H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: Agile multifunctional quadruped Robot for all-terrain precision aGriculture applicatiOnS

Principal Investigator: Evangelos G. Papadopoulos

Reader-friendly title: Argos

Scientific Area: Engineering Sciences and Technology

Institution and Country: National Technical University of Athens (GR)

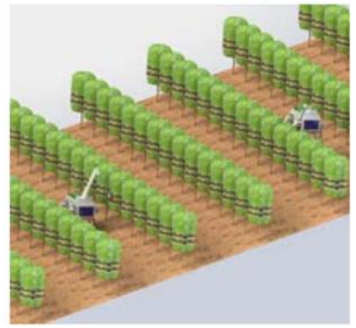
Host Institution: National Technical University of Athens

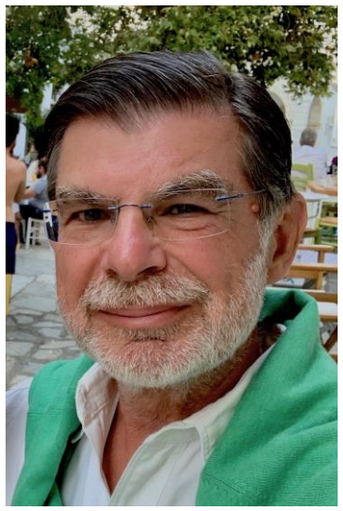
Collaborating Institution(s): University of Delaware, USA

Project webpage (if applicable):

Budget: 188.000 euros

Duration: 36 months





Research Project Synopsis

In this research program, we focus on fundamental research objectives that will allow bringing agile quadruped robots with inspection capabilities into the Precision Agriculture (PA) domain. Driven by the need for increased quantity and quality of agricultural products, our main goal is to provide autonomous trained field assistants to take over significant agricultural tasks. ARGOS, a quadruped robot with a multifunctional manipulator, will be designed and built to move with agility between plant-rows, approach selected plants and monitor their condition. The system will be tested to perform autonomous and semi-autonomous locomotion in a real vineyard.

The main proposal objectives are: *Objective 1*: To design and develop the quadruped robot ARGOS featuring increased efficiency, agility, and stability. Special focus will be given to the design of its limbs and body so that actuation and control of the robot is facilitated. *Objective 2*: To design novel controllers (high, and low level) that guarantee system stability in the presence of disturbances, and allow setting desired goals, such as robot speed or apex height. *Objective 3*: To develop a high-end perception and localization system enabling ARGOS to navigate successfully and perform tasks such as crop monitoring in real vineyards.

Project originality

We envision ARGOS to be the first quadruped optimally built for inspection tasks in a vineyard. Apart from the expected advances regarding design and control, ARGOS must also integrate SOTA vision-based strategies to perceive its environment along with navigation and planning capabilities to move reasonably in the field. We detect a major opportunity for innovation in designing a system optimally for specific task(s), rather than designing optimal controllers for a general-purpose robot that has already been developed. For instance, choices concerning the leg morphology (number of segments, number of active degrees-of-freedom (DoFs), number of compliant DoFs, etc.), and the leg geometry (segment lengths, knee-forward, knee-backward, other configurations, etc.) are not justified systematically in the literature.

Expected results & Research Project Impact

The development of legged robots for demanding agricultural operations constitutes an innovative application of an emerging technology with vast potential. ARGOS is expected to signal the departure from the conventional design paradigm of monolithic, inflexible and environmentally unfriendly agricultural solutions to more effective ones by bringing the concepts of agility, flexibility and cost effectiveness. It is expected that this work will contribute to the science of robotics, nonlinear dynamics and control, mechanical design, perception, navigation and planning, and deep learning. The expected scientific results will enable the use of legged robots in agriculture and extend their application in areas such as search and rescue, and manipulation tasks in high-risk environments. This research project will deal with two keys problems for perception in PA, (i) plant row recognition and robot localization, (ii) obstacle recognition. Challenges lie in fusing uncertain sensor results with each other, e.g.: GPS with data from a 360° stereo camera and RGB-D sensors. Work in this project will contribute in SLAM for outdoor environments, e.g., mapping of unstructured environments including 2D & 3D approaches, advancing the capabilities of legged robots. Last, research on how the Digital Twin concept or on how using a digital copy of the physical system can improve robot performance and enable us perform real-time optimization, lies beyond the robotics state of the art.

The importance of this funding

ARGOS is a versatile robotic platform, which can initiate research towards other directions such as precision pruning and spraying. Research in this project could be the base for robotization and monitoring at the plant level. Experts typically believe robots will take over the dull, dirty and dangerous tasks from humans. For researcher at CSL, ARGOS is a stepping-stone towards applying their research to a contemporary field, that of Precision Agriculture, with a direct significant positive impact on society and the economy in addition to science. Lastly, funding is very important for the research team, as it provides significant resources to continue its arduous, difficult, costly and time-consuming research activity in the field of legged robots.

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