must examine these and other factors in order to provide the best possible basis for allocating resources, establishing rules, formulating policy, making decisions and finally work with useful control system. The emerging awareness that agriculture contributes in many varied forms to societal goals leads to a need for better understanding of the "multiple functions of agriculture." Or economic activities have strong relationships to land-use, but agriculture also has unique social and environmental dimensions.

More people are becoming aware of the effects to the soil that years of farming and using chemical fertilizers and other chemicals have caused. In that case is necessary to build up a clear control system for fertilizer chemicals in crop production, crop process in food production and food market. Today exist many laws, public notices, states standards in crop production and post processing and in many times is not able to get all important information about specific crop in one paper. To place this information on web pages make things easier, but crop production is less unite with country side and rural areas and people living in this part mainly do
not have much experience with Information technologies than people in the cities. Fifth Framework Program start up a research activities and build up a models to spread out systems of progressive farm management (System of Precision farming) by using a Information technologies in crop production and food market. This group of farmers and people working in service and grain purchase companies has got a yearly experience how to start with information technologies and use IT in their work. These experiences are mainly from data collection, data processing, data application and data controlling in crop fertilizing and crop protection. These systems run well, but soil tillage, seeding, fertilizing, chemical crop protection and yield mapping is only one part of crop production and crop quality control.

The effectiveness of decision-making in agriculture production generally is depending on quality and frequency of monitoring and data collection in the field, surround environment and weather conditions. The most important in any decision making is right time of decision making in right place. Today’s, many decisions and applications are done to avoid lack of nutrients in the soil for crop feeding or to minimise diseases and pests in soil and crop before they start to grow up and be danger for crop and finally food. The one of several advices of applications in the field, before reason of application show up, is much higher efficiency of application to make a better condition in soil for crop feeding as is for example good level organic contain, nutrients in the soil and their optimal rate between each other or number of pests in crop before they start to damage a crop. Second big advice of this decision making is big save on amount of use fertilizer and chemicals. In this case is also surround environment and water less attack by fertilizer and chemicals because crop and soil can keep a nutrient in safety level (optimal level) and chemicals can demote to harmless level.

**Field decision making system – Prefarm**

Field decision making system (FDMS) running by farmers and service organizations in crop production must be supported by Complex data collection system (CDCS) in Geographic information system (GIS). CDCS can be improved by integrating sensor web applications. Effectiveness of any information system can be evaluated on the basis of its ability to deliver relevant, accurate, and timely generally weather, soil and crop condition at time. Conventional model of agricultural practices is data collection in GIS being added by web based preliminary decision support systems for crop feeding (include soil and crop fertilizer) and crop protection(against weeds, pests, fungi, etc). The main task of this proposal is to integrate weather, soil and crop sensors net created on specific agriculture region (200 sq kmeters in the case of Czech pilot), which collect and process on-line data during whole year for FDMS especially in crop fertilizer during vegetation season and chemical crop protection. Weather forecast and on-line measured data from soil and crop conditions will start up the decision making process on the field applications, which is prepared on remote sensing, lab analysis, crop scouting and agronomical decision. The data could be also combining with measurement from remotely sensed data. Many actions that prevent grapes diseases are based on weather conditions.

As a result of two project in 5Th Framework program WIRELESSINFO and PREMATHMOD, was introduced commercial product Prefarm (supporting fusion, assimilation and analysis of data), which is currently one from most successful advisory Web based system in Europe.
Integration of meteorological sensors

The Prefarm system was combined with weather control model, which bring initial on-line data to above mentioned models. From agriculture point of view the focus is on

- Data collection
  - Detail monitoring of local weather during whole year on-line in the setting grid of monitoring area – air temperature, rain fall, air humidity, air pressure, wind.
  - Detail monitoring of soil and crop condition in vegetable season – “data on time” – soil moisture, soil temperature, temperature in crop to extend collected data from system PREFARM, BACCHUS, DIVINO to more detail analyze advantages and disadvantages for crop protection.
  - n application and fertilizer.
- Data processing
  - Weather prediction model – basic information for above mentioned models, short time (one –two days) and middle time (7 days) weather prediction. This prediction follow global weather forecast in region, but main aim of that is focus on specific crop. For example: Data from weather forecast are presented for farmers as graphic presentation of weather conditions and demand on diseases and pests:
The weather forecast in Agro meteorological models is different for each crops, because each crop has a specific condition of growing and different focus in food change. Also genetic of each crop is different. Some varieties are more resistant against to specific diseases, some less. Monitoring of statistical volumes for cost evaluations and final result of application as follow:

