Automating the Achievement of SDGs: Robotics Enabling & Inhibiting the Accomplishment of the SDGs

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Abstract

The role of robotics is rapidly growing in importance in the particular non-industrial application domains, affecting society, economy and the environment. Robot systems are typically developed to address a specific technical, service-type or economical need, but often their broader impact is insufficiently investigated, if at all. For robots to play a beneficial role at society-level in the future, it is important to identify the mainstream directions in the field that enable the UN Sustainable Development Goals (SDGs), and encourage their development. Similarly, it is required to understand the negative impacts some applications can have on the achievement of the SDGs, and to ensure societies have the ability to prevent or mitigate them. Inspired by an exploration of the role of artificial intelligence in achieving the SDGs, this paper presents a preliminary version of a consensus-based expert elicitation process on the role of robots - as enabler or inhibitor - for a more sustainable future. For every SDG, the authors were able to identify potential positive and negative impacts of robotics. It remains difficult, though, to sketch a simple and comprehensive overview of the different ways in which robotic applications can unfold (direct or indirect) impact. Existing projects and studies are not intuitively comparable because they take many different directions and are not at the same level of abstraction, technological readiness, or implementation. Derived from the findings, recommendations on future policy developments are considered.

Introduction

In 2015, 93 countries agreed to establish the United Nations Sustainable Development Goals (SDGs). They are a framework of recommendations and principles to achieve a better and more sustainable future for all. After the Millennium Development Goals (MDGs), they address global challenges, such as poverty, inequality, climate, environmental degradation, prosperity, peace, and justice.

To facilitate the realization of these standards, member states rely on different approaches and manifestations of innovations. Besides well-known methods from governmental toolboxes, like political and regulatory improvements or the stakeholder-driven discourse about the establishment of new governance frameworks, fostering and leveraging technological progress becomes more and more crucial to address the increasingly complex problems tomorrow's world and its civilization will be facing. Albeit predicting the future is impossible, the analysis of the so-called 'Megatrends' [1] provides one commonly accepted method for estimating driving forces that will have an impact on the whole planet earth and humanity over the next 15 to 25 years. Extrapolating these trends, it is possible to make predictions for future needs, developments of future markets and overall requirements for technological innovation. Mobility, globalization, global warming, over-ageing society, urbanization, digital life / connectivity, individualization, and orientation towards a healthy lifestyle are an often-cited subset of megatrends that will heavily influence the evolution of disruptive technologies, such as robotics and automation [2].

Currently, the world is experiencing the peak of the digitalization wave. But the next, maybe even bigger disruption is already afoot: Robotics and Automation. Riding on the wings of Artificial Intelligence, they will permeate all areas of our living realm. Over the next 50 years, they will have at least as much impact on society and our world as the internet and mainstream IT have unfurled over the last five decades. Subsequently, our grandchildren will grow up as the first "Generation 'R'" of "Robotic Natives" – in daily contact with these technologies – and will often rely on the development of digital technologies [3]. Today, though, they still remain limited in their potential impact (e.g., because of the important associated costs, or the lack of available devices in critical situations, for instance during the COVID-19 crisis). It is very possible that robotics will play a key role in the implementation of international strategies (e.g., the Great Reset initiative of the World Economic Forum) to help shape the recovery and

rebuild society and the economy in a more sustainable fashion.

Robotics & SDGs

The progress of robotics and its increasingly broad adoption will be comparable to the rapid dissemination of mainstream computer technology the world has seen in the past. It will even follow similar waves (Miniaturization, Mobilization, Ubiquitiousness and Pervasiveness) [3]. As promising and beneficial it could be, its development also comes with its own critical systemic, environmental, and social challenges [4, 5, 6]. All hopes need to be reconsidered in the light of the important limitations and ethical dilemmas raised using robotics to achieve the SDGs. Our objective is to identify, define, analyze, and disentangle the various impacts that its development may generate in relation to the SDGs.

To do so, it is necessary to combine the experience of the robotics community with the expertise of multidisciplinary specialists in fields such as economics, sociology, law, , environment, biology, design, among others (e.g., in [7]). The authors therefore developed a methodology inspired by a study by Vinuesa et al. 2020 (in Nature Communications) [8] on the role of AI as either an enabler or an inhibitor in achieving the SDGs. Vinuesa's approach can be summarized as a consensus-based expert elicitation process.

