TrimBot2020 Deliverable D8.10

Proceedings of the 3rd workshop

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Abstract: This document describes the organization and outcome of the Workshop on Agricultural Robotics, that we organized in conjunction with the fair on agriculture and food technology AgriFoodTech 2019. The workshop hosted five talks, one on TrimBot2020 and the remainig four on various aspects of technology and robotics applied to agricultural and gardening autonomous applications. The workshop was accompanied by an exhibitor booth where we presented the resuls of the project to a broad and varied audience.

Deliverable due: Month 48

1 Introduction

The recent progress made in robotics, artificial intelligence and computer vision technologies stimulated a growing application of automation to agriculture-related tasks.

We organized a workshop in the context of the AgriFoodTech annual fair of agricultural and food technology in the Netherlands. The aim of the workshop was to discuss recent technological achievements of the application of AI and robotics in agriculture and gardening processes. We coupled the workshop with an exhibitor booth (on December 11 and 12) where we showed the final results of the TrimBot2020 project to an audience composed of people from academia, industry and education bodies.

In the workshop, examples and progress in the fields both from (deep) machine learning and computer vision, and a robotics and control perspective were presented by academic and industry representatives. The results of the European H2020 project TrimBot2020 that successfully integrated robotics and computer vision to build the first outdoor gardening robot were also presented.

In the following, we provide more details about the program, talks and attendance of the workshop. We also attach a flyer, part of the project promotional material, that we produced to advertise the workshop.

1.1 Program

Date: Thursday December, 12th 2019
Place: Zaal 2, AgriFoodTech 2019, Brabanthallen, 's-Hertogenbosch, Netherlands
Program:

- 13:55 Introduction [5min]
- 14:00 TrimBot2020 presentation by Radim Tylecek [30min]
- 14:30 Invited talk by Sjaak Wolfert [30min]
- 15:00 Invited talk by Andreas Kamilaris [30min]
- 15:30 Invited talk by Michael Blaich [30min]
- 16:00 Invited talk by Andreas Linz [30min]

Attached to this document, we report the program flyer used for advertising the workshop. The program of the workshop was also included in the general program of all the talk sessions of AgriFoodTech 2019 and is available at tha url https://agrifoodtech.nl/program/program-day-2/

1.2 Talks

TrimBot2020 - an autonomous outdoor gardening robot with passive vision control
Dr. Radim Tylecek, University of Edinburgh

The TrimBot2020 project has developed a vision-controlled robot for autonomous navigation and trimming of gardens, which works in uncontrolled outdoor conditions without the need for

active illumination or sensors. The robot navigates over varying terrain and approaches rose bushes and boxwood topiary, to trim them to an ideal shape. The platform is derived from the Bosch Indego robot lawnmower and is equipped with 5 pairs of stereo cameras that provide a 360 deg view. It navigates using a user-defined garden map and 3D scene analysis and then visually servos to align itself to its trimming position next to the bush. Trimming of the bush is done using a novel electric plant cutter attached to the Kinova Jaco arm, which is mounted on the platform. Trimming occurs after scanning of the bush shape from an arm-mounted stereo camera. Two different actuators and control algorithms were designed for topiary bushes (rotating blades) and rose bushes (stem clipper). Achieving this garden application required a combination of robotics and 3D computer vision research and innovation activities. Original developments in 3D sensing of semi-regular surfaces with physical texture (overgrown plant surfaces), coping with outdoor lighting variations, identifying different objects and types of surfaces, self-localising and navigating around obstacles, visual servoing to potentially moving target plants, leaves and branches, and innovative engineering were required to deliver all this on a small battery-powered consumer-grade vehicle.

The Internet of Food and Farm 2020

Dr. Sjaak Wolfert, Wageningen University and Research

The internet of things (IoT) has revolutionary potential. A smart web of sensors, actuators, cameras, robots, drones and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry. The goal is ambitious: to make precision farming a reality and to take a vital step towards a more sustainable food value chain. With the help of IoT technologies higher yields and better quality produce are within reach. Pesticide and fertilizer use will drop and overall efficiency is optimized. IoT technologies also enable better traceability of food, leading to increased food safety. IoF2020 is part of Horizon 2020 Industrial Leadership and supported by the European Commission with a budget of EUR 30 million. The aim of IoF2020 is to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. For this purpose key stakeholders along the food value chain are involved in IoF2020 together with technology service providers, software companies and academic research institutions. Thirty-three use-cases organised around five sectors (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe.

