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Humanoid Robot in Health Care

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Submitted by

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BONAFIDE CERTIFICATE

This is to certify that the Seminar entitled **“USE OF HUMANOID ROBOT IN HEALTH CARE”**, is being submitted by **Rapole Manish (18K81A05A7)** in partial fulfilment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE AND ENGINEERING** is recorded of bonafide work carried out by her. The result embodied in this report have been verified and found satisfactory.

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ABSTRACT

Humanoid service robots made swift progress in extending a helping hand to the strained global healthcare during the COVID-19 pandemic. This case provides an overview of the robots' inclusion in healthcare regarding pre- and intrapandemic contexts. Specific focus is devoted to humanoid service robots as their shape, size, and mobility make them advantageous in using the physical spaces designed for humans.

A collection of examples from hospitals worldwide is presented in illustrating the humanoid service robots' deployment in healthcare during the COVID-19 pandemic. The pointed future directions aim to facilitate better decision- and policy-making that may ease human anxiety and promote greater acceptance.

Due to the increasing number of COVID-19 cases, there is a remarkable demand for robots, especially in the clinical sector. SARS-CoV-2 mainly propagates due to close human interactions and contaminated surfaces, and hence, maintaining social distancing has become a mandatory preventive measure. This generates the need to treat patients with minimal doctor-patient interaction. Introducing robots in the healthcare sector protects the frontline healthcare workers from getting exposed to the coronavirus as well as decreases the need for medical personnel as robots can partially take over some medical roles.

The aim of this paper is to highlight the emerging role of robotic applications in the healthcare sector and allied areas. To this end, a systematic review was conducted regarding the various robots that have been implemented worldwide during the COVID-19 pandemic to attenuate and contain the virus. The results obtained from this study reveal that the implementation of robotics into the healthcare field has a substantial effect in controlling the spread of SARS-CoV-2, as it blocks coronavirus propagation between patients and healthcare workers, along with other advantages such as disinfection or cleaning.

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1. INTRODUCTION

In October 2019, only a few months before the COVID-19 pandemic outbreak, Diligent Robotics managed to raise US$3million seed funding to launch an autonomous robot assistant to deliver medical supplies and lab samples across the hospital. A few months into the pandemic, robots for hospitals received even further interest, where US$10million in Series A funding followed, As of mid-2020, humanoid robots started to serve in hospitals worldwide to collect patient information from those with possible exposure to the SARS-Cov-2 virus, thereby reducing human contact.

Similarly, human-size robots are used in Rwandan COVID-19 clinics to take patients' temperatures and deliver supplies (Beaubien, 2020). Robots not only helped in healthcare during the pandemic, but they also assisted in spraying disinfectants, walking dogs, showing properties for real estate agents, cleaning floors in grocery stores, sorting at recycling centres (Howard and Borenstein, 2020), and helping in contactless check-in and supporting security in airports (Hornyak, 2020; Lo, 2018). A recent examination of the reported uses of robots around the globe indicates that they play crucial roles in various aspects of managing the crisis (Figure 1) (Murphy et al., 2020) .

2. RELATED WORKS

The use of robots for surgery has given rise to a large number of new methods which has led to the emergence of a wide variety of robots for use in the medical domain. [1] Points out numerous research areas in the application of robotics in healthcare settings. Such as robotic surgical Systems [2, 3], laparoscopy surgery and tele-rounding robots [4], robot-assisted rehabilitation [5-7], caregiver and patient's assistants [8-10], robotic applications in dentistry, bio-prosthetic [11]. The list continues as the technology advances and even more applications of robot in healthcare could be envisaged. Humanoid robots that could be used to remotely carry out tasks are also very important. Such robots are endowed with human capabilities to assist caregivers and patients particularly in contaminated environments. These remotely operated robots are to possess certain characteristics for human robot interaction. However, tele-operated semi-autonomous robots can be used to perform assisted healthcare tasks during outbreaks which would reduce the time personnel need to spend in dangerous contaminated areas while putting on their personal protective equipment in high temperature and humid conditions particularly in the West African region.

