

USE OF MODERN DIGITAL TECHNOLOGIES IN AGRICULTURE IN SLOVENIA

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Abstract The presentation summarises the development and current state-of-the-art of the Doctoral Study Programme ‘Agriculture’, and researches carried out in the Faculty of Agriculture Life Sciences in the field of the use of modern digital technologies in precision agriculture, such as the application of image analysis for fruit yield estimation. A second important topic represents the reduction of plant protection products in orchards, which is based on 3D tree reconstruction with LIDAR (Laser Detection and Ranging) and EMV (Electro Magnetic Valve) triggering in pulse width modulation. First experiments towards a future self-guided tractor driving, spraying or weed management by simply navigating a field robot has already been developed and tested.

Keywords:

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1 Introduction

The beginning of agriculture study in Slovenia is connected with the Faculty of Agronomy founded in Ljubljana in 1947 [1]. Today, there are two Faculties in Slovenia offering PhD study in Agriculture, namely the Faculty of Agriculture and Life Sciences – University of Maribor and the Biotechnical faculty at the University of Ljubljana.

The history of the Faculty of Agriculture and Life Sciences began in 1960, when the College of Agronomy (CA) was founded, offering two-year Study Programmes. The time of establishment coincides with the period of rapid growth of large-scale state and collective farms. In the academic year 1971/72, a new curriculum was introduced, with an emphasis on transferring knowledge to private farmers. In 1992, after Slovenia declared independence, the need for global development led to the transformation of CA. The study programmes were prolonged from five to eight semesters.

1995 represents one of the most important milestones in the history of the Faculty. The Institution went from College to Faculty, and it was officially reorganised as the Faculty of Agriculture, today offering seven Bachelor's degree Programmes, three Master's degree Programmes and two PhD Programmes. In the academic year 2000/2001, the first five PhD students matriculated from the 6 semester Study Programme [2], and after five years, in 2006, Tatjana Unuk defended successfully a PhD thesis entitled '*The analysis of interaction between crop load and nitrogen rates and its use in optimisation of apple (Malus domestica B.) cv. golden delicious yield*' [3]. In the academic year 2019/2020, the PhD Study Programme passed an additional innovative step by introducing 10 elective courses in the second semester of the first studying year, so the PhD students could easily adapt to research and scientific activities on their own dissertation topics.

The last modification of the PhD Study Programme Agriculture is predicted for the academic year 2020/2021, in which a 6 semester study is extended with an additional 2 semesters so the students would have more time for writing the scientific articles and PhD thesis.

2 The structure of the PhD Study Programme ‘Agriculture’

From the academic year 2020/2021, the PhD study Agriculture is organised as an 8 semester Study Programme (240 ECTS credit points), consisting of eight compulsory courses and a list of ten elective courses. From this set, a student should select a maximal three elective courses with a total of 24 ECTS. In the following paragraphs, we will present the Programme briefly.

2.1 Compulsory courses in the Study Programme ‘Agriculture’

Compulsory courses represent 214 ECTS credits points, from which (60 ECTS) are achieved by students in the first year. In all other semesters, there is only one compulsory course per semester.

Since the very first academic year 2000/2001 there was only one compulsory course *Scientific research methods in agriculture* in the first semester, however, from 2021 a new compulsory course will be introduced, *Project management (transferable skills)*.

2.2 Elective courses in the Study Programme ‘Agriculture’

With additional elective courses starting in the academic year 2020/2021 we focused on actual problems connected with modern agriculture. For this reason, 10 modern elective courses, which represent the most novel interpretation of particular scientific fields, were offered to the students in the second semester:

- *Selected topics from organic agriculture,*
- *Behavioural ecology of domestic animals,*
- *Functional foods,*
- *Selected topics in the physiology of agricultural plants,*
- *Trends in pre – and postharvest treatment of fruit,*
- *Management of weeds and invasive plants,*
- *Soil management in Viticulture in relation to climate change,*
- *Factors and Risk Assessment in Nutrition,*
- *Selected topics of Grassland management and Forage production,*

- *Selected chapters of precision agriculture,*
- *Specifics of organic farming (principles, environmental issues), legislation, inspection and certification, labelling.*

3 PhD Thesis and researches connected with the digitalisation of agriculture

Digital technologies including the Internet, mobile technologies and data analytics, Artificial Intelligence, digitally-delivered services and apps, is changing agriculture and the food system. The world's first entirely machine-operated crop known as "smart farming" – a crop sown and tended without a human ever entering the field – was harvested in 2017. Digital technologies can also help governments to improve the efficiency and effectiveness of existing policies and programmes. For instance, freely available and high-quality satellite imagery reduces the cost of monitoring many agricultural activities dramatically [4].

3.1 PhD thesis

On the Faculty of Agriculture and Life Sciences the first PhD from the field of Digitalisation was defended already in 2004 by Stajnko. It was a Thesis about the application of digitalisation in apple production *Application of image analysis for potential monitoring of growth and development of apple fruits 'Malus domestica' Borkh* [5]. After this milestone, several PhD Theses were finished successfully:

- Detecting objects in natural environments using spatial-frequency analysis and multiview geometry [6],
- The use of image processing and machine learning methods for the assessment of germination of the tomato (*Lycopersicon lycopersicum* L.) [7],
- Ability of NIR spectroscopy to predict meat characteristics [8],
- Using machine learning methods for apple quality forecasting [9].

Currently, two PhD Theses are running on the PhD. Programme connected with Digitalisation; one about modelling the modern tillage equipment with the help of 3D software tools, and another dealing with non-invasive piglets` observation during sucking the milk.

3.2 Scientific research work

From the first semester of study the young PhD students are always introduced to the scientific research groups, which enables the best possible material and financial conditions for a particular PhD thesis. In many cases, excellent works were developed from such cooperative workshop, which were later integrated as vital parts of bilateral or applicative projects. Recently, there have been two projects running connected with Digitalisation in Agriculture:

- Reconstruction of a tree crown on the principle of measurement with the LIDAR measuring system [10], which deals with the development of alternative plant protection product application techniques in with sensing systems for electronic canopy characterisation;
- Simultaneous localisation and mapping in a complex field environment [11], in which a highly innovative robotic management of the vineyard is being developed, which is based on the dialogue between a robotic sensor and DSS (Decision Support System) software [12].

3.3 Student activities

A special Chapter in the development of young researchers – PhD students in the field of Digitalisation, is represented by the project FRAMBEAST [13], in which a group of young people under the guidance of their mentors, coming from different Faculties of the University of Maribor, developed a self-driving robot capable of locating and driving in between the rows of corn plants on the field. The 1st prize in Freestyle at the Field Robot Event 2019 represents the best achievement so far [13].

4 Conclusions

The presented developments and achievements in the PhD Study Programme Agriculture show that the Doctoral study is a dialectical, constantly evolving system, which should not only adapt, but also investigate new innovative technological achievements with the technologically advanced research field Digitalisation of Agriculture. In the future activities, mentor Professors will be aimed at strengthening cooperation with foreign research organisations on the one hand, and through

increased cooperation with industry on the other. In this way, in addition to the greater scope of participation in the triangle, student and user, faster transfer of knowledge from scientific research environments to the end users of new technologies will also be ensured.

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