Teaching precision farming for agricultural engineers: experiences and lessons learned

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SUMMARY

In recent decades innovations of the agricultural sector are increasingly driven by digital technologies. So called precision farming solutions provide attractive advantages for farmers.
Although implementation of precision agricultural technologies was initially rapid, its spread has slowed down, due to the lack of quality educational programs giving the right level of knowledge and following rapid technological development. The challenge for farmers and enterprises is to effectively measure, collect and analyze spatial data to make efficient management decisions.
In the last few years engineering training on this topic has been launched at several universities in Hungary. This paper describes the results achieved and the experiences gained in the postgraduate education of precision farming at Obuda University Alba Regia Technical Faculty. The new technology is largely based on knowledge that has previously belonged to the field of geomatics, such as remote sensing, UAS, terrain modeling, GNSS, GIS so there is a need to teach them. A new course was created after studying educational needs on precision agriculture and state of the art of technologies. In addition to basic knowledge of precision farming technologies, the training focuses on data acquisition and processing as well as specific thematic applications are part of the curriculum. The focus is given to case studies covering a broad range of applications. In the article we present a specific curriculum, examples and experiences in solving real challenges proposed by farms, related to the use of these technologies.

SUMMARY

W ostatnich dziesięcioleciach innowacje w sektorze rolniczym są w coraz większym stopniu związane z rozwojem technicznym i digitalizacją. Tak zwane rozwiązania rolnictwa precyzyjnego zapewniają rolnikom atrakcyjne korzyści. Choć początkowo wprowadzanie technologii rolnictwa precyzyjnego było szybkie, jego rozpowszechnianie uległo spowolnieniu z powodu braku programów edukacyjnych, zapewniających odpowiedni poziom wiedzy potrzebny do optymalnego wykorzystania możliwości związanych z zastosowaniem wyników rozwoju technologicznego. Wyzwaniem dla rolników i przedsiębiorstw rolniczych jest wykonywanie efektywnych pomiarów, gromadzenie i analiza danych przestrzennych w celu podejmowania skutecznych decyzji dotyczących zarządzania.

Biorąc pod uwagę zapotrzebowanie z ostatnich lat, na kilku uniwersytetach na Węgrzech rozpoczęto podyplomowe kształcenie inżynierskie w tym zakresie. W niniejszym artykule opisano wyniki i doświadczenia zdobyte podczas kształcenia podyplomowego w zakresie rolnictwa precyzyjnego na Wydziale Technicznym Uniwersytetu Alba Regia Obuda. Nowa technologia w dużej mierze opiera się na wiedzy, która wcześniej należała do dziedziny geomatyki, takiej jak teledetekcja, UAS, modelowanie terenu, GNSS czy GIS, dlatego istnieje potrzeba ich nauczania w kontekście rolniczym. Nowy kurs został stworzony po przeanalizowaniu potrzeb edukacyjnych w zakresie rolnictwa precyzyjnego i najnowszych technologii. Oprócz podstawowej wiedzy z zakresu technologii rolnictwa precyzyjnego, szkolenie koncentruje się na pozyskiwaniu i przetwarzaniu danych oraz zastosowaniu informacji przestrzennej w podejmowaniu decyzji.
W artykule przedstawiamy konkretny program nauczania, przykłady i doświadczenia, aby odpowiedzieć na rzeczywiste wyzwania związane z wykorzystaniem tych technologii w gospodarstwach. Nacisk kładzie się na studium przypadków obejmujące szeroki zakres zastosowań.

1. INTRODUCTION

Modern agriculture must rely on expert knowledge and implement new technology to enable farmers for profitable production while fulfilling environmental and food safety conditions. The traditional methods of cultivation have not taken into consideration the variability of habitat conditions. The doses of fertilizers and pesticides are determined for the mean conditions of the field. During the traditional cultivation a large variation in mineralization in a given field resulted local overdose on rich soil or poorly fertilized on poor soil.
Precision agriculture technology is a farm management system, which relies on various measurements, data collections and analysis, as well as decision making. Measurements include soil chemical and physical characteristics determination, grain yield and quality measurements, and several remotely sensed property determination as well.
Exploiting the potential of technology requires the development of methods based on the analysis of real and current data. Recognizing risk factors and reducing their impact on crop production (on crop growing) are key issues in today’s agriculture.
The introduction of precision technologies in agriculture has been motivated by the high degree of variability of agro-ecological conditions within fields. One of the criterion for introducing precision agricultural technologies is the development of an up-to-date arable crop information system that provides information on soils, crop land cultivation, plant status, etc. In order to set up such an information system, it is essential to use modern data gathering and analysis technologies. Remote sensing is the most effective tool for surveying the Earth's surface and tracking its changes. The European Parliament Service (2016) study says the introduction and uptake of PF requires new skills to be learn. High-quality educational programs providing the right level of knowledge and rapid technological development are required. Educational institutions have an important role to play by introducing modern tools, methods and solutions to farmers (Varnik et al., 2017).
Although the introduction of precision agricultural technologies was initially rapid, its spread has slowed down due to the lack of high-quality educational programs providing the right level of knowledge and rapid technological development. There are several studies in the literature that deal with how to exploit the full power of precision agriculture. According to the findings of Wiebold et al. (1998) precision agriculture should be needs-based. In other words, we must have a better understanding of what barriers to increased adoption of precision agriculture exist and what is required to move present users to the higher level. As many studies concluded, one of the factors that results in low adoption rate of precision Farming include the lack of farmers and agricultural students education (Yang et al,. 2015).
In recent years, progress has been made in this area and several courses have been developed and published that focus on teaching the elements of technology or the whole process of PF (Valero et al., 2021, Bauer – Verőné Wojtaszek et al., 2021).

