Kanth, Rajeev & Wójtowicz, Patryk & Toppinen, Arto & Jakorinne, Asmo & Rouvali, Juhani & Räsänen, Teemu 2021. Savonia's Teaching, Research and Development Activities on Unmanned Aircraft Systems. In Proceedings of the 30th Conference of Open Innovations Association FRUCT. Oulu, Finland, 27-29 October 2021. Eds. Balandin, Sergey & Roning, Juha & Shatalova, Tatiana, 398 - 399.

Savonia's Teaching, Research and Development Activities on Unmanned Aircraft Systems

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***Abstract*—In this article, we have presented the teaching, research, and development-related activities on unmanned aircraft systems (UAS) carried out at the Savonia University of Applied Sciences. We aim to demonstrate a few applications such as snow-depth measurement, mapping of gas leaks and operation of bio-waste composting pits, and the feasibility study for installing bird warning balls on the power grids. Also, we have highlighted the major ongoing UAS project activities, education, and future directions.**

I. Introduction

The need for education and research on unmanned aircraft systems has been emerging quite rapidly in recent years [1]. The applications and usage of UAS have also been growing at a rapid pace. The academic institutions and the companies together are piloting several use-cases for building a society smarter than ever. More pilotings are being carried out in agricultural applications, logistics, forest, and power-grids monitoring. In Finland, Savonia University of Applied Sciences has been conducting several engineering and technology-related education in the north-Savo region. The bachelor's degree in the Internet of Things program includes a tertiary education on sensors, microcontrollers, real-time systems, data analytics, and also low-level programming. The multidisciplinary studies of Savonia help students to explore more on the applications and integration of UAS with other thematic areas. In this article, we are emphasizing the teaching, research, and developments activities towards UAS.

The rest of the article has been structured as follows. In the next section, we will be discussing Savonia's departmental research and teaching activities on UAS. After that, we will elaborate more on our drone-based project, UCNDrone, a consortium of ten universities and applied science universities of Finland. Followed by it, future directions and conclusions are presented.

II. Savonia's Activities on Unmanned Aircraft Systems

In this section, we are going to present our past and present research and development activities using UAS. Mostly, the Environmental Engineering, Electrical Engineering, and Internet of Things departments are utilizing UAS in teaching, research, and development activities.

A. Snow-Depth Measurement with UAS

The Savonia University of Applied Science is one of the versatile universities, and we have been conducting a bachelor's degree program in information technology, specializing in the internet of things. Students are executing and observing the integration of UAS along with sensors and embedded systems project work. Moreover, Some of the students are working on UAS that can be integrated with 5G communication technology for several societal applications. Most importantly, we have developed a novel technique to measure the snow depth with the DJI-Phantom 4 Pro unmanned aerial quadcopter integration. The integrated device has been mounted on the quadcopter, and measurement has been done using frequency modulated continuous wave (FMCW) radar sensors. During this experiment, a significant challenge was to store the measured snow-depth data in the cloud. In this regard, FMCW has a limited capacity to connect and disconnect to the sensors and provide instant visualizations. To mitigate the snow-depth data storing problem, we built our own graphical user interface using Savonia's own cloud system (SAMI-Cloud) to visualize and store the data in real time. This work was conducted by Drone Lentoon Project funded by the European Social Fund and ELY research center [2].

B. Use of UAS by the Department of Environmental Technology

Unmanned aircraft systems have been used for a variety of environmental applications for a decade [3]-[4]. The Department of Environmental Technology of Savonia has been working closely with the UAS for several applications. The main goal is to utilize UAS to monitor the state of the environment and create up-to-date 3D models for infrastructure construction and natural environment modeling needs. In such applications, we are actively taking care of aircraft flight operations as well as data processing. Much has been achieved, but there is still much to learn. During the year 2021, we have used DJI Matrice 300 RTK drone and Zenmuse H20T thermal camera in the following applications:

- mapping gas leaks from landfills using infrared thermography,
- evaluating the operation of biowaste composting pits using infrared thermography, and
- mapping of groundwater springs using infrared thermography.

