Robots against the Coronavirus: the need for a new generation of robots to help global society

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***Abstract*—The explosion of the pandemic and the need for social distancing has meant that robotics has more and more space in our daily lives. The Coronavirus epidemic (COVID-19 or SARS-CoV-2) presents us with a challenge that we are currently facing, and which globally highlights our fragility. This fragility and consequent loneliness is perceived more and more every day; that implies the importance of using new technologies able to cope with a new aspect that had not been thought of so far, but which is now dictated by the pandemic consequences. As a result, these new issues brought by the pandemic imply an increasing need to make robots more and more intelligent and empathic with human beings.**

I. Introduction

We have not yet reached the day when artificial intelligence will take the place of the humans who created it. But certainly, we are witnessing the presence of robots in factories, hospitals, bars, airports, offices, museums, etc. Around the world, the presence of those mechanical beings that talk, move, and act as humans, is becoming more and more evident. Their presence is not only very useful, but also with no risk of contagion. Unfortunately, this factor should be definitely taken into account, since in this period of pandemic even many healthy workers (medical doctors, nurses, GPs, etc. ...) died because of the Coronavirus.

However, these robots very often respond to the execution of predetermined and static procedures, which usually suffer from a lack of ability to be adapted to different social contexts; this mostly happened during the first pandemic wave. The challenge, therefore, is to create social assistance robots that perform interactions with one or more people, and are capable of maintaining open-context dialogues ([1], [2], [7]). The use of these new robots will, for instance, enable patients to express their fears and concerns that they have not been able to express to their physicians; robots will also be able to explain complex medical concepts that patients have not totally understood.

There is great potential in the field of AI and Robotics to help fight Covid-19. The potential of robotics and technology will not only be a valuable aid in hospital wards, but also for stores, restaurants, and bars that offer take-away food, through the use of machines that might disinfect the environment or might be even capable of automatically crossing streets and sidewalks in cities, in order to deliver food to customers who have ordered online ([3]–[6], [8]). Robots in this difficult period will also have to help us feel more connected and participate in meetings and other social and/or work activities that will not allow for physical presence, allowing us to move everything online or resort to telepresence devices. Robots are now part of our lives, and in the near future they could become not only work colleagues, but even an integral part of our society ([9]–[12]). Thus, as it was possible to analyze, the COVID-19 pandemic will further boost the market. High demand for robotics disinfection solutions, robotic logistics solutions in factories and warehouses or robots for home delivery are examples of this trend. In terms of value, the sales of medical robotics accounts for 47% of the total professional service robot turnover in 2019 (see Fig. 1 and Fig. 2).

Moreover, such robots will have a positive impact on people's health, making them feel less lonely and more open to socialization. In order to reach all the mentioned goals, artificial intelligence, machine learning, computer vision, human-machine interaction analysis, audio processing, human behavior analysis, and sense-motor control of robots will be a valuable help for us to design and develop a new generation of social robots ([13], [15]).

As a result, the pandemic has therefore changed both human-to-human interaction and consumer preferences, and this will open up new opportunities; automation and employment are not mutually exclusive, but will continue to coexist, but with robots performing not only repetitive jobs, but also helping humans with tasks where compassion, empathy, and quick decision-making will also be needed ([14], [16]).

II. Potential, characteristics, and application context of the robots needed in the healthcare system

The future of medical robotics, also exacerbated by the pandemic, will involve a greater evolution of machine learning, data analysis, prediction of different medical symptoms, computer vision, etc... It will go towards different types of robots that will continue to evolve, in order to be able to complete tasks autonomously, efficiently and accurately.

In addition, with the help of the various current computer systems, it will be possible to attribute to machines characteristics typically human. For example, through deep

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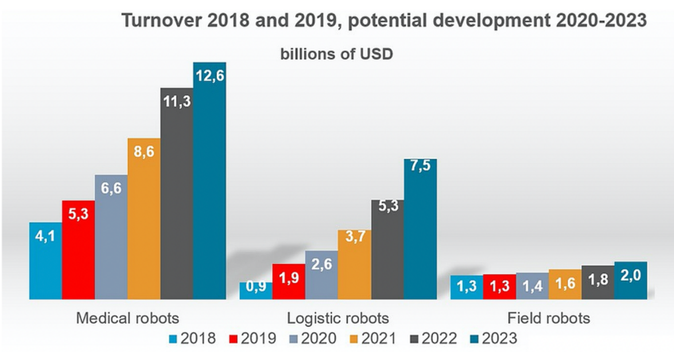

