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# Robotics in the AI era: A vision for a Hellenic Robotics Initiative

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# Robotics in the AI era: A vision for a Hellenic Robotics Initiative

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## ABSTRACT

In January 2021, the Hellenic Institute of Advanced Study (HIAS) assembled a panel including world leading roboticists from the Hellenic diaspora, who volunteered their scientific expertise to provide a vision for Robotics in Greece. This monograph, entitled “Robotics in the Artificial Intelligence (AI) era,” will hopefully trigger a dialogue towards the development of a national robotics strategy. Our vision is that Robotics in the AI era will be an essential technology of the future for the safety and security of the Hellenic nation, its environment and its citizens, for modernizing its economy towards Industry 4.0, and for inspiring and educating the next generation workforce for the challenges of the 21st century. To contribute towards making this vision a reality,

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K. Daniilidis, L. Guibas, L. Kavraki, P. Koumoutsakos, K. Kyriakopoulos, J. Lygeros, G. J. Pappas, M. Triantafyllou and P. Tsiotras (2021), “Robotics in the AI era: A vision for a Hellenic Robotics Initiative”, Foundations and Trends® in Robotics: Vol. 9, No. 3, pp 201–265. DOI: 10.1561/23000000069.

after reviewing global trends in robotics and assessing the Greek robotics ecosystem, we arrived at the following key findings and recommendations: Firstly, we think that Greece should develop a national Hellenic Robotics Initiative that serves as the nation's long-term vision and strategy across the entire Greek robotics ecosystem. Also, certain societal drivers should be key in the areas of focus. Safety and security is an area of national importance necessitating a national initiative, while agrifood, maritime and logistics provide opportunities for internationally leading innovation.

We recommend the establishment of a mission-driven, government-funded, organization advancing unmanned vehicles in societal drivers of national importance, and Greece should leverage its unique geography and become a living testbed of robotics innovation turning the country into a development site for exportable technologies. In our opinion, universities should create Centers of Excellence in robotics and AI as well as consider innovation-leading research institutes such as the Italian Institute of Technology. We recommend investing in robotics education using Maker Spaces in order to prepare the workforce with 21st century skills to become Industry 4.0 innovators. Furthermore, we believe that the government should collect, measure, and analyze data on the robotics industry, robotics uses, labor shifts, and brain gain and promote awareness via a Hellenic Robotics Day. And finally, the government should regulate robot safety without stifling innovation, provide safe experimentation areas and mechanisms for certifying safety of locally developed robots. This monograph has many additional suggestions that enhance the above main recommendations. As authors, we advocate bringing the robotics ecosystem together in order to sharpen and expand these findings to an ambitious, long-term, and detailed national strategy and roadmap for robotics in the AI era.

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### **About the Hellenic Institute of Advanced Study**

The Hellenic Institute of Advanced Study (HIAS) is a non-profit, private foundation, established as a US 501 (c)(3), initiated by the Hellenic diaspora in order to:

- Create bridges and serve as a hub for scientific exchanges between the Hellenic diaspora and their peers in Greece;
- Foster the development of international, transdisciplinary collaborations on problems of societal relevance including Energy, Health, Education, AI, Environment, Transport, Maritime, Agrifood, and Inequality.

HIAS is founded on scientific excellence, is inclusive, and represents the strengths of the entire Hellenic scientific community independent of any personal or political affiliation.

# 1

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## Introduction

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This monograph, entitled “Robotics in the Artificial Intelligence (AI) era,” presents findings and recommendations from a group of experts assembled by the Hellenic Institute of Advanced Study (HIAS), who had volunteered their scientific expertise to provide a vision for Robotics in Greece. We hope this monograph will trigger a dialogue across stakeholders in government, industry, and academia and contribute towards the development of a national robotics strategy.

### **1.1 Global Economic and Technological Trends in Robotics**

Robots are divided into two main categories, industrial robots and service robots. Over the past 60 years, industrial robots have been heavily used globally in the automotive, semiconductor and manufacturing sectors. In Greece, the number of industrial robots is over-estimated at 600 robots total, resulting in a density of 17 robots per 10,000 people, significantly below the European average of 114 robots per 10,000 people. Clearly, industrial robotics has not arrived yet in Greece (Section 2).