Furthermore [12] highlighted some healthcare robots that have been developed for similar fields of application [13, 12]. The robot Cody is able to wash human limbs autonomously and an evaluation of the patient's system showed that acceptance strongly depends on the interpretation of robot intention [14]. Other robots serve as rehabilitation [15], the nurse assisting lifting of patients [16] or even blood sampling [17]. While research on humanoid robots for general or supportive patients care particularly for disease containment has hit the ground running in other developed countries due to the recent outbreak of Ebola virus disease that shook the world it is also important for those affected directly to find a solution to their problem. We propose a broad overview of some of the current and potential applications of robotics in health care settings and we carefully selected some robots for patient's care.

3. METHODOLOGY

Our objective is therefore to identify robots that can be implemented in the healthcare sector which can be used easily and improve the quality of treatment. To address this topic, an extensive and comprehensive literature review was conducted to compile published research papers pertinent to the topic of COVID-19 and robotics, by following the PRISMA guidelines. Based on our inclusion/exclusion criteria, any duplicate, inaccessible papers were removed, and only those papers written in English between 1998 and 2021 were included; collectively, 92 eligible studies were included in the meta-analysis.

Qualitative and quantitative data were assessed to obtain relevant information which was included in this study. Bibliometric analysis, as shown in Fig.3.1, was performed by retrieving relevant papers and detecting associations among COVID-19 and robots, the latter of which were of higher importance in terms of potential and performance. For the bibliometric analysis, numerical subsets that provided satisfactory results were chosen. The main keywords in the title and abstract of the retrieved papers were extracted and compiled, and their cooccurrence was graphically represented (Fig.3.1). This graphical representation provides significant information on how different subheadings are closely interlinked within the context of healthcare robotics. The greater the number of co-occurrent words of a topic, the greater their importance, as it highlights and categorizes robots (such as socially assistive robots or surgical robots) which have been implemented in the healthcare sector and relevant papers have been published, along with their corresponding operation and technological application.

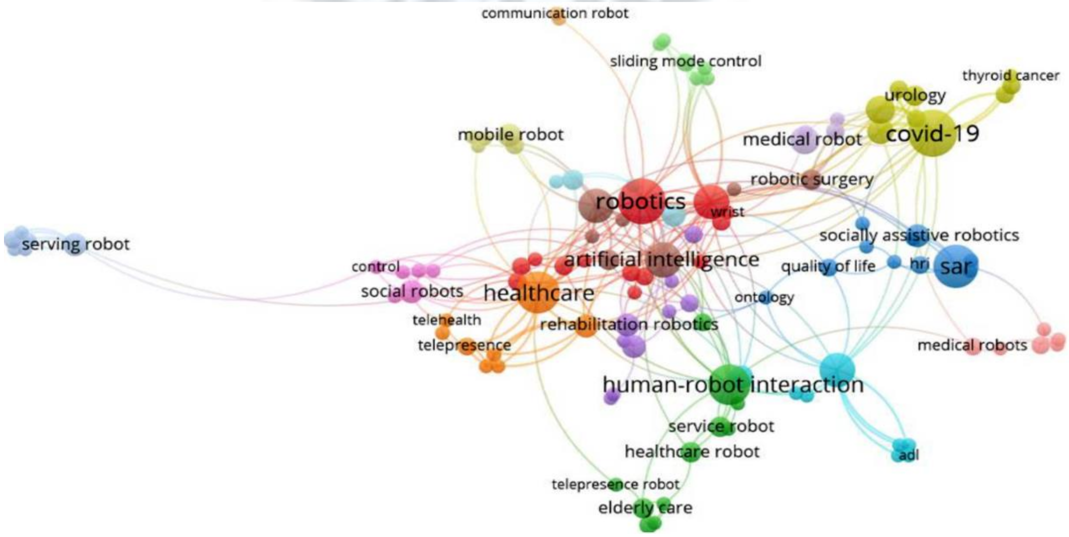

Fig.3.1: Co-occurrence of robots

Classification and Operation of Medical Robots

The implementation of robotics in the field of healthcare presents countless advantages on its own, and especially in the era of the COVID-19 pandemic that has befallen us, we are presented with probably no better alternative than the introduction of robots to attenuate the problems associated with this pandemic. We also provide a brief review on the types of medical robots and their operations and discuss the medical tasks that can be fulfilled by these robotic applications in this section.

