Robotics and Automation in Healthcare

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Abstract: Robotics is an interdisciplinary branch of computer science and engineering which involves the design, construction, operation, and use of robots. Healthcare organizations globally and regionally has started to adopt robotic technologies by the late 80s to manage their operations in a variety of fields. The robotic systems can assist the healthcare system and defend public health in a number of ways especially when deep health crises are exacerbated by the extreme socioeconomic pain. Robots in the medical field had transformed how surgeries are performed, streamlining supply and delivery in pharmacy, rationalized disinfection, and enabled the providers to focus on engaging with and caring for patients.

Index Terms: automation, robots, surgery, microbots, bacteria, medicine, healthcare workers

I. INTRODUCTION

Robotic automation means the designing, constructing and using robots to carry out a task which would otherwise be done by a human worker. Robots are used as a versatile way to automate a physical task or process done by humans. Collaborative robots are designed in such a way that they carry out the assigned task in the same way a human would do it. Robotic process automation (RPA) is a software technology that makes it easy to build, deploy, and manage software robots that emulate human's actions interacting with digital systems and software. By performing business process functions at a high volume using ru-based software, this type of automation frees up human resources to focus on more difficult jobs. Agriculture, transportation, military and law enforcement, as well as consumer and domestic items, all employ robots today. However, the potential of robots to help with the medical care of people may be the biggest contribution that they are giving to humanity. In the 1980s, robotics began to take off, and the first medical robots assisted with surgery. The first surgical aid robots employed robotic arm technology. As the years go by, artificial intelligence (AI) has made data analytics and computer vision possible, which has transformed medical robots and increased their functionality in a wide range of healthcare settings. Robots are now utilised in clinical settings outside of the operating room to assist healthcare professionals, provide medication to hospital patients, and perform cleaning and disinfection tasks. The majority of national and international healthcare organisations are using robotic technologies to run a variety of operations. These professions include telemedicine, pharmacy, rehabilitation, and surgery. A high standard of patient care, effective clinical procedures, expedited pharmacy supply and delivery, rationalised disinfection, and a secure working environment for patients and healthcare professionals are all made possible by the use of robotics in the medical area.

II. HEALTHCARE ROBOTICS: EVOLUTION

Robots in medicine assist by freeing up medical staff from routine chores that divert their attention from more important duties and by reducing the risk and expense of medical treatments for patients. The 1980s saw the experimental usage of mechanical robots in surgical settings, but it wasn't until the 1990s that the technology was completely perfected. The U.S. National Aeronautics and Space Administration (NASA) looked at the idea of remote surgery, or telesurgery, in the 1970s since astronauts in orbit were a promising main target group. The main concept was that a surgical machine might be installed on a space station and operated by a surgeon on Earth. The United States Defence Advanced Research Projects Agency considered a similar scheme (DARPA). Researchers at DARPA tried to create a remote telesurgery equipment that would make it possible to operate on wartime casualties. In 1985, the first surgical robot, the PUMA 560, was utilised in a stereotaxic technique. Computed tomography was used to guide the robot while it inserted a needle for a brain biopsy, a process that had previously been susceptible to mistakes due to hand tremors. In 1988, transurethral prostate surgery, which needed several repetitive cutting motions, was performed using PROBOT, a device created by Imperial College London. Integrated Surgical Systems, Inc. (ISS) and IBM created ROBODOC, which was utilised to successfully prepare a femur cavity for hip replacement in human patients, in 1992. Compared to human surgeons, it completed the procedure more rapidly and accurately.