Contrary to industrial robotics which is very mature, the service robotics sector (unmanned aerial vehicles, healthcare, logistics and

agrifood robotics) is in its infancy and fast-rising. Professional service robots is a \$27 billion market worldwide and is growing at an annual rate of 30%. Furthermore, 20% of all service robot companies are young startups. This creates an exciting opportunity for aspiring Greek innovators to enter this young and fast-growing field and modernize the economy towards Industry 4.0.

Technologically, innovation in robotics is no longer about advances in robotic hardware, as many industrial robots or aerial vehicles have been commoditized, but rather about advances in robotic software making the hardware more intelligent (using AI), more connected (using 5G), safer for humans (collaborative robotics), and more valuable (using Robot-as-a-Service). The transition from hardware to software will drive robotic innovation and open new markets over the next decade (Section 3).

## **1.2 The Greek Robotics Ecosystem Today**

A holistic analysis of the entire robotics ecosystem in Greece today reveals numerous strengths, weaknesses, and threats, but also opportunities for the future (detailed analysis in Section 4). Strengths include the excellent basic research community in Greece that has a very good international reputation, placing Greece in the top ten among EU countries in terms of funding and scholarly production. In addition, Greece has a plethora of well educated, English-speaking researchers in a relatively low-cost environment within Europe. In robotics, like several other scientific areas, there are many world-class scientists and innovators in the Hellenic diaspora, willing to contribute their expertise.

Unfortunately, scientific excellence in Greece does not translate to a significant impact on the nation's economy or safety. The low number of industrial robots, the lack of industrial research leaders in robotics or AI, and the limited technology transfer out of universities and research centers create a large valley of death in the robotics innovation cycle. This is the primary weakness in the whole ecosystem that results in very few innovation-leading technologies, limited high-end job opportunities accelerating brain drain. Limited national, defense, and industrial funding magnify this weakness.

Over the past 10 years, there has been a rapidly growing threat due to the proliferation of low-cost, unmanned aerial, ground, surface, and underwater vehicles in the region and the world. This is creating significant safety and economic risks to the Greek nation. As this is a threat that will grow over the next decade, it is critical that Greece avoids being technologically surprised in the future.

But there are also significant opportunities. Aspiring Greek industry and innovators can become regional leaders in the young but fast-growing field of professional robotics (such as unmanned vehicles). There is an opportunity to modernize the economy towards Industry 4.0, while leveraging industrial leadership in maritime, tourism, and agri-food sectors. A growing innovation ecosystem in robotics, AI, and Industry 4.0 is very promising. Robotics researchers can pursue initiatives from the State (ΕΣΠΑ) or the EU (Horizon EUROPE) during 2021–2027. New international educational programs could prepare students for Industry 4.0, while there is excitement among secondary school students for robotics.

### **1.3 A Vision for a Hellenic Robotics Initiative**

Robotics in the era of artificial intelligence will transform every aspect of Greek society, security, and economy. Agricultural robots can assist Greek farmers in reducing exposure to dangerous spraying pesticides, while selective harvesting for increasing yield and quality operations. Robots with advanced perception can be used for automatic inventory inspection and management. Underwater vehicles can be used for inspecting ship hulls and pipelines or Greek ports, while aerial robots can ensure the delivery of urgent medical supplies in remote islands in the Aegean or mountainous rural regions. This is not science fiction. The technological revolution described above is starting to happen around the world, including Greece (Section 5). As we are still in early days in this revolution, this creates a historic opportunity for Greece to become a regional leader in this emerging yet critical future technology.

Our vision is that robotics empowered with artificial intelligence will be an essential technology of the future for the safety and security of the Hellenic nation, its environment and its citizens, for modernizing

its economy towards Industry 4.0, and for inspiring and educating the next generation workforce for the challenges of the 21st century.