Fig. 1. The increase of the service robots for medical, logistic and field use

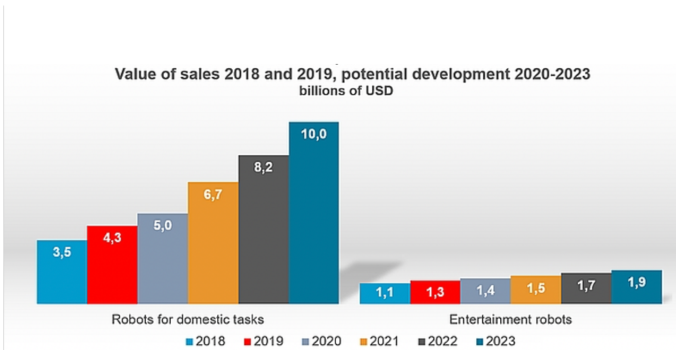

Fig. 2. The increase of service robots for personal and domestic use

learning algorithms (inspired by the structure, functioning and connections of biological neural networks), it will be possible to reproduce human reasoning.

Artificial intelligence in the medical field will also lead to early diagnosis and administration of increasingly precise and less invasive therapies.

The first robots in the medical field offered surgical care via robotic arm technologies (Fig. 3). Over the years, computer vision enabled by artificial intelligence and data analytics have transformed healthcare robotics, expanding functionality into many other areas of healthcare.

Fig. 3. Intelligent and autonomous surgery robotic systems

The pandemic has made it even clearer that robots will need to be used not only in the operating room, but also in clinical settings to support healthcare workers, improve patient care, or for example, for activities to reduce exposure to disease agents (Fig. 4). It is now clear that the operational efficiency and risk reduction provided by healthcare robotics offer value in many areas. In addition, for instance, robots are able to clean and prepare patient rooms independently, helping to limit person-to-person contact in infectious disease wards. Robots with AI-based medicine identification software reduce the time it takes to identify, establish and distribute medicines for patients in hospitals.

Fig. 4. Robot improving patient care during isolation

This emergency situation, therefore, highlights that, as soon as technologies evolve, robots will need to function more autonomously, ultimately performing certain tasks with complete autonomy. As a result, this will mean that physicians, nurses, and other healthcare professionals will be able to focus on greater empathy in caring for patients ([17], [18], [20]). But this empathic relationship will also serve in a certain way to the robot, in situations where it may be only the robot to interface with the patient, since for instance (s)he is suffering from coronavirus and therefore highly contagious for medical staff. Therefore, it will be necessary to think of a new generation of robots that can be used in the different clinical situations that the pandemic has strongly emphasized.

Healthcare robotics, if improved and shaped according to the diverse needs that the pandemic itself has highlighted, will therefore increasingly enable a high level of patient care, efficient processes in clinical scenarios, and a safe environment for both patients and caregivers.

Medical robots will increasingly need to support minimally invasive procedures, tailored and frequent monitoring for patients with chronic diseases, smart therapies, and social engagement for elderly patients. In addition, with robots able to ease workloads, nurses and other healthcare workers will have the ability to provide patients with greater empathy and human interaction, elements that can promote long-term wellness if this is done in a safe environment without contagion issues.

Additionally, the pandemic has also highlighted the importance of *telemedicine*, which *telerobotics* is an example of (Fig. 5). Specifically, telerobotics aims to create the world's first ever remote work system. It includes an immersive and controllable/interactive multi-sensory cyber-physical platform that not only allows the worker to remotely experience the world, but also to physically interact with it. The idea is to have a robot monitoring, inspecting, and repairing the asset; most of the time the robot completes these tasks autonomously. However, when the robot needs help, telerobotics means that experts can promptly be present ([19], [21], [22], [25]). Field engineers can promptly inspect and repair any asset, from anywhere in the world, via the resident robot system.

As motion control technologies have advanced, surgical assisting robots have become increasingly precise. These robots help perform complex microprocedures without the need to make large incisions. As surgical robotics evolves, robots will need to be increasingly based on artificial intelligence and will ultimately use computer vision to navigate to specific areas of the body, while avoiding nerves and other obstacles. Some surgical robots may even be able to complete tasks autonomously, allowing surgeons to monitor procedures from a console.