The age of laparoscopic surgery began in the 1980s and 1990s. Surgeons discovered that by using laparoscopes, they could operate on patients with smaller incisions and shorten their recovery and hospital stays. A minimally invasive surgical procedure was illustrated by the method. Surgical robots that could help with minimally invasive operations were being developed by some surgeons. The da Vinci Surgical System, created by Intuitive Surgical, Inc., as well as the AESOP and Zeus Robotic Surgical systems, all created by Computer Motion, Inc., had all undergone testing by the late 1990s. The Zeus system performed numerous innovative robotic surgeries in the 1990s, but in 2003 it was halted after Computer Motion was acquired by Intuitive Surgical. The da Vinci Surgical System consequently gained a leading position among robotic surgical systems deployed globally. The da Vinci was made up of a surgical console, tools that modelled human wrists, and a vision system. Technically speaking, it was a "slave" system because the surgeon operated from a distance using "master controllers" that directed the direct motions of the binocular camera and the wristimitating tools. The da Vinci system had the benefit of achieving all three robotic surgical objectives—remote console and surgeon, elimination of unnecessary movements, and minimally invasive access.

Although some of the health care robots of today make PUMA seem a little archaic in comparison, this milestone signaled the beginning of a new era in which robotic devices support physicians and surgeons during medical procedures. Robots are becoming more accurate, autonomous, and able to perform complex surgeries on their own because to advancements in sensor and motion

control technologies. There are several fields where robotic technology is present that directly impact patient care. They can be used to sterilize operating rooms and patient rooms, lowering risks for both patients and medical staff. They perform sample collection, transportation, analysis, and storage tasks in laboratories. In pharmaceutical labs, robots also prepare and deliver drugs. In larger facilities, robotic carts ride elevators and pass through automatic doors while transporting food and even bed linens from one floor to another. Robotic "gears and wires" helpers are also available that can provide physical therapy and aid in the movement of paraplegics. Whether robotics will displace human workers from positions in the healthcare industry is the key question. There are a number of reasons why machines won't take the place of people. But in the end, essential human interaction cannot be replaced by artificial assistance.

III. USE CASES FOR ROBOTS IN HEALTHCARE

Robots in Surgery

A high degree of accuracy is necessary for some surgeries, including orthopedic and neurological operations. The patient could sustain harm or possibly pass away if the scalpel slips or the forceps are misplaced. Surgical robots can't shake or make other strainrelated movements that a human surgeon may. The software of the device accounts for any trembling in the controller's hands so that it has no impact on the procedure. Human hands are unable to perform several 360-degree rotations, while robotic hands can. As a result, they have more freedom to move. Each arm can bend like a human wrist because to the little joints it is fitted with. This is an improvement over conventional laparoscopic tools, which are stiff and difficult to maneuver since they cannot bend. The robotic arm eliminates the inherent constraints of human wrists, enabling more sensitive, accurate, and efficient movements during surgery. Additionally, it has a 3D high resolution camera that offers a view of the surgical site that is superior to what would otherwise be possible, even during open surgery. Most times, robotic surgery is minimally invasive. As a result, the patient experiences less discomfort, minimum bleeding, and scarring, and only needs a brief period of recuperation. Robotic surgery is more exact, nerve bundles are dissected more accurately, erectile function is retained, and there is a higher possibility of cure than with non-robotic surgery. This is made possible using endo-wrist and 3D imaging technology. Additionally, the surgeon has greater control, strength, dexterity, flexibility, and a superior vision of the surgical site. Robotic surgery enables the surgeon to become more at ease, complete the procedure with more focus and attention, and carry out complex procedures that are more difficult or impossible to do with previous techniques.

Fig.1 Robot assisting in surgery

Microbots in Disease Detection and Treatment

A microrobot is a tiny robot made specifically to complete specific tasks. They could perform tasks that no other robot could because of their small size and ability to navigate through the body. It may be possible to create biohybrid microrobots, which combine a living species and an artificial carrier, to manipulate tissue, transport cargo, and target specific cells inside the body. Microrobots are considerably less likely to damage tissue than conventional medical techniques since they are smaller than living human cells. By aiming for specific regions in the body, microrobots could significantly reduce the side effects of drugs. Using microbots for drug delivery is relatively easy compared to the fabrication and mobility problems. For instance, they may remove plaque-clogged arteries, take highly precise tissue samples, or treat dangerous tumors from the inside.