In making this vision a reality, the authors have arrived at the following recommendations:

**Hellenic Robotics Initiative:** Greece should develop a Hellenic Robotics Initiative that serves as the nation's long-term vision and strategy across the entire Greek robotics ecosystem. It should emphasize Greek national priorities, promote innovation leading programs, and prioritize efforts that will lead to demonstrable impact on the nation's security, economy, and prosperity. The first step is to assemble a Hellenic Robotics Council, bringing together the nation's leaders across the robotics ecosystem, initially tasked with developing a strategic roadmap. Once developed, it is critical that all future governments show long-term strategic and fiscal commitment in this initiative (see Section 6).

**Societal Drivers:** The national robotics strategy should start by identifying societal drivers where robotics technologies can have a demonstrable societal or economic impact. In the opinion of this panel, safety and security in the broadest sense (defense, civil protection, border protection, environment protection, and emergency response) is an area of national importance that necessitates a national initiative in robotics. Additional societal drivers that exploit unique Greek differentiators (talent, geography, and industrial areas of strength) include the maritime, logistics, and agrifood sectors, where there is an opportunity for innovation-leading efforts (see Section 6.1).

**Mission-Driven Research Organization:** Mission-driven research is defined as research that follows an impact-focused approach to address great challenges of national importance. In this spirit, we recommend the establishment of a new Hellenic Center for Advanced Robotic Technologies, which will be a government-funded, mission-driven organization with the long term mission to advance, develop, and transfer innovative unmanned vehicle technologies in air, land, and sea in the service of national safety and

security and other societal drivers of national importance. This panel recommend establishing a task force, tasked with a visioning and feasibility study for such an organization (see Section 6.2).

**Industrial Research and Innovation:** Thanks to her unique geography, Greece can become a living testbed of field robotics and applications in extreme environments. Instead of trying to find domestic markets, Greek innovators can turn Greece into a demonstration site of robotic technologies that then can be exported. Historically, many significant robotics technologies (self-driving vehicles, drones, warehouse robots, medical robots) were university spin-offs. Therefore, in addition to public-private investment partnerships (like Equifund) and angel investing, we recommend programs like Pittsburgh's Innovation Works. Such programs work closely with universities and research centers to identify ideas for commercialization and mentor researchers to launch startups. Lowering any barriers to mobility across academia, industry, and startups for faculty, researchers, and students is key for facilitating this process. Other ideas include bringing the ecosystem together in clusters and TechExpo (see Section 6.3).

**Basic and Applied Robotics Research:** Given the interdisciplinary nature of robotics, it is critically important to establish Centers of Excellence in robotics and artificial intelligence, bringing together faculty and students in robotics, computer vision, control systems, automation, and machine learning, addressing scientific challenges in societal sectors of national importance. Basic science funding should ambitiously grow, while defense funding and joint funding mechanisms should be considered. Greece should also envision the creation of a research institute similar to the Italian Institute of Technology (IIT). What sets apart the Italian Institute of Technology from other research institutes is its emphasis on technology transfer and innovation without sacrificing research excellence. IIT was created in 2006 and has already received an impressive 50+ ERC grants among 80 principal investigators, 1,000+ patents, 24 existing startups with 50+ startups under development. This is precisely what Greece is lack-



ing from its basic research institute portfolio. A similar Greek institute could strategically focus on future areas such as robotics, AI, Industry 4.0 among other areas of national importance (see Section 6.4).

**Educating a Nation of Innovators:** We advocate investing in robotics education to prepare the future generations with 21st century skills not only for a career in robotics but also to become innovators in Industry 4.0. This is precisely the vision of the so-called maker movement which empowers intellectually diverse student-teams to innovate while addressing real-world challenges. Educating the nation to develop innovators in robotics means a cultural shift to become a nation of makers, builders, hackers, and tinkers. This requires a significant investment in Maker Space laboratories (one per university), but most importantly, requires a paradigm shift in educational goals. We also recommend new undergraduate programs in robotics and AI, international masters programs, industrial competitions, improving diversity, and strengthening outreach in secondary education (see Section 6.5).

