IN THIS CHAPTER

- Monitoring patients more effectively
- Assisting humans in various tasks
- Analyzing patient needs locally and remotely
- Performing surgery and other tasks by medical professionals

Chapter 7

Using AI to Address Medical Needs

Medicine is complicated. There is a reason it can take 15 or more years to train a doctor, depending on specialty (see `https://work.chron.com/long-become-doctor-us-7921.html` for details). By the time the school system packs a doctor with enough information to nearly burst, most other people have already been in the job force for 11 years (given that most will stop with an associate's or bachelor's degree). Meanwhile, the creation of new technologies, approaches, and so on all conspire to make the task even more complex. At some point, it becomes impossible for any one person to become proficient in even a narrow specialty. This is a prime reason that an irreplaceable human requires consistent, logical, and unbiased help in the form of an AI. The process begins by helping the doctor monitor patients (as described in the first section of this chapter) in ways that humans would simply find impossible. That's true because the number of checks is high, the need to perform them in a certain order and in a specific way is critical, and the potential for error is monumental.

Fortunately, people have more options today than ever before for doing many medical-related tasks on their own. For example, the use of games enables a patient to perform some therapy-related tasks alone, yet receive guidance from an application to help the person perform the task appropriately. Improved prosthetics and other medical aids also enable people to become more independent of professional human assistance. The second section of this chapter describes how AI can help assist people with their own medical needs.

Just as it proves difficult, if not impossible, to fix various devices without seeing the device in use in a specific environment, so humans sometimes defy the analysis needed to diagnose problems. Performing analysis in various ways can help a doctor find a specific problem and address it with greater ease. Today, a doctor can fit a patient with a monitoring device, perform remote monitoring, and then rely on an AI to perform the analysis required for diagnosis — all without the patient's spending more than one visit at the doctor's office (the one required to attach the monitoring device). In fact, in some cases, such as glucose monitors, the patient may even be able to buy the required device at the store so that the visit to the doctor's office becomes unnecessary as well. One of the more interesting additions to the health care arsenal during medical emergencies, such as pandemics, is the use of telepresence, which enables the doctor to interact with a patient without actually being in the same room. Even though the third section of this chapter doesn't go into the various analysis devices, you do get a good overview of their uses.

Of course, some interventions require the patient to undergo surgery or other procedures (as described in the fourth section of this chapter). A robotic solution can sometimes perform the task better than the doctor can. In some cases, a robot-assisted solution makes the doctor more efficient and helps focus the doctor's attention in areas that only a human can address. The use of various kinds of technology also makes diagnosis easier, faster, and more accurate. For example, using an AI can help a doctor identify the start of cancer far sooner than the doctor could perform the task alone.

Implementing Portable Patient Monitoring

A medical professional isn't always able to tell what is happening with a patient's health simply by listening to their heart, checking vitals, or performing a blood test. The body doesn't always send out useful signals that let a medical professional learn anything at all. In addition, some body functions, such as blood sugar, change over time, so constant monitoring becomes necessary. Going to the doctor's office every time you need one of these vitals checked would prove time consuming and possibly not all that useful. Older methods of determining some body characteristics required manual, external intervention on the part of the patient — an error-prone process in the best of times. For these reasons, and many more, an AI can help monitor a patient's statistics in a manner that is efficient, less error prone, and more consistent, as described in the following sections.

Wearing helpful monitors

All sorts of monitors fall into the helpful category. In fact, many of these monitors have nothing to do with the medical profession, yet produce positive results for your health. Consider the Moov monitor (https://welcome.moov.cc/), which monitors both heart rate and 3-D movement. The AI for this device tracks these statistics and provides advice on how to create a better workout. You actually get advice on, for example, how your feet are hitting the pavement during running and whether you need to lengthen your stride. The point of devices like these is to ensure that you get the sort of workout that will improve health without risking injury.

Mind you, if a watch-type monitoring device is too large, Oura (https://get.ouraring.com/overview) produces a ring that monitors about the same number of things that Moov does, but in a smaller package. This ring even tracks how you sleep to help you get a good night's rest. Rings do tend to come with an assortment of pros and cons. The article at https://www.wareable.com/smart-jewellery/best-smart-rings-1340 tells you more about these issues. Interestingly enough, many of the pictures on the site don't look anything like a fitness monitor, so you can have fashion and health all in one package.

Of course, if your only goal is to monitor your heart rate, you can get devices such as Apple Watch (https://support.apple.com/en-us/HT204666) that also provide some level of analysis using an AI. All these devices interact with your smartphone, so you can possibly link the data to still other applications or send it to your doctor as needed.