Fig.2 Microbots inside human body

Nursing Robots

Nurse robots can perform duties akin to those performed by human nurses without being worn out. Nurses and carers can focus on more critical activities and engage in human interaction and empathetic care while nurse robots do trivial or less urgent responsibilities, promoting the patient's long-term health. The market for care robots is also seeing a major increase in demand. The key factor driving demand for care robots is the difficulties faced by the elderly population as well as those suffering from dementia

and other mental illnesses. Care robots assist patients with a variety of daily tasks, including mobility and transportation assistance, routine body checks (such as taking the patient's temperature, blood pressure, and sugar levels), retrieving food and water, reminding them to take their medications, and more. The care robots are highly useful and lessen the daily workload for healthcare workers. The need for care robots is projected to rise in the next years due to the improvement in capabilities and the expanding elderly population. Even aged and crippled patients receive care from them, and they are conversed with so they do not experience discomfort or boredom. More than just moving racks or taking blood samples are possible in the world of healthcare robotics. Caretakers can communicate with patients, inquire about their living situations, and determine whether additional appointments are necessary with the help of remote-controlled medical robots. This would greatly increase efficiency by removing time-consuming home visits. Heavy lifting by nurse robots, such as shifting hospital beds or picking up patients, eliminates some workplace hazards for healthcare employees. Additionally, the movement of supplies and linens handled by service robots reduces contact with germs and viruses.

Fig.3 Robot checking pulse of a patient

Sanitation Robots

The COVID-19 pandemic increased interest in robotic sanitation and cleaning systems. More than ever, people prefer to have their homes cleaned thoroughly and frequently. Cleaning had previously been viewed as a low-risk, low-skill occupation. All of a sudden, it was a job with a high danger of infection. Robotic floor cleaners are now commonplace. They are capable of independently mopping, vacuuming, and polishing floors. Hospitals are using robots to carry out the disinfection and sanitation procedure since inadequate hygiene and sanitation can result in numerous diseases. These specialist robots perform the air circulation and surface disinfection processes while scanning the hospital setting. In particular, UV sterilization robots eliminate bacteria, viruses, and other dangerous microbes that can lead to diseases. As bacteria and illnesses spread more widely every day. Because bacteria are ubiquitous and can infect everyone, the robots are made to clean surfaces and maintain cleanliness in hospitals to prevent patients from contracting any diseases or bacteria.

To disinfect surfaces, several commercial cleaning robots use Ultra-Violet (UV) radiation. UV radiation is efficient at killing germs and viruses, according to studies. This "touchless" cleaning technique is relatively quick than manual approaches that include wiping with a towel because it doesn't need any physical contact. Bathroom cleaning robots are still in their infancy on the market. Cleaning products are available with "touch-free" systems. Bathroom cleaning robots are still in their infancy on the market. Cleaning products are available with "touch-free" systems. It is a multipurpose device with a power spray as its first function. A vacuum is used to extract the contaminated water after that. Finally, the device employs a blower to dry everything off. One portable machine contains all of this.

The technology for robotic pool cleaning is well-established. The robots' sophisticated navigation allows them to completely cover the pool. To remove dirt, trash, and algae, they have brushes on board. Some models include a remote control. The majority of the ideas are still in their infancy for outdoor applications. Robotic garbage collectors are starting to show up to clean beaches and parks. Without a doubt, this reduces labour costs and spares workers from having to crouch down and clean. But a cleaning worker must still utilise the gadget.

Fig.4 Room cleaning robot

Clinics and dispensaries

In hospitals, medication is dispensed and delicate goods could be handled by dispensing robots. Robotic dispensers are particularly useful because they can accurately and quickly deliver medication. They are also capable of handling viscous or sensitive liquids. Robots for medical transportation are used to move medications from one location to another. The systems that are currently available can be divided into two categories: random storage machines (where the picking head places the stock in a spot chosen by the system computer) and channel storage systems (where stock is loaded manually into predetermined channels). In comparison to the former, the latter can reach a higher pack storage density. Although the doctors or staff members may forget to give the patient their medications, robots are unable to do so and will administer them at the appropriate time. Robotic prescription dispensing system: The fundamental advantage of robots is that they complete tasks quickly and accurately.