Transferring manure from livestock farms to be used as fertilizer in crop fields

Dr. Andreas Kamilaris, University of Twente

Intensive livestock production might have a negative environmental impact, by producing large amounts of animal dejections, which, if not properly managed, can contaminate nearby water bodies with nutrient excess. However, if the animal manure could be transferred to nearby crop farms, to be used as a fertilizer for the crops, then the problem of pollution/contamination would be mitigated, transforming manure from a waste to a resource. This valorization of manure from waste to a resource falls within the principles of circular economy, but the transportation of manure also comes at an environmental and economic cost. It is a single-objective optimization problem, in regards to finding the best solution for the logistics

process of satisfying nutrient crops needs by means of livestock manure. This paper proposes a centralized optimal algorithm (COA) to solve the problem, based on a realistic simulator that considers numerous real-world constraints, which have not been addressed by related work.

Smart Agriculture at Bosch - From Farm to Fork
Dr. Michael Blaich, Bosch GmbH
The Internet of Things has the potential to unleash a remarkable leap in farm productivity and efficiency. Bosch contributes to publicly funded research projects like Trimbot2020 and uses its industry-proven technology and IoT competence to quickly deploy agriculture-specific services. The portfolio ranges from services for smart crop and animal farming like field or milk monitoring systems up to applications for smart irrigation or smart spraying.

Agro Robots & Precision Farming Applications powered by ROS
Dipl.-Ing. Andreas Linz, Hochschule Osnabrück
Developing new Field Robots or Precision Farming Applications will be more efficient by using software, which is reusable, extendable, offers useful tools and supports different simulation environments. All this is fulfilled by the open source software ROS (Robot Operating System), a middleware and framework with a huge tool collection for robotics and simulation. ROS is widely spread in research but meanwhile also in development departments of big companies. The presentation gives an overview of research activities ”powered by ROS” at the University of Applied Sciences Osnabrueck.

1.3 Attendance

The workshop was well-attended. As there were four parallel sessions, the people attending the workshop changed for every talk. On average, the workshop room hosted 35/40 people. in Figure 1, we show few pictures of the workshop talks and room. We are glad that the workshop attracted a discrete number of people and that the talks stimulated interesting discussions on the covered topics.
More pictures taken during the workshop can be found at the url: http://trimbot2020.webhosting.rug.nl/workshop-on-agricultural-robotics-photos/

1.4 Exhibitor booth

We also organized at AgriFoodTech 2019 (https://agrifoodtech.nl/) a demonstration of the final project results within an exhibitor booth. AgriFoodTech is the annual fair of agricultural and food technology of the Netherlands, that attracts people from industry, academia, governmental and public bodies, and general public with interest in technological progress in the agricultural field.

We exhibited the final TrimBot2020 prototype platform with the robotic arm with the bush trimming tool mounted on top, and a second robotic arm with the rose clipping tool. Live demonstration were not performed due to safety constraints, but videos of the final prototype demonstration held in September in Wageningen were shown.

We received the interest of a conspicuous number of visitors – about 35/40 persons per day – that stopped at the booth and showed interest towards the project results. Most of the visitors (about 60%) were from companies or investors. We also welcomed a group of young students from a dutch high school that expressed a strong interest in artificial intelligence, machine learning and related technologies, and their application to robotics. The presence of the final TrimBot2020 prototype in the booth and the demonstration videos that were streamed continuosly on the TV screen helped increase their enthusiam and interest towards science and research.

The main questions we received were about the technological innovations that the TrimBot2020 project developed in the past four years, with special interest to the camera system and the visual servoing for approaching the bushes and for arm control. Comments about the marketization of TrimBot were made, with focus on the single components (e.g. camera system, cutting tools, etc.) that received the most of the commercial interest.

More pictures of the exhibitor booth and discussions with booth visitors can be found at the url: http://trimbot2020.webhosting.rug.nl/exhibitor-booth-at-agrifoodtech-2019-photos/

(a) (b) (c)

Figure 1: Few photos of the workshop presentations and room.

(a) (b) (c)

Figure 2: Few photos of the exhibitor booth at AgriFoodTech2019.

Workshop on Agricultural Robotics

12 December 2019, 14:00-16:30

AgriFoodTech 2019, Zaal 2, Brabanthallen
's-Hertogenbosch, The Netherlands

Program

14:00 - 14:30 **TrimBot2020: an autonomous outdoor gardening robot with passive vision control**
Dr. Radim Tylecek, University of Edinburgh

14:30 - 15:00 **The Internet of Food and Farm 2020**
Dr. Sjaak Wolfert, Wageningen University and Research

15:00 - 15:30 **Transferring manure from livestock farms to be used as fertilizer in crop fields**
Dr. Andreas Kamileris, University of Twente

15:30 - 16:00 **Smart Agriculture at Bosch - From Farm to Fork**
Dr. Michael Blaich, Bosch GmbH

16:00 - 16:30 **Agro Robots & Precision Farming Applications powered by ROS**
Dipl.-Ing. Andreas Linz, Hochschule Osnabrück

Organized by the TrimBot2020 consortium - www.trimbot2020.org