HONEYCLOUD - Combining Research and Teaching in a Project for the Digitalization of Beekeeping

Alexander Hilgarth / Michael Dorin / Sergio Montenegro

The HONEYCLOUD project is a research project of the University of Würzburg in the field of bioeconomics. Within the scope of technology transfer, tools and methods that were originally developed for aerospace applications are now to be made available for precision agriculture. In particular, the field of precision beekeeping was selected for this purpose. An IT infrastructure to support the honeybees and the work of beekeeping is to be developed. The aim is to ensure that the electronics remain unobtrusive and that the beehive does not become a switch cabinet. This results in an experimental test setup that can be used in the field of teaching Internet-of-Things (IoT) systems. In this way, hardware and software components are created in the project and used directly in teaching.

HONEYCLOUD - Combinando investigación y docencia en un proyecto para la digitalización de la apicultura

El proyecto HONEYCLOUD es un proyecto de investigación de la Universidad de Würzburg en el campo de la bioeconomía. Dentro del alcance de una transferencia de tecnología, las herramientas y métodos que se desarrollaron originalmente para aplicaciones aeroespaciales ahora estarán disponibles para la agricultura de precisión. En particular, se seleccionó el campo de la apicultura de precisión para este propósito. Se debe desarrollar una infraestructura de TI para apoyar a las abejas y el trabajo de la apicultura. El objetivo es asegurar que la electrónica permanezca discreta y que la colmena no se convierta en un armario de distribución. Esto da como resultado una configuración de prueba experimental que se puede utilizar en el campo de la enseñanza de sistemas de Internet de las cosas (IoT). De esta forma, se crean componentes de *hardware* y *software* en el proyecto que se utilizan directamente en la enseñanza.

HONEYCLOUD - Combining research and teaching in a project for the digitalization of beekeeping

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Introduction

Since the second half of the 19th century, the combination of research and teaching has been a practiced concept at German universities. In this tradition, students of the Chair of Aerospace Information Technology at the Julius Maximilian University of Würzburg are involved in real research projects. They are given the opportunity to work on the projects as student assistants or as part of their final thesis to acquire knowledge and to make concrete contributions. The same applies to the current HONEYCLOUD project, which will research whether a system for beehive monitoring could be a marketable product and how it could then be implemented in practice.

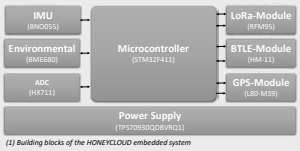
In terms of subject matter, the project is concerned with digitalization—i.e., the transformation of processes previously carried out analogously in the real world into a digital and networked mode of operation. This will be done by applying methods and tools from the aerospace domain to the field of bioeconomics. At first glance, the two domains appear to be far from each other. If compared, many differences can be formulated as opposites. For a manufacturers, space technology is a "market of one"—i.e., a market with a single customer and a single product specifically adapted for him/her. However, bioeconomy obviously affects all people and refers to a mass market. On closer examination, there are concrete similarities. In both areas, sensor data must be reliably recorded, forwarded, stored and evaluated in order to be able to regulate a system if necessary. The systems used should be small, light and energy-efficient.

Materials and methods

The main tool developed at the department for the purpose of satellite programming is RODOS (Realtime Onboard Dependable Operating System)". The Onboard Data Processing course introduces students to the theory and application of the operating system. Students get to know the operating system as a tool for handling complexity. RODOS was developed at the German Aerospace Center (DLR) under the initiative and supervision of Sergio Montenegro. It is a very compact real-time operating system which, among other things, offers preemptive multitasking and middleware for communication. It has been written in C++ and allows object-oriented application development.

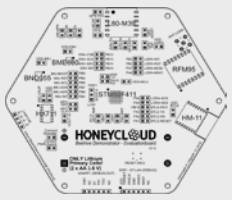
With regards to the cost-sensitive target application, a development hardware was created for HONEYCLOUD, based on commercially available off-the-shelf components, which was excellently suited as a cost-effective teaching platform. This platform consists of a relatively complex evaluation board and various wireless sensor systems. The architecture is designed in such a way that all variants of these wireless sensor systems represent a subset of the evaluation board. This means that any pin assignments or lines to subsystems, if any, are identical for all circuit variations. This allows a code or thread to be reused as a building block without the need for adjustments.

Development hardware for research and teaching IoT systems in beekeeping



(1) Building blocks of the HONEYCLOUD embedded system

(2) Floorplan of the evaluation-PCB



(6) Fully functional beehive electronics demonstrator equipped with HONEYCLOUD sensor node Type D: IMU/Environmental /Scales-ADC/BTLE

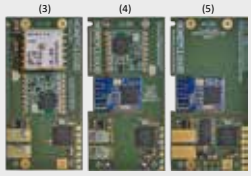
(7) Fully assembled evaluation-PCB

(8) Interior view of a weigh beam. A beehive is placed on two parallel weighing beams.

(9) Empty Langstroth honey frames equipped with 3D-printed sensor housings

Results

Currently, there is an experimental IT infrastructure that can be built from cost-effective components. All typical IoT system components are covered. The platform consists of various wireless sensor nodes (edge devices) whose architecture is a subset of the on-site base station (data aggregator). This base station acts as a gateway and sends the data to a data center, which consists of a network of Linux-based single board computers (Raspberry Pi). The MongoDB distributed database and the Hadoop framework analysis run on this network. Future project work should enable an automated analysis of the data collected in the field test with the participation of beekeepers.



Variations of the HONEYCLOUD sensor nodes. From left to right: (3) Type C: LoRa/GPS-Beacon, (4) Type B: LoRa/Bluetooth LE Bridge, (5) Type A: Scales-ADC/Bluetooth LE

Conclusions

The project is still in progress, but it has already shown that some aspects of the project are advantageous for use in teaching. Aerospace is always interdisciplinary. The study path of aerospace informatics merely determines that the topic is approached from the natural sciences (mathematics and computer science) and not, as is usually the case, via mechanical engineering. Students thus come from computer science, but they willingly take up topics from the field of construction, for example. In this way, student's works are prepared using parametric-shaped parts created with a geometry that is controlled by the properties of circuit diagrams. The interdisciplinary approach with the combination of aerospace and agriculture was originally planned as a strategy to increase innovation in research. It has been shown that this interdisciplinarity harmonizes very well with the interdisciplinary nature of the course.

Further information

The University of Würzburg is seeking partners for exchange in research and teaching in the field of precision farming as well as for future international cooperation projects in the field of precision farming. We are looking forward to your feedback.

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