Fig.5 An automated dispensary

IV. KEY CHALLENGES AND RISK

Human lives can be lost due to one mechanical failure. Small hazards of bleeding and infection cannot be disregarded in the case of surgical robots. It's critical to take into account a robot's cost effectiveness in addition to the system's acquisition, upkeep, and training expenses when purchasing robots for the healthcare industry. Whether robotics will displace human workers from positions in the healthcare industry is the key question. There are a number of reasons why machines won't take the place of people. But in the end, essential human interaction cannot be replaced by artificial assistance. One reason is that most hospitals only have around 300 beds. The technology is simply out of reach for them. The installation of navigation systems throughout the facilities is necessary for the automated guided vehicles, which also need a special hall or floor tracks. Other carts function with the aid of an embedded laserdrawn hospital map that shows elevators, turns, and automated doors. Additionally, such procedure is rather expensive. Additionally, their lifetime maintenance expense is a major aspect. Even physicians who are well educated and skilled in their fields frequently struggle with poor levels of technological literacy. This is also one of the biggest problems. Therefore, the chances of effectively training a direct robot user or care provider to utilize the robot are significantly reduced if they themselves find it difficult to use it. Safety and dependability are crucial when people and robots are close to each other. Children and others with cognitive impairments are particularly vulnerable to being misled by robots. In spite of recent efforts to persuade robot manufacturers to use value-centered design approaches, this is a significant and understudied issue in the robotics world. Movement Latency: The time it takes for the robot to respond to the surgeon's directions is one of the most important issues with robotic surgery. The robotic arms and computer don't start talking to one other right away. Although this isn't a concern for typical surgery, it makes it challenging for surgeons to act promptly when issues arise.

V. HEALTHCARE ROBOTICS ADOPTION: OPPORTUNITIES

Help or comfort patients or guests as needed. It is now obvious that the operational effectiveness and risk mitigation that health robotics offer contribute value in a number of different ways. Higher Surgical Accuracy: Some operations need for a high level of precision. A single misstep with the knife or misplaced pair of forceps might harm the patient or even result in their death. Robotic surgeons are impervious to the trembling or other motions brought on by stress that a human surgeon could suffer. Robots range from "humanoid robots" (two legged) to those with many legs, depending on the controller's hands. Fruitful Interaction: The safe physical interaction between humans and robots has received a lot of attention, notably in the areas of collision avoidance, passive compliance control, and recent developments in soft robotics to enable delicate interactions. Recent developments in algorithmic verifiability for robots operating in partially understood workspaces have also been made, and these could be useful in the future. Reduced fatigue in surgeons: Surgery takes a lot out of the attending surgeon, especially lengthy operations. The crew spends hours on its feet performing the surgery and caring for the patient. With the aid of surgical robots, the surgeon may perform procedures while sitting comfortably. Improved patient recovery times: They even take care of elderly and disabled patients, talking to them to keep them from getting bored or feeling pain. They assist in reducing hospital stays and developing individualized and focused therapies. Rapidly reducing costs, RPA decreases team workloads, allowing workers to be transferred to other important tasks that still require human input, increasing productivity and ROI. The surgery won't be impacted by the patient's trembling because the machine's software accounts for the movement. Surgery time is reduced since it operates promptly and without wasting any time. Telerobotic devices on the market now and in the past lack haptic or sensory input. Despite the fact that this technology has received a lot of research funding and patents, it has not yet been used in clinical settings. In order to support, aid, or enhance the user's skills, wearable robots are human-worn devices that monitor body signals and provide information to the user through biofeedback. Robots with legs are called "legged mobile robots," and they move by touching the ground with their movable legs.

VI. CONCLUSION

Robotic systems that can operate autonomously are able to carry out tasks with little to or no involvement from a human operator. By relieving healthcare workers of time-consuming and repetitive activities and enabling clinicians to concentrate on tasks that call

for a specialized touch, advanced technologies, such as AI-guided robotics and automation, offer a potential solution to the provider crisis. Although some tasks was that had adverse effects on workers could be carried out efficiently by robots, doing so can have a negative impact on human workers. For a variety of reasons, it is not viable to fully automate the healthcare industry. High expense is one among them.

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