Fig. 5. Robot that assists patient in hospital via Telemedicine systems

A. Service robots and maintaining safety at work for medical professionals

Service robots will need to simplify various routine tasks, reduce the physical demands on human staff, and ensure more consistent processes. These robots will need to keep track of inventory and should therefore be able to place timely orders, helping to ensure proper placement of supplies, equipment and medications. In addition, mobile cleaning and disinfection robots will allow hospital rooms to be sanitized and prepared quickly for incoming patients.

Moreover, service robots will need to help keep health-care workers safe by transporting supplies and bedding in hospitals, where exposure to pathogens is a risk (see Fig. 6). Cleaning and disinfection robots will also limit exposure to pathogens and help reduce hospital-acquired infections. In addition, social robots will be able to provide more and more assistance in hospitals, such as lifting weights, moving beds, patients, trolleys with medicines, and thus helping to reduce the physical effort of health workers.

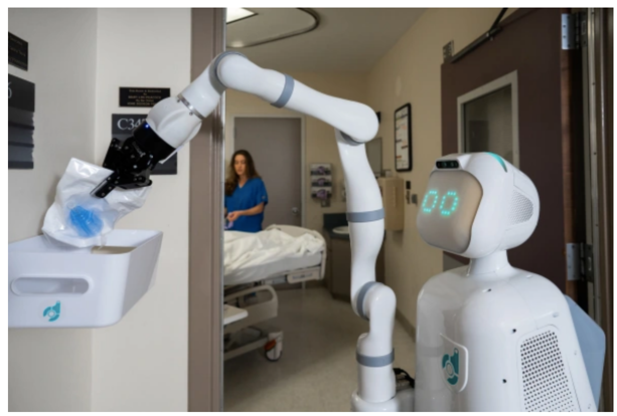

Fig. 6. Robot that assists patient in hospital in different tasks

III. Liability for the use of new robots with a more advanced concept of autonomy

The new class of robots that will be necessary in the future will be equipped with different AI techniques, which will allow robots to assume a significant margin of autonomy in decision-making that inevitably translates into a certain unpredictability of robot behavior ([23], [24]). However, in case of an eventual and unfortunate damage caused by the A.I. robot, this will not allow to frame the fundamental issue of legal liability within the boundaries outlined by the current regulatory solutions, which are therefore still inadequate.

Moreover, existing liability rules cover only those hypotheses in which the cause of a robot's action or omission can be ascribed to a specific human agent; for liability to be established, it is necessary that the agent could have foreseen and avoided the robot's harmful behavior. In fact, the limits of the ordinary rules on liability are clear, as they specify that robots cannot be held personally liable for their own acts or omissions that cause damage to third parties.

This could unfortunately determine the increasingly sporadic use of robots equipped with AI by the medical class, which will thus implement the so-called defensive medicine.

From what has just been said, it is clear the urgency of the introduction of an ad-hoc discipline that could exploit the recognition of a legal status to the intelligent robot to achieve the construction of a sustainable responsibility system able to balance the many interests at stake, including the need for a serene exercise of the health profession and the protection of the patient. Therefore, in the administration of the provision of care, a close cooperation between human intelligence and artificial intelligence should be developed, while still remembering that the robot equipped with AI will have, as its main goal, the facilitation and speeding up of the interpretation of different clinical data according to the patient's needs, but never the complete replacement of the doctor himself.

IV. Conclusion

Modern robots currently make a massive use of machine learning and data analysis techniques. For instance, in medicine surgeons often analyze the videos of their procedures to learn from them and improve for the next case. Future systems allow for automated recording and analysis of data. Using deep learning and artificial intelligence, these systems open up new possibilities for different applications, leading to reduced complications and the development of autonomous robotic systems for a greater range of procedures. Additionally, these technologies also open up new ways of training and evaluating surgeons and, conversely, also a new field for training surgeons on how to operate the new robots of the future.

Many people think that artificial intelligence will take jobs away from humans or even want to go so far as to take over the world. The truth is that robots want to help people, not to replace them. In fact, we can use them to get more dangerous and menial jobs done, thus leaving more time for humans to be creative.

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