2. NEEDS ANALYSIS AND DEVELOPMENT OF LEARNING MATERIALS

2.1 Needs analysis

In the preparatory phase of the curriculum, a survey was carried out to assess educational needs. During the research a foresight analysis was conducted on existing scientific studies considering PF. We have also organized several meetings and workshops. Farmers, advisers and specialist from different fields were invited to take a part in discussion and needs analysis. After compiling the results from the state of the art, technological trends and educational needs the course contents and structure were outlined. Also, a partnership and cooperation agreements were signed between university and AXIÁL LTD, one of the market leaders in Hungary and two farmers to support education.

The aim of the curriculum is to present the achievements of modern technologies and their integration into precision farming. The course is practical-oriented, i.e. in addition to the necessary theoretical knowledge, the program emphasis on practical application. It develops users and problem-solving skills by using demonstrations, interactive exercise and case studies. In this context, the students learn about the tools for data collection, data sources and methods of data evaluation needed to get various information and support decision making. The practical part of the training includes field demonstrations of precision machines, sensors and UAV flights. The training concludes with an analysis of the impact of precision farming and a presentation of the environmental, sustainability and economic benefits.

2.1 Development of Learning Materials

This curriculum provides practical-oriented knowledge of precision agriculture technologies, covering both the applications and the different technologies (e.g. satellite remote sensing systems and UAV, geographic information systems (GIS), global navigation satellite systems (GNSS), variable rate application etc. that make precision farming (PF) possible.
It has a duration of one and half years divided into 3 semesters, 240 contact hours and 90 ETCS.

Goals of the course:

- The course provides a comprehensive knowledge of the concepts, technologies and implementations strategies of PF
- It enables students to become familiar enough with the concepts and the technologies for PF
- It provides basic knowledge in image processing, geographic information systems and agricultural information systems
- It develops practical and problem-solving skills by using examples, case studies, laboratory activities and field demonstrations
- It develops software (e.g. SMS Basic, QGIS) skills
- After completing the course student will be able to collect and critically analyze appropriate data, to define the plant status, development/grows problems, to map variability within a field and to solve the problems

Learning Objectives:
Upon completion of this course, student will be able to:

- Define precision agriculture technology and understand the overall scope of PF

- Understand the role of data collection and database management system
- Explore the role of GIS in precision farming and site-specific crop production.
- Define remote sensing (Satellites and UAV) and characterize its role in precision farming.
- Use satellite images in mapping crop and soil conditions
- Identify the soil and management factors that influence crop yield
- Understand the concept of spatial variability (Variable-Rate Technology) and soil sampling
- Understand how global positioning system work and how this technology is used in PA
- Use special software

1.Table Curriculum and description of the subject programs

The first semester/ Subjects	*Duration/ hours*
Precision farming	21
Remote Sensing	18
Soil Science in Agriculture	15
Geoinformatics (GIS)	21
Topography and Digital Elevation Models	15
The second semester/ Subjects	
Project module	18
Data and software in precision farming	12
UAS data acquisition and applications	15
GNSS technology and precision farming	15
Seminar, thesis 1.	15
The third semester/ Subjects	
Thesis 2.	30
Applications of Drone Technologies	15
Data integration in precision farming	9
Accounting	9
EU agricultural and environmental policy, environmental management	9

The main topics of the training:

- Basics and main elements of precision farming
- Data collection using remote sensing (space, aerial and UAV imagery)
- Spraying drones, robots in agriculture
- Image processing (vegetation indices, classification methods), image analysis with advanced software
- Crop monitoring
- Harvester data analysis
- SMS Basic in practice (data visualisation, analysis, planning)
- GNSS technology
- Data integration and geospatial analysis
- Topography and digital elevation models
- Software: QGIS, SMS Basic, Agisoft, eCognition

As an example, a detailed description of one of the subjects is given in the next chapter.

3. TEACHING GNSS SUBJECT FOR AGRICULTURAL ENGINEERS

Everyone has heard of GPS, and GPS navigation is widely used in transportation, but we cannot say that engineers are aware of the basics and essential knowledge. Several technologies are used in precision farming (including, for example, PPP RTK, which is also little known to surveyors), so it is appropriate to give a complete picture of the GNSS topic. Teaching of the topic is basically divided into three parts, just as GNSS itself can be divided into three parts (Fig. 1.).