Disinfecting/Spraying Robots

The use of portable robots for cleaning and disinfecting objects is increasing rapidly around the world. Cleansing and cleanliness are necessarily important for safe indoor/outdoor conditions in the case of contagious diseases like COVID-19. Primary source contacts like door handles and elevators represent the main sources for the transmission of such viruses through direct contact. Therefore, an automated cleaning task not only ensures safety but also improves effectiveness. This category proposes an AI-enabled structure for automating the cleaning process through a Human Support Robot (HSR). The general cleaning process includes cleaning the premises, door handles, and control of the HSR, for fulfilling the requirements of the cleaning undertakings. The identification part uses machine learning in order to view the space and give proper directions to the robot. Control between the spraying and cleaning is created in the robotic operating system. The control module utilizes the data gained from the discovery module to create an assignment/operational space for the robot, alongside assessing the ideal situation to drive the controllers.

UVD-bot is one such example of disinfection robot. It is a self-driven germicidal robot which uses ultraviolet light (UVC-254 nm). UVC light used in this robot is effective against the coronavirus as it disrupts the DNA base pairing, hence rendering the virus harmless. The result, of which it can perform the sanitation of a room within 10 minutes, is 100 percent autonomous and extremely efficient in disinfection. The robot is primarily used to carry out sanitization of hospital premises, thus preventing the direct contact of individuals from the contaminated zones. Moreover, its operational advantages include its simplicity of usage, so it can be operated by anyone without any advance technical skills.

Hospitality Robot

The role of receptionist and nursing robots has been increasing rapidly due to the pandemic which has led to an increase in fatality rates among healthcare workers. The abovementioned roles are accomplished by three different types of robots: (i) receptionist robot, (ii) medical server, and (iii) nurse robot. The job of a receptionist robot is to gather information and assist patients. The medical server obtains and stores the required data about the patients on the medical server and provides summaries of the saved data to human caretakers via a web interface. The main functions of nurse robot include serving medicines and food to the patients. This would prevent the hospital staff from getting in contact with infected patients. Therefore, to minimize the contact between human nurses and receptionists, many delivery and monitoring robots were deployed during this pandemic.

Sona 2.5 is an example of hospitality robot. It was designed using smart obstacle avoidance technology, it also includes a vision camera for face detection, and it can carry a load up to 15 kg due to which contactless delivery is possible. Sona 2.5 was originally designed as a restaurant service robot, but its functioning was reprogrammed to adequately meet the needs during the COVID-19 pandemic. Hence, its function also includes managing the delivery of medicines and food to the affected patients, as well as monitoring their body temperature.

As per a research paper by Malik et al., KARMI-Bot is a similar multipurpose robot with a load-carrying capacity up to 25 kg. The robot can also have additional capabilities such as self-charging [34]. Primarily, it has the features to analyse and map the vacant ward and further perform tasks such as delivering food and medicines on schedule to the particular patient, video conferencing with doctors, and auto self-sterilization. On the other hand, the primary objective of Co-bot (Corona Combat Robot) is to serve food and water to the COVID-19 patients and also bring back empty trays or plates. It has a load-carrying capacity of 20 kilograms and can be used to serve several people in one go .

Rail bot (R-Bot) serves the required roles with the additional advantage that it can also be operated in complete darkness due to its infrared capabilities and the presence of a night lamp with a battery life of about 6 hours. R-Bot is operated using a mobile application via Wi-Fi; it also supports two-way audio and video communication thereby aiding doctors to monitor their patients with ease [36]. It is equipped with thermal sensors that can map the temperature reading of a person and alert the appropriate personnel when someone with a temperature higher than the average is detected. The purpose of this robot is to distribute medical goods and food from a safe distance. R-Bot can carry a load of up to 80 kg and move at a speed of 1 km/hr.