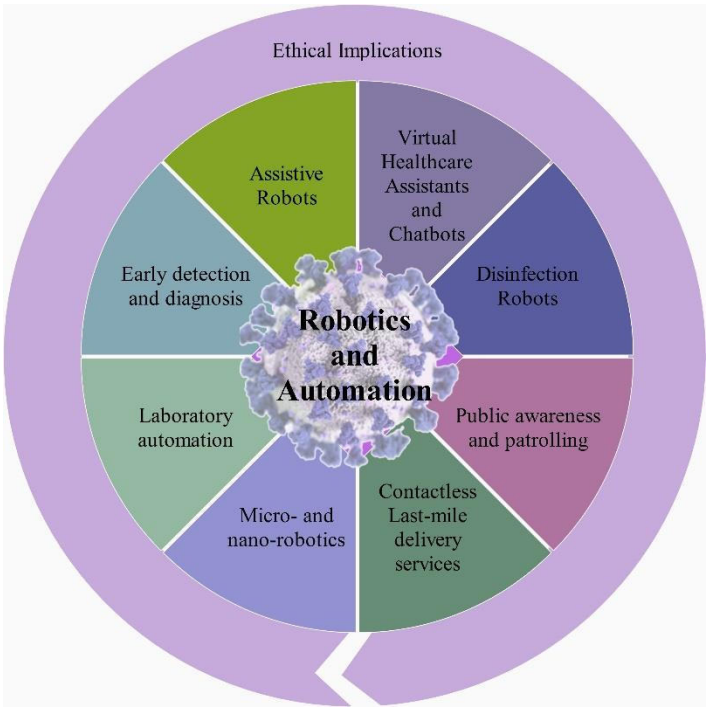

Figure 1 – The societal level benefit of robotic technologies has clearly been demonstrated recently, when numerous robot solutions arose to diagnose and treat COVID-19, fight the coronavirus pandemic and alleviate their dire consequences. Such functions relate to SDG 3,4,8,11,15 [13].

In addition, the authors of the present study will consult the robotics community through a dedicated workshop at a major conference in Robotics [IROS2021] in the objective of leveraging the collective experience and intelligence of the robotics community. The results of this study could be an important tool for politicians, civil society and trade unions. They can be used as a basis for stakeholders to establish the guidelines and governance frameworks [10, 11] that will allow robotics to contribute to a more sustainable world.

Robots as Enablers & Inhibitors for SDGs

Robots can be regarded as physical entities with sense-think-act capabilities to work in the physical world. The authors used the definition as stated in the Encyclopedia of Robotics: "A robot is a complex mechatronic system enabled with electronics, sensors, actuators and software, executing tasks with a certain degree of autonomy. It may be pre-programmed, teleoperated or carrying out computations to make decisions " [12].

Robots offer a wide range of means to help achieve the SDGs. For instance, Robotics can enable innovative and effective learning methods and open new avenues for pedagogy to improve the quality of education in both developed and developing countries. This quality education is a key driver of economic growth and a main catalyst for poverty eradication and sustainable development. Robotics also has broad-ranging impacts on industry to ameliorate work conditions, increase productivity and reliability while reducing waste and improving quality and competitiveness. By using drones for search and rescue missions in case of natural disasters, or by delivering food in war zones with self-driving trucks, robots could reduce the impact of such catastrophes. Robots can be used to monitor environmental changes in air, land and water, and may allow a better understanding and preservation of ecosystems. Precision agriculture and smart farming can increase productivity and reduce waste of food, thus helping to provide food security. Similarly, robots will increase the overall productivity in many industries by automating tedious tasks, thus reducing the price of goods and the risk of work-related injuries. They could improve access to transportation and healthcare and augment the quality of life of elderly and physically challenged individuals. Robots as part of space exploration programs push the boundaries of human knowledge and are a formidable inspiration for people

of all ages to learn about science, technology, engineering, and mathematics (STEM).

The most recent and prominent example is the use or robotics to fight the current pandemic: Since the outbreak of the novel coronavirus (SARS-CoV-2) and its highly contagious disease COVID-19, robotics communities quickly mobilized and gathered to offer solutions ranging from early detection and diagnosis solutions, assistive and disinfection robots, robots used for public awareness and patrolling, contactless last-mile delivery services, to lab automation. Robots perform many assistive tasks during the pandemic to mitigate the risk to healthcare professionals. Applications of these robots include, but are not limited to, helping medical staff avoid infection from virus patients, early detection and diagnosis, medical care, nursing, patient monitoring, performing lab work, cooking and serving medication, meal delivery to patients in isolation wards, indoor and outdoor disinfection and public awareness and patrolling. Contactless last-mile delivery has witnessed an unprecedented importance and a sharp demand rise during the pandemic to ensure sufficient social distance between medical staff and patients in the hospitals and between people during delivery. Several systems have been deployed and tested during the pandemic for medical supplies, medications, food, grocery and other goods. Various research labs, businesses and start-ups have innovatively changed their work goals to use robotics and automation to speed up the quest for a cure against COVID-19. Vaccine discovery and production require massive amounts of experiments and processes. Robots can be used in laboratories to automate repetitive and time-consuming tasks such as sample processing, goods delivery, and for conducting experiments [13, 14].