Relying on critical wearable monitors

A problem with some human conditions is that they change constantly, so checking intermittently doesn't really get the job done. Glucose, the statistic measured by diabetics, is one statistic that falls into this category. The more you monitor the rise and fall of glucose each day, the easier it becomes to change medications and lifestyle to keep diabetes under control. Devices such as the K'Watch (https://www.pkvitality.com/ktrack-glucose/) provide such constant monitoring, along with an app that a person can use to obtain helpful information on managing their diabetes. Of course, people have used intermittent monitoring for years; this device simply provides that extra level of monitoring that can help make having diabetes more of a nuisance than a life-altering issue. (The number of remote patient-monitoring devices produced by various companies is growing; see the article at https://tinyurl.com/c52uytse for details.)

WARNING

MEDICAL DEVICES AND SECURITY

A problem with medical technology of all sorts is the lack of security. Having an implanted device that anyone can hack is terrifying. The article at https://tinyurl.com/rjnathrw describes what could happen if someone hacked any medical device. Fortunately, according to many sources, no one has died yet.

However, imagine your insulin pump or implanted defibrillator malfunctioning as a result of hacking, and consider what damage it could cause. The Federal Drug Administration (FDA) has finally published guidance on medical-device security, as described in the article at https://tinyurl.com/w24cvfc7, but these guidelines apparently aren't enforced. In fact, this article goes on to say that the vendors are actively pursuing ways to avoid securing their devices.

The AI isn't responsible for the lack of security that these devices possess, but the AI could get the blame should a breach occur. The point is that you need to view all aspects of using AI, especially when it comes to devices that directly affect humans, such as implantable medical devices.

Some devices are truly critical, such as the Wearable Cardioverter Defibrillator (WCD), which senses your heart condition continuously and provides a shock should your heart stop working properly (see https://tinyurl.com/ybcew7h4 and https://tinyurl.com/jkzbv3x8 for details). This short-term solution can help a doctor decide whether you need the implanted version of the same device. There are pros and cons (https://tinyurl.com/8umynwjn) to wearing one, but then again, it's hard to place a value on having a shock available when needed to save a life. The biggest value of this device is the monitoring it provides. Some people don't actually need an implantable device, so monitoring is essential to prevent unnecessary surgery.

Using movable monitors

The number and variety of AI-enabled health monitors on the market today is staggering (see https://tinyurl.com/wt368ewk for some examples). For example, you can actually buy an AI-enabled toothbrush that will monitor your brushing habits and provide you with advice on better brushing technique (https://tinyurl.com/6ft7u37y). Oral B also has a number of toothbrushes that benefit from the use of AI: https://tinyurl.com/35xdarjj. When you think about it, creating a device like this presents a number of hurdles, not the least of which is keeping the monitoring circuitry happy inside the human mouth. Of course, some people may feel that the act of brushing their teeth really doesn't have much to do with good health, but it does (see https://tinyurl.com/6mfzc4hk).

Creating movable monitors generally means making them both smaller and less intrusive. Simplicity is also a requirement for devices designed for use by people with little or no medical knowledge. One device in this category is a wearable electrocardiogram (ECG). Having an ECG in a doctor's office means connecting wires from the patient to a semiportable device that performs the required monitoring. The QardioCore (`https://tinyurl.com/3t4abkxb` and `https://store.getqardio.com/`) provides the ECG without using wires, and someone with limited medical knowledge can easily use it. As with many devices, this one relies on your smartphone to provide needed analysis and make connections to outside sources as needed.


REMEMBER

Current medical devices work just fine, but they aren't portable. The point of creating AI-enabled apps and specialized devices is to obtain much needed data when a doctor actually needs it, rather than having to wait for that data. Even if you don't buy a toothbrush to monitor your technique or an ECG to monitor your heart, the fact that these devices are small, capable, and easy to use means that you may still benefit from them at some point.

Making Humans More Capable

Many of the current techniques for extending the healthy range of human life (the segment of life that contains no significant sickness), rather than just increasing the number of years of life depends on making humans more capable of improving their own health in various ways. You can find any number of articles that tell you 30, 40, or even 50 ways to extend this healthy range, but often it comes down to a combination of eating right, exercising enough and in the right way, and sleeping well. Of course, with all the advice out there, figuring out just which food, exercise, and sleep technique would work best for you could be nearly impossible. The following sections discuss ways in which an AI-enabled device might make the difference between having 60 good years and 80 or more good years. (In fact, it's no longer hard to find articles that discuss human life spans of 1,000 or more years in the future because of technological changes.)

