ROBOtic Replicants for Optimizing the Yield by Augmenting Living Ecosystems

Reporting

Project Information

RoboRoyale

Grant agreement ID: 964492

Project website

DOI
10.3030/964492

EC signature date
20 January 2021

Start date
1 November 2021

End date
31 October 2026

Funded under
EXCELLENT SCIENCE - Future and Emerging Technologies (FET)

Total cost
€ 3 269 938,75

EU contribution
€ 3 269 938,75

Coordinated by
UNIVERSITY OF DURHAM
United Kingdom

Periodic Reporting for period 1 - RoboRoyale (ROBOtic Replicants for Optimizing the Yield by Augmenting Living Ecosystems)

Reporting period: 2021-11-01 to 2022-10-31

Summary of the context and overall objectives of the project

Earth's ecosystems are in a rapid decline of species diversity and abundance. One of the most affected groups is insects, which play a key role in pollination and are hence crucial for ecosystem stability. The Western honeybee is a particularly significant pollinator species, as it plays a vital role in supporting a significant portion of the human diet and is, therefore, a highly significant economic factor.

RoboRoyale is developing and combining micro-robotic and biological technologies into a system that can support the well-being of the honeybee queen, which is responsible for the reproductive success and efficiency of a colony. We aim to develop a minimally invasive approach to affect a honeybee colony in a positive, supportive way, such as regulating and enhancing the egg-laying activity of a honeybee queen by supplementing her courtyard with a multi-robotic system that interacts with the queen. The bio-hybrid system will serve as an important scientific tool to study honeybee biology, support colony health and efficiency, and provide a stabilizing factor in the surrounding ecosystem. Also showing that one can achieve a positive impact on large-scale ecosystems by using microrobots to affect one single living organism will bring radical new insights into novel possibilities of bio-hybrid technology. The potential impact of the project will lead to foundational scientific and biotechnological approaches to synthesize symbiotic super-organisms of cooperating robots and animals.

The main objectives of the project are:
-Investigate how to improve the efficiency, welfare, reproductive rate and health of a honeybee colony by regulating the behaviors of its queen.
-Develop bio-compatible cooperating robots the size of bees, allowing successful colony-sustaining behavioral interactions with the honeybee queen, a vital and highly sensitive animal that requires constant care.
-Increase awareness of public and industrial stakeholders towards recognizing the opportunities of high-tech as means of transforming current low-tech agriculture & livestock management, which is detrimental to their environments and ecosystems, into an added-value, sustainable service industry based on bio-hybrid technology.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

We successfully developed the main actuator of the system. The queen visual tracking was developed, successfully tested and is already producing valuable research data. We successfully integrated the tracking system with the main actuator and collected a large amount of data from queen trajectories over several months. We developed a prototype end-effector, which is a multi-agent system manipulating interactive agents in relation to the queen, and evaluated its motion control performance through numerical simulation. We also developed a system to test the bio-compatibility of materials in terms of biological acceptability in the hive. We developed a model that describes the behavior of the queen, her court, and the interactions between them. The consortium made significant progress despite the obstacles due to the pandemic. Various in-person and online workshops and meetings were conducted. Several conference and journal publications were produced to present the theoretical concept and the first results of the RoboRoyale project to the community and to the public. Building on insights from the first project period, the consortium has planned a clear path on how to proceed in future project periods.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider

societal implications of the project so far)

Scientific and technological contributions to the foundation of new future technology:
-RoboRoyale provides an autonomous multi-robotic system that works in conjunction with highly complex social insects, honeybees. This system creates a bio-hybrid entity while also contributing to the surrounding environment (i.e. the ecosystem in which the bio-hybrid entity is placed) such as through pollination. This innovative approach represents a significant achievement and will inspire new methods and symbiotic applications.
-RoboRoyale will provide precise monitoring of queen behavior over an extended period of time (weeks and months) for the first time, recording millions of queen motion activities and the state of the colony at various times of the year. This will provide the scientific community with access to completely new sources of data based on long-term observations of queens, which has not been previously available. It will be invaluable for understanding behavior and biology of queens, and for developing improved strategies for hive management.
-The data collected from this “core” of the colony (the queen and her courtyard) will be of unprecedented high-quality and resolution, allowing for the recording and automatic analysis of microscopic-scale interactions between conspecifics. This technology will enable new scientific insights into fundamental biological processes that would not be possible without it.
-Utilizing the collected data to monitor the ecosystem status will be made possible through a list of potential indicators in the behavior of the observed animals, or through measurements on the animals, to determine a proxy for the health of the ecosystem in which the bio-hybrid system is located.

Potential for future social or economic impact or market creation:
-RoboRoyale has developed a new generation of observation hives that provide an innovative method for observing and interacting with the queen and court bees within their normal social context. The queen tracking system has the ability to continuously track the queen and court bees with high resolution and a high frame rate. This new observation system can also be adapted for research on other social insects.
-The open-source multi-camera system for real-time localisation for RoboRoyale is capable of precisely estimating the positions of objects across large areas. This feature is crucial not only in robotics and biology research, but also, e.g. in manufacturing or logistics.
-The concept of the multi-agent end-effector could inspire next generation of multiarmed systems for single port surgery manipulators, which are specialized medical instruments for minimally invasive surgery. Such manipulators can perform independent tasks, such as coagulation, cutting, and suturing, while the centralized unit ensures safety parameters, such as preventing bleeding.

Building leading research and innovation capacity across Europe by the involvement of key actors:
-RoboRoyal brings together roboticists, ethologists, engineers, material scientists, complexity scientists and ecologists. The consortium will focus on the novel way of system design by bringing together a highly interdisciplinary consortium to effectively build infrastructure (biohybrid entities and methods) that can be used by a wider community and also by actively reaching out through conferences, exhibitions and other events.
-Due to the interdisciplinary nature of the project, a strong connection will develop between technical and natural sciences. The interdisciplinarity in these fields will further increase as new scientific and

economic opportunities arise, tightening cooperation between technical and natural sciences.
-RoboRoyale supports early career scientists and provides students with the opportunity to complete their theses as part of the project, and to work temporarily at other institutes across Europe. Also, the project actively works to integrate female scientists into male-dominated fields of research, such as engineering.

Last update: 16 April 2023

Permalink: https://cordis.europa.eu/project/id/964492/reporting