- time and date of application
- rate of application
- area of application
- method of application
- weather during application
- objective of application
- person, who applied
- person in charge

**Sensor specification and grid of its placement**

- Sensor grid will contain a follow:
  - Stationary basic station, place in representative place in area(not in the field) – 5- 7 basic values of measurement(temperature, air pressure, wind, sun shine, air humidity, dew point, rainfall)
  - Season stations – small sensor focused on soil and crop temperature and soil and crop humidity. Sensor will be specific for crop and will be removed from the place after season.
  - Mobile stations – small station placed on application machines for weather data measuring and crop conditions during application on the field (air temperature, air humidity, crop temperature, crop humidity)
Mobile Communication Unit (MCU)

The universal Mobile Communication Unit is designed as heterogeneous network based on interconnection of Bluetooth, WiFi 802.11b.g and GPRS. The Mobile Communication Unit should be a solution for professionals, with focus on QoS. The main requested tasks and characteristics are:

- TCP/IP protocol family and infrastructure
- Internet / Intranet connectivity
- High reliability
- Fast data transmissions
- Easy to implement server solutions
- Wireless access anywhere
- Very low communication fees
- Uninterruptible On-Line Data communication
- Global coverage Integration of different communication platform (GPRS, WIFI, Bluetooth)
- Possible integration with satellite network in form of in form of transportable satellite receiver
- Integration of multimedia on line transmission.
- Integration with EGNOS and GALILEO system
In the cooperation with WLAB company from Frascati incubator, the Wireless Sensor Network based on Tmote Sky technology was realised.

A wireless sensor network is a collection of wireless sensors that form a certain network topology. A sensor node consists of a sensing device, a sensor signal conditioning unit, and a communication module (radio interface). Each sensor node delivers the collected data to one (or more) neighbouring nodes using a multi-hop communication method. A local clustering node then aggregates the information from a group of nearby sensor nodes. The clustering nodes are connected with mobile unit and through mobile unit is information transferred on Web server. For implementation was selected TMoteSky technology.

Tmote Sky is an ultra low power wireless module for use in sensor networks, monitoring applications, and rapid application prototyping. Tmote Sky leverages industry standards like USB and IEEE 802.15.4 to interoperate seamlessly with other devices. By using industry standards, integrating humidity, temperature, and light sensors, and providing flexible interconnection with peripherals, Tmote Sky enables a wide range of mesh network applications. Tmote Sky is a drop-in replacement for Moteiv’s successful Telos design. Tmote Sky includes increased performance, functionality, and expansion. With TinyOS support out-of-the-box, Tmote Sky leverages emerging wireless protocols and the open source software movement. Tmote Sky is part of a line of modules featuring on-board sensors to increase robustness while decreasing cost and package size.

**Key Features**

- 250kbps 2.4GHz IEEE 802.15.4 Chipcon Wireless Transceiver
- Interoperability with other IEEE 802.15.4 devices
- 8MHz Texas Instruments MSP430 microcontroller (10k RAM, 48k Flash)
- Integrated ADC, DAC, Supply Voltage Supervisor, and DMA Controller
- Integrated onboard antenna with 50m range indoors / 125m range outdoors
- Integrated Humidity, Temperature, and Light sensors
- Ultra low current consumption
- Fast wakeup from sleep (<6µs)
- Hardware link-layer encryption and authentication
- Programming and data collection via USB
- 16-pin expansion support and optional SMA antenna connector
- TinyOS support : mesh networking and communication implementation
- Complies with FCC Part 15 and Industry Canada regulations
- Environmentally friendly – complies with RoHS regulations
Acknowledgements

The paper is prepared on the base of outputs from projects:

PREZEM - the solution was achieved with financial support from state resources provided by the Ministry of Education, Youth and Sports of the Czech Republic for support of project with registration 2B06124C and name “Reducing of impacts and risks on environment and information acquisition for qualified decision-making by methods of precision agriculture”

NAVLOG - the solution was achieved with financial support from state resources provided by the Academy of Sciences of the Czech Republic for support of project of the program “Information Society” with registration number 1ET109890411 and name “ IP based navigation and logistic systems ”.

IMPULS - 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 “IMPULS-2004” with registration number FI-IM/106 and name “ The technology of on line mobile data collection, analysis and modeling for environmental applications”.

References

Charvat at all, 2003 Wirelessinfo final report, Praha
Collaboration@Work October 2005, The 2005 Report on new working environments and practices, DG INFSO, Brussels,
http://www.ami4for.org/
http://bivoj.vugtk.cz:20080/mobildat/