Wegree Robot as per Podpora et al. aids the healthcare workers by reducing their contact with potential COVID-19 carriers and assisting patients effectively. The robot instructs visitors to perform tasks like sanitizing their hands, taking temperature readings using a noncontact thermometer linked to the robot, and wearing a protective face mask. The robot also instructs people about the various guidelines that they should follow such as making use of phone and email for trivial matters and encourages people to stay at home.

Teleoperation and Telepresence Systems

Teleoperation systems consist of a motion sensing device and collaborative dual-arm robot (YuMi, IRB 14000), through which the data of upper limb movement of the operator can be obtained and used to control the robot's motion remotely. A pair of gloves is used to monitor the finger motions. Telepresence systems are similar to teleoperation, as they include VoIP (voice over Internet protocol) applications, allowing healthcare workers to monitor patients via two-way audio-visual communication. Usually, such robots have a capacitive touch screen fixed to the forepart of the robot. Here, the interaction of the patient and the healthcare staff is achieved through the audio/video conference system which is based on WebRTC (Web-Real-Time Communication). In order to limit the contact between the patient and the doctor, the robot is equipped with voice recognition in order to communicate with the patient. Furthermore, to monitor the patient's emotional state, a deep neural network is used. A small mobile robot assembled with a suitable sensor can be a potential solution in such a case. The given robot is expected to navigate itself through the premises and collect data of safe and unsafe environments which healthcare workers can use for assisting and locating infected people. This process of 3D mapping is carried out by using a lightweight and a highly mobile self-sustaining robot which can be framed within the generic environment and mapping SLAM (Simultaneous Localization and Mapping) problem.

Surgical Robots

Applying autonomy to surgery has been a continuous effort for engineers and medical researchers, since it promises various advantages such as mechanical precision, stability, and the ability to work in hazardous environments. There are vast differences among surgical procedures, as a few of them are far easier to conduct, whereas others are highly complex. For example, autonomous cardiac ablation of the pulsating heart requires the involvement of robots because this operation cannot be completed effectively by the surgeon without relying on a surgical robot to introduce precise lesions in the heart. Therefore, during the pandemic, most surgical robots offer huge advantages, as they can be deployed to perform complex surgeries on COVID-19-affected patients and also reduce the excessive burden of the healthcare professionals.

Radiologist Robots

A radiologist is a person who interprets medical imaging to diagnose patients. A radiologist robot can effectively perform the same function. This robot is equipped with computational imaging capabilities and makes use of artificial intelligence (AI) and deep learning to make a diagnosis based on all available data. It can also be used to perform X-rays and MRIs. A radiologist robot is very advantageous, as it reduces the risk of healthcare professionals by preventing them from coming in contact with the harmful radiations emitted during the imaging cycles. Currently, experts are working on an AI algorithm which can detect the presence of SARS-CoV-2 and is presumed to detect the coronavirus with up to 96% accuracy.

Rehabilitation Robot

Rehabilitation robots, or rehab robots, serve the purpose of nursing injured or disabled patients back to their normal condition through assistive and therapeutic training. A typical case would be assisting a person to be able to walk again after an accident. Different types of rehab robots are targeted to treat patients with various diseases, like those who are recovering from stroke, cerebral palsy, or other bodily injuries such as knee, ankle, upper and lower limbs, wrist, and elbow. Most of the robots in this category are designed in a way that the children and elderly find them entertaining as they are designed with various AI functions that not only treat the patients but also keep them motivated; few of the functions include ability to understand facial emotions and ability to play games. During the COVID-19 pandemic, increasing use of telerehabilitation has been witnessed; in particular, rehab robots equipped with cameras and speakers are used for the purpose of clinical evaluation and monitoring from a distant location, hence further eliminating the need of jeopardizing the health of both patients and doctors.

4. RESULTS AND DISCUSSION

In this article, we present a detailed study of medical robots that have been deployed in various healthcare crises over the past few years, ranging from the Ebola epidemic to the very recent COVID-19 pandemic. As it is shown in Figure 2, a drastic increase is anticipated in the market size of medical robots post-COVID-19 pandemic for various categories of robots used for disinfection, nursing, and teleoperation. These markets had a valuation of lower than 1 billion dollars in 2017, but this is expected to increase 3.8 times by 2027.