**Workforce Impact:** In Greece it is expected that 23.4% of jobs face a very high probability of automation, with another 35.3% of the workforce facing the distinct possibility of changing the type of job they do. In response, we recommend that the government develops a framework for collecting, measuring, and analyzing data on the robotics industry, robotics uses, labor shifts, and brain gain. In order to help the mid-career workers, there is a need to provide funding and policy initiatives to support upskilling and retraining. The government should also declare an annual Hellenic Robotics Day with the goal of raising the public's awareness of new robotic technologies, economic and workforce impact, as well as inspiring the next generation about robotics, AI, and Industry 4.0 (see Section 6.6).

**Regulation, Legal, Ethics:** Robots need to ensure the safety of humans at all times. But novel robots (e.g., self-driving cars) result in innovation that is ahead of safety regulation. It is critical to

quickly embrace safety standards that ensure human safety but without stifling robotics innovation. Safe areas for experimentation as well as mechanisms for certifying robot safety developed by Greek companies will be important. Defining property rights over robot data will be very important both in protecting data owners and also in creating a new economy for data while incentives for proactively cyber-hardening infrastructure will be critical for secure and resilient robot operation. Universities should develop intellectual protection policies while robot programming should embrace ethical values and principles that are consistent with the Greek and European ethos (see Section 6.7).

Our monograph has many additional suggestions that enhance the above main recommendations. We advocate bringing the robotics ecosystem together in order to sharpen and expand these findings to an ambitious, long-term, and detailed national strategy and roadmap for robotics in the AI era.

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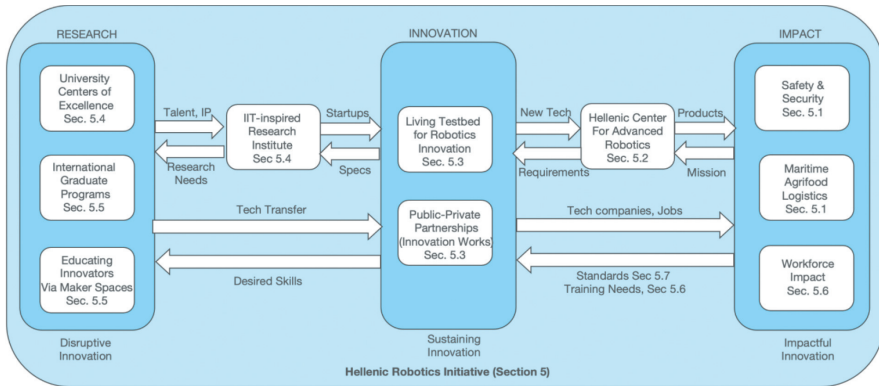
## Summary

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This monograph has provided numerous findings and recommendations towards a Hellenic Robotics Initiative. In order to better understand how the individual recommendations described in the previous sections form a holistic approach towards improving the overall Greek robotics ecosystem, one can capture the relationship between our main recommendations in Figure 7.1.

From the perspective of the overall robotics ecosystem, our main recommendations aim at strengthening the relationships between the research, innovation, and societal impact pillars, in addition to strengthening the pillars themselves. In this sense, our goal is not only to strengthen the ecosystem as is but also to transform it by emphasizing impact-driven innovations as well as innovation-driven research. Taken together, the proposed recommendations will pave the way for basic research to result in innovation growth as well as societal and economic impact. In reverse, anticipated workforce impact should lead to novel training programs as well as educational reform across all levels.

Given the numerous recommendations in this monograph, where does one start? Perhaps the most important recommendation is to view the Greek robotics ecosystem as a whole. Therefore, the first step should be to assemble a Hellenic robotics council among leaders in



**Figure 7.1:** Summary of the Hellenic Robotics Initiative recommendations.

Greek academia, research centers, industry, and government in order to sharpen, contextualize, and expand this monograph to a detailed national strategy with a phased implementation roadmap for robotics in the AI era. We hope that this monograph will be useful in their strategic discussions and we welcome the opportunity to continue this dialogue as the Hellenic Robotics Initiative becomes, hopefully, a reality.

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