In addition, we have calculated the stockpile volumes of sorted waste using a 3D model formed from orthophotos. UAS

ISSN 2305-7254

has been used in collaboration with local environmental authorities and companies, and these issues have been included in the content of environmental technology education. The first implementation of the environmental monitoring course is currently underway.

Within the Department of Environmental Technology, Smart Water Group is a partner in the research project Smart Water Management (SWIM) together with the Technical Research Centre of Finland (VTT). This project will test drones paired with augmented reality (AR) applications (HoloLens 2) for water utility crew assistance to support technical inspection of large and complicated to reach infrastructure and hazardous areas. All pilot applications will be conducted within the test and demonstration area in Kuopio - Savilahti (SuperDMA). In the other pilot application - we will test the LiDAR device (DJI Zenmuse L1) to scan open-pit pipeworks before the backfill. Using a drone allows for safe access to the construction areas and rapid reproduction of the details of complex structures such as valves or connectors along trench (often measured in kilometers) at different build stages. This application will deliver accurate reconstruction after groundworks are finished to be accessed using augmented reality.

C. *Use of UAS by Electrical Engineering*

Savonia carried out an unmanned aircraft system (UAS) feasibility study with local power companies during spring 2018. The aim was to find new uses and applications of UAS devices for power companies. The teachers and students were involved in the project. The results were presented to a large group of students and people in the industry.

The study continued with workshops with local power companies in order to find practical and valuable applications to UAS devices. The three main ideas stood up: installing bird warning balls to aerial conductors, partial discharge or corona detection with a camera, and developing data processing applications for the collected data of UAS devices. The work continues with power companies.

III. Savonia's activities on UCNDrone project

Savonia University of Applied Sciences actively participating in Finnish Ministry of Education and Culture funded project. In this project, the consortium has been creating a network-like operating model of ten Finnish universities to strengthen training and research on unmanned aircraft systems and respond to changes in society and working life by listening to the business communities. The solutions and training developed in the network are central to emerging technologies, societal changes, and green technologies. The universities have participated in the project in a multidisciplinary manner in accordance with their own strategic priorities. Recently, Savonia University of Applied Sciences has focused on integrating students' internships and bachelor's degree thesis with unmanned aircraft systems. We have been actively involved in co-developing the education and research related to UAS. The essential current activity is to carry out a national survey for UAS education and research. The consortium members of the UCNDrone network have their own strengths in their respective areas however, we cooperate to identify national and international development targets and keep Finland as the forefront of education and research in the field of UAS.

IV. Future Directions

Savonia University of Applied Sciences has been strengthening its internet of things programs by deploying UAS based students' internships and collaborating with companies dealing with UAS. We focus on several sensors mechanisms that could be embedded with aircraft for several applications areas such as forestry, agriculture, logistics, transportation, and environmental monitoring. In the future, environmental technology applications will also focus on laser scanning with LiDAR technology [5]. It is used to capture the details of complex natural structures like streams, rivers, and water reservoirs in order to produce more accurate reconstructed digital elevation models. LiDAR also allows the classification of ground objects according to their properties. For example, trees, vegetation, and buildings can be classified from point clouds. In addition, we continue our development work to utilize thermal imaging and photogrammetry as a tool for environmental monitoring.

IV. Conclusion

All the three departments (IoT, Environmental Technology, and Electrical Engineering) of Savonia University of Applied Sciences actively cooperate to identify the UAS skill needs of the companies and develop teaching according to their needs while taking into account the ability of students to create new businesses. The multidisciplinary UAS research and its integration to water lab, sensors, and embedded computing, data collection, and processing will make society, especially Savo-region, even more innovative.

Acknowledgment

The authors would like to express the thank to the Ministry of Education, Science and Culture of Finland for funding the UAS (Drone) University Collaboration Network (UCNDrone) project.

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