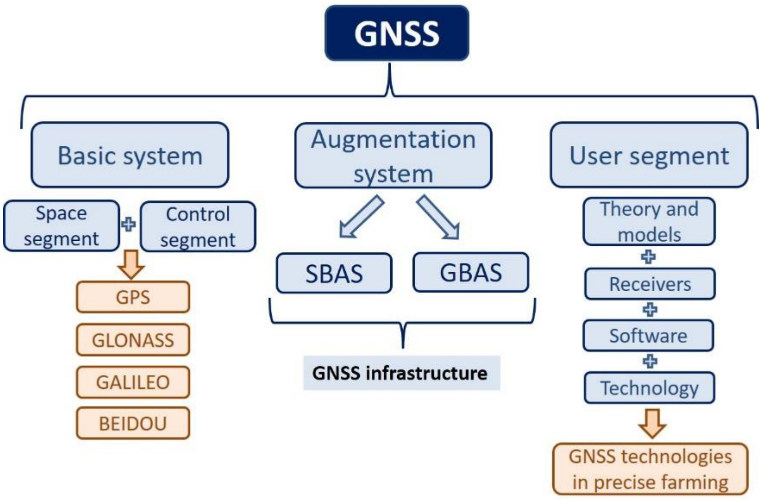

Fig. 1. The elements of GNSS

In the introduction of the topic, we review the principle of satellite positioning, the role of time measurement, the essence of code- and phase measurement, and the sources of error. This is followed by the presentation of the first comprehensive part, the basic systems, of which there are now four fully operational systems. For all four basic systems, the space segment and the control segment are briefly described, covering the current state. In the second part, the so-called GNSS infrastructure is highlighted in two parts. Among the satellite-based augmentation systems, EGNOS is given priority. In the case of ground-based augmentation systems, we briefly discuss the worldwide GNSS networks, the European networks and, above all, the Hungarian possibilities. In Hungary there is not only state-supervised active GNSS network, but some agricultural companies also operate their own nation-wide permanent network (there is also a VRS-based network that can receive and provide GPS, Glonass, Galileo and Beidou signals). In the third part, we focus on technologies from the elements of the user segment. Particularly for technologies involved in precision farming, such as DGPS, conventional RTK, single-based RTK, network RTK, and RTX.

The theoretical part is followed by a practical presentation, for which we ask the help of external colleagues. Examples include simulation of tractor control software or field demonstration of the sprayer drone where network RTK and conventional RTK technology are also used (Fig. 2.).

Fig. 2. Dron and GNSS demonstration

We think it is important not only to convey knowledge, but encourage students to address the topic themselves. Thus, in the moodle e-learning system developed at the university, we require the submission of two tasks; one of these is a mandatory task and an alternative. In the latter case, you can choose from three alternatives: writing an essay based on your own experience; Rinex file analysis, measurement planning. These solutions worked during the pandemic.

SUMMARY

In the article we present a Precision Farming course developed at Obuda University Alba Regia Technical Faculty in Hungary. This curriculum provides practical-oriented knowledge of precision agriculture technologies, covering both the applications and the different technologies (e.g. satellite remote sensing systems and UAV, geographic information systems (GIS), global navigation satellite systems (GNSS), variable rate application etc. that make precision farming (PF) possible. It has a duration of one and half years divided into 3 semesters, 240 contact hours and 90 ETCS.

The training was first launched in 2017. A new course starts every year. Participants in postgraduate courses in precision farming typically have a higher education in agriculture, but also come from other disciplines. In Hungary, there are several agricultural universities offering two-semester courses, but the number of applicants in our institute is increasing every year. This is due to the increased emphasis on the technical aspects of precision farming technologies, complementing the agricultural knowledge acquired through the basic education. In addition to the theoretical basics, the course participants also learn the different technologies of data aquisition and how these can be applied in practice.

An important component of the developed course and learning materials is the set of exercises and case studies related to the application, which improve the understanding of the content. Students can learn the practical implementation of the knowledge gained in the theoretical parts. Students can use the material to develop their own case studies in a different environment.

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BIOGRAPHICAL NOTES

Małgorzata Verőné Wojtaszek: associate professor, CSC, director of the EKIK Centre for Precision Farming Research, has been engaged in teaching and research of remote sensing for more than 25 years. She has been a professional leader and participant in several national and international remote sensing projects. Her achievements in the application of remote sensing (e.g. agricultural applications, soil degradation, remote sensing based soil moisture measurements and models) have been published in several national and international papers. She is the course leader of the Precision Farming Engineering at the Obuda University. In 2017, Dr. István Nagy, Minister of Agriculture of Hungary, awarded her the Antal Fasching Prize, the most prestigious Hungarian award for her achievements in education and research.

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