Antti Lajunen*, Animesh Kumar, Niila-Sakari Keijälä, Julius Pietarinen, Klaus Kivekäs

Development of learning environment for agricultural automation

Abstract: Increasing use of automation and automated systems in agriculture requires dedicated methods in the university education. This extended abstract describes the development and implementation of a practical learning environment, DigiFarm, dedicated for teaching agricultural automation. The environment consists of three different elements called automated processes, robot operation, and digital farming. An educational robot arm with a conveyor belt is used for demonstrating automated processes. A mini robot called ROSbot serves as the platform for developing and executing basic robot tasks such as path tracking and object detection. Digital farming processes are simulated by a mini greenhouse which includes measurement and control systems for controlling the plant growing conditions. The main objective of the DigiFarm environment is to strengthen and deepen the knowledge of automation technology and digitalization of master students at the system level of agricultural processes.

Keywords: learning environment, automation, digitalization, agricultural robots, digital farming

*Corresponding Author: Antti Lajunen: Department of Agricultural Sciences, University of Helsinki, E-mail: antti.lajunen@helsinki.fi

Other Authors: Department of Agricultural Sciences, University of Helsinki, E-mail: animesh.kumar@helsinki.fi, niila-sakari.keijala@helsinki.fi, julius.pietarinen@helsinki.fi, klaus.kivekas@helsinki.fi

1 Background and Aims

Automation in agricultural vehicles and processes is expected to increase significantly over the next decades. The size of farms has been steadily increasing which has increased the use of automation technology for better control of processes and higher productivity [1]. The efficiency and sustainability of agricultural production are based to a certain extent on the digital technologies implemented in the agricultural processes [2]. It is essential in the education of agricultural technology to ensure that future experts have sufficient knowledge and skills, especially about automation and related digital technologies [3]. In order to obtain similar benefits from automation technology in agriculture than in other industrial sectors, automation technologies must be thoroughly taken into account in the education with relevant practical teaching methods.

The DigiFarm learning environments was developed in the project DigiTally (Improving digital skills in Mechanical Engineering, www.digitally.fi) which started in September 2021, and it is funded by the REACT-EU (Recovery Assistance for Cohesion and the Territories of Europe). There are four educational institutes as project partners: Metropolia (coordinator), Aalto University, University of Helsinki, and Omnia. Each of the participants have their own focus areas depending on their educational focuses and there are several topics that are shared and jointly developed by the project partners. One of these themes is automatization and robotization.

2 Materials and Methods

In the project context, the focus of the University of Helsinki was deeply in the automation of agricultural processes. Therefore, DigiFarm environment is focusing on the basic skills that are required to understand and develop automation systems and advanced topics such as control automation and object detection for deeper understanding of automation methods.

The basic skills include the basics of ROS (Robot Operating System) and python programming. ROS is widely used open source midware in robotic solutions and it does not require any expensive hardware or software for implementation. There exist two versions of ROS named ROS and ROS2. The original ROS runs only in Linux distributions whereas ROS2 is compatible also with Windows and iOS. The challenge for ROS is that there are several versions of ROS and there are certain compatibility requirements between ROS and operating system versions. Another challenge is the need for understanding ROS processes such as building a ROS package that relates to typical programming procedures.

The advanced topics include three specific practical learning platforms: 1) automated processes, 2) robot operation, and 3) digital farming. As measurement technologies have important role in agricultural processes, all these three platforms include different types of sensors and data logging systems. The automated processes are demonstrated with an educational robot arm Niryo One (Figure 1) which corresponds to a typical robot arm used in industry with six degrees of freedom. In this context, the main focus is to integrate sensors, detect object based on their properties, operate the arm based on the measurements, and synchronized operations with a conveyor belt.

Figure 1. Educational robot arm Niryo One.

In the teaching of robot operations, a mini robot ROSbot (Figure 2) is used. The robot is specifically built for educational purposes and has integrated sensors for environment mapping (stereo camera, lidar and distance sensors). The robot includes a control and data logging board, and computing board (Asus TinkerBoard). The robot runs with ROS and has preinstalled package of ROS with necessary libraries. The robot will provide a platform for the development of autonomous operation by using different sensor data. It is possible to perform an accurate and precise SLAM (simultaneous localization and mapping), one of the simplest solutions is to use a laser scanner and an odometry system.

Figure 2. ROSbot mini robot.

Digital farming methods are demonstrated with a mini greenhouse (Figure 3) that includes controllable under irrigation system, sensors for measurement of soil and air properties and conditions, and control system for adjusting temperature, moisture, and lighting conditions. The first version of the measurement and control system was built up on Raspberry Pi with Grove Base Hat in which most of the sensors are attached. In this context, students will learn how to develop real-time data processing system that is used for controlling the growing conditions.

Figure 3. Mini greenhouse.

In the educational context, the three different learning platforms are used first for the demonstration of agricultural automation and digitalization. Then, dedicated project works are carried out by student groups. In all of these projects, specific automation systems are developed, documented, and also demonstrated.

The first experiences of a master student class were considered very positive, and students were able to work independently when developing their projects. It was recognized that well defined automation system and clear instructions were essential for deeper learning in each learning platform. The teaching of ROS can be challenging if the students does not have any prior programming experience.

3 Bibliography

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