As depicted in Figure 3, there is a desperate need for improvement in healthcare facilities worldwide, and in accordance with that, there are several significant studies which provide countless ways to upgrade the existing robots and make them more economical and reliable. Healthcare robots indulging in tasks of assisting children and elderly patients must have settings that are simple and easy to use . Robot's ergonomic and novel design should be reviewed, and its corresponding software has to be simplified, so as to make it cost-effective and reliable for usage. Therefore, a general modularization approach is needed for the implementation of these robotic devices. This would also reduce overall costs by standardizing the associated computer systems and sensors, thereby making them more homogeneous. The current pandemic served as a catalyst for the healthcare sector, the latter of which should undergo a major technological advancement to encounter these uncertain situations and also improve its overall quality and efficiency.

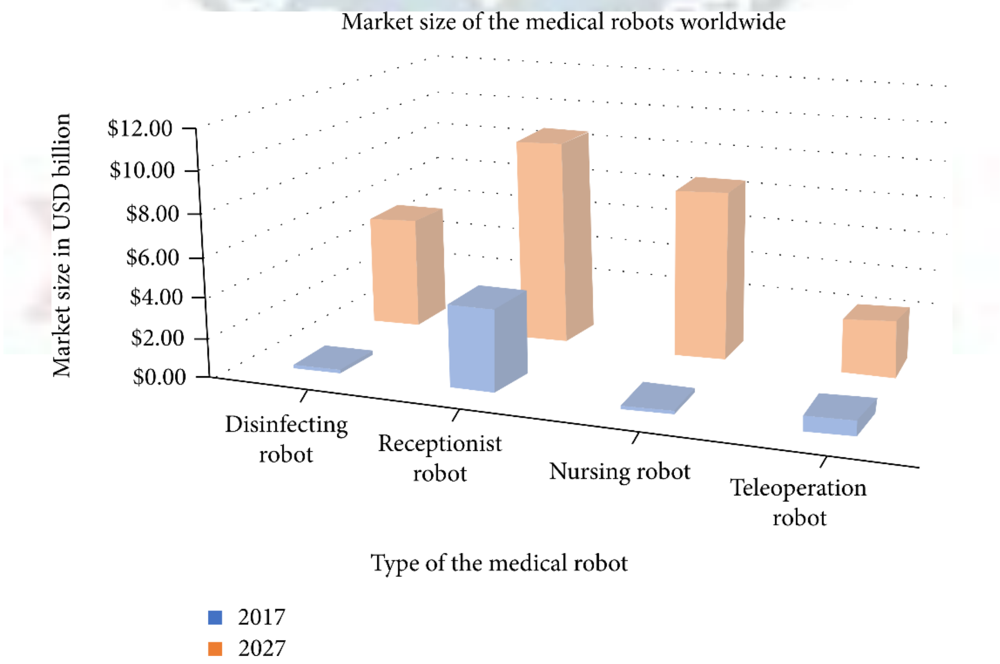

Fig.4.1: Market size of the various medical robots used worldwide.

5. CONCLUSION

In this study, we presented a thorough overview of the various types of robots that are used in the clinical sector to perform tasks in SARS-CoV-2-contaminated zones. The aim of this study is to serve as an informative resource for the current advancements in the medical sector, which would prove highly beneficial to combat highly infectious diseases like COVID-19 on various forefronts. One limitation of this study is that while an effort was made to cover as many healthcare robot applications that have been used against COVID-19 as possible, it mainly focused on scientific publications, possibly leaving out novel industrial applications. The world of the healthcare sector, post pandemic, appears to be more reliant on robots in order to prevent human-to-human transmission. There was a huge demand for medical robots in developed markets due to their numerous advantages in functionality and ability to restrict the spread of SARS-CoV-2. The onset of use of robotics might only increase at a greater rate because of the ongoing pandemic. Therefore, many countries may increase their interest in robotic advancements to gain financial and medical stability along with better healthcare, which would lead to a drastic increase in the use of medical robots.

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