But robots may also impede progress towards the SDGs. First, they can be abused and involved in major ethical issues (e.g., the increase of surveillance, the use of robots by oppressive regimes, a potential lack of acceptability within the general population, issues regarding data privacy and further augmenting the digital divide) [4, 5]. Additionally, robotization of industries will cause routine manual and routine cognitive job losses. This will primarily affect workers with low education and countries who do not have the means to invest in such technology or to educate a workforce able to benefit from this process. Given the macroeconomic situation of most of the developing countries and the high initial cost of adopting robotics technologies, there are even further challenges such as the overproduction-underemployment dilemma. There is a common misconception about robotics and automation and the lack of highly qualified personnel able to deal with these technologies. In order to ensure a higher level of acceptance and adoption of robotics and automation in the society, education on these technologies is crucial. Similar inequalities can be seen in the use of robots in agriculture, which can prevent small farmers from competing with multinationals, thus enhancing urban exodus and threatening food sovereignty. In addition, robots are often manufactured containing rare-earth materials and produce e-waste, which causes an inherent danger to the environment if not dealt with properly. Robots consume energy to sense, think and act and are commonly much less energy efficient compared to human workers. They may also ease the feasibility of projects which may have damaging consequences on the ecosystems, such as in the exploitation of natural resources: fossil fuel extraction, forestry, mining, etc. Furthermore, they can delay structural changes needed to address global warming (e.g., with the rise of autonomous cars) or encourage over-consumption of products (e.g., autonomous drone delivery systems).

The Promising but Ambivalent Role of Robotics in the Achievement of the SDGs

Nearly for every SDG, the authors were able to identify potential positive and negative impacts of robotics. It tends to show the dual nature of Robotics' contribution towards the SDGs - as is inherently applicable to all disruptive technologies [5, 15, 16]. A complete, more digestible, and graphically enhanced overview will be made available in the final publication later this year.

However, it remains difficult to have a thorough overview of the different ways robotic applications can have an impact. We need a deeper understanding of the challenges at stake. Robotics will have a great impact on our society and economy, but also bring with them complex challenges. Some believe robots are showing us the way towards a utopia, whilst others predict doom-laden scenarios. Nonetheless, it seems evident, that our grandchildren will grow up in daily contact with different forms of automation technologies, making them the first Robotic Natives – which leaves us the last generation of Robotic Immigrants. With our very analogue migration background, we will have to overcome some challenges and struggles in accepting, adopting, and embracing robotics.

The enablers or inhibitors are inseparably intertwined with peoples' hopes and fears. But it is us, humans, who invent and develop technologies. We have the duty and

power to shape our own future. The professional work experience, skills and insights of the robotics community (and of interdisciplinary experts from a wide array of disciplines) can, should and will have a catalytic impact.

*Figure 2 – Symbolic representation of impact of robotics o**n the SDGs***

Selection of Empirical Facts & Issues

This bullet list provides a first (incomplete) selection of the empirical facts and issues that were identified by our research:

- Robotics will have an increasing role in critical situations, from supporting healthcare workers during COVID-19, to help in sensitive or dangerous operations (e.g., minesweeping, nuclear waste disposal) [1, 2, 4, 7, 13].
- Robotics could leverage important health inequalities, for instance by democratizing surgery (e.g., by providing universal access to high quality surgical and medical care on a global scale), with telesurgery in the past and now with autonomous diagnostic and treatment delivery options [14].
- To achieve the SDGs, robotics will play an active role within public, academic, and private initiatives [7, 8, 9].
- Robotics and automation can contribute to optimize complex processes (e.g., food production), to improve difficult tasks (e.g., cleaning waste, pollution, water), to monitor the effect of climate change and human activity (e.g., with drones or autonomous sensors)[1, 2, 4, 7, 8, 9].
- However, robotics has an important carbon footprint, uses vast amounts of energy, needs rare materials, generates large quantities of waste, and can oftentimes be outdated fast because of technical progress (e.g., as commercial products) [4, 5, 6, 10].
- Furthermore, robotics sometimes remains experimental and limited, not deployed at a large scale, and raise critical ethical and social issues (e.g., from increasing surveillance to accelerating job losses)[4, 5, 6, 10, 11, 16].
- To avoid being an empty promise, Robotics needs to better document its own impact and challenges, while contributing to achieve SDGs [5, 6, 10, 11].
- Technologies like robotics and AI must be transparent, explainable an understandable [5, 6, 10]

Policy Recommendations

Derived from our findings, we want to recommend these ideas on future policy development for consideration:

- International organizations, such as the United Nations, should provide specific (sub-)goals for

each domain (e.g., robotics) to better translate the 17 SDGs in different fields of practice.

- International organizations in Robotics (e.g., IEEE, euRobotics, IFR, …) should be encouraged to:
  - analyze and document at a large scale the impact of robotics to the environment (subfield by subfield).
  - highlight each year their most efficient and evidence-based contributions to fight climate change and achieve other SDGs.
  - develop and provide tools (e.g., checklists, practical guidelines, frameworks, governance) to help researchers, engineers, public decisionmakers and entrepreneurs to better integrate SDGs within their projects and roadmaps.
  - develop and provide tools to help researchers, engineers, public decisionmakers and entrepreneurs document and calculate the impact of their projects on the environment (e.g., carbon foot-print calculators, lifecycle methodologies) and – if possible – society
  - help to explain their technologies and development progress as transparently and realistically as possible to foster public understanding and acceptance.
- International conferences in Robotics should require submitters to explain a) the environmental and b) societal impact of their projects, as well as c) the potential contributions of their projects to the SDGs.

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