Using games for therapy

A gaming console can serve as a powerful and fun physical therapy tool. Both Nintendo Wii and Xbox 360 see use in many different physical therapy venues (`https://tinyurl.com/4dkp23k`). The goal of these and other games is to get people moving in certain ways. The game automatically rewards proper patient movements, and a patient receives therapy in a fun way. Making the therapy fun means that the patient is more likely to do it and get better faster. You can now find very informative studies about the use of games and their combination with telehealth strategies at `https://tinyurl.com/b6bt29r7` and `https://letsplaytherapy.org/video-games-and-telehealth/`.

BIAS, SYMPATHY, AND EMPATHY

Getting good care is the initial aim of anyone who enters any medical facility. The assumption is that the care is not only the best available but also fair. An AI can help in the medical field by ensuring that technical skills remain high and that no bias exists whatsoever — at least, not from the AI's perspective.

Humans will always exhibit bias because humans possess intrapersonal intelligence (as described in Chapter 1). Even the kindest, most altruistic person will exhibit some form of bias — generally unconsciously — creating a condition in which the caregiver sees one thing and the patient another (see the "Considering the Five Mistruths in Data" section in Chapter 2). However, the people being served will almost certainly notice, and their illness will likely amplify the unintended slight. Using an AI to ensure evenhandedness in dealing with patient issues is a way to avoid this issue. The AI can also help caregivers discover mistruths (unintended or otherwise) on the part of patients in relating their symptoms, thereby enhancing care.

The medical field can be problematic at times because technical skill often isn't enough. People frequently complain of the lack of a good bedside manner on the part of medical staff. The same people who want fair treatment also somehow want empathy from their caregivers (making the care unfair because it's now biased). Empathy differs from sympathy in context. People exhibit *empathy* when they are able to feel (almost) the same way the patient does and build a frame of reference with the patient. (It's important to note that no other person feels precisely the same way as you do because no other person has had precisely the same experiences that you've had.) Two exercises in the "Considering the software-based solutions" section, later in this chapter, help you understand how someone could build a frame of reference to create empathy. An AI could never build the required empathy because an AI lacks the required sense awareness and understanding to create a frame of reference, and the intrapersonal intelligence required to utilize such a frame of reference.

Unfortunately, empathy can blind a caregiver to true medical needs because the caregiver is now engaging in the mistruth of perspective by seeing only from the patient's point of view. So medical practitioners often employ *sympathy,* through which the caregiver looks in from the outside, understands how the patient might feel (rather than how the patient does feel), and doesn't build a frame of reference. Consequently, the medical practitioner can provide needed emotional support, but also see the need to perform tasks that the patient may not enjoy in the short term. An AI can't accomplish these tasks because an AI lacks intrapersonal intelligence and doesn't understand the concept of perspective well enough to apply it appropriately.

Of course, movement alone, even when working with the proper game, doesn't assure success. In fact, someone could develop a new injury when playing these games. The Jintronix add-on for the Xbox Kinect hardware standardizes the use of this game console for therapy (https://tinyurl.com/uzetv2tc and https://tinyurl.com/y42rmh4v), increasing the probability of a great outcome.

Considering the use of exoskeletons

One of the most complex undertakings for an AI is to provide support for an entire human body. That's what happens when someone wears an *exoskeleton* (essentially a wearable robot). An AI senses movements (or the need to move) and provides a powered response to the need. The military has excelled in the use of exoskeletons and is actively seeking more (see https://tinyurl.com/3sawszrb and https://tinyurl.com/tu525nuw for details). Imagine being able to run faster and carry significantly heavier loads as a result of wearing an exoskeleton. The video at https://tinyurl.com/p489dvj gives you just a glimpse of what's possible. The military continues to experiment, and those experiments often feed into civilian uses. The exoskeleton you eventually see (and you're almost guaranteed to see one at some point) will likely have its origins in the military.

Industry has also gotten in on the exoskeleton technology (see https://tinyurl.com/2j86w592 as an example). In fact, the use of exoskeletons is becoming ever more important as factory workers age (https://tinyurl.com/9h9j8sh9). Factory workers currently face a host of illnesses because of repetitive stress injuries. In addition, factory work is incredibly tiring. Wearing an exoskeleton not only reduces fatigue but also reduces errors and makes the workers more efficient. People who maintain their energy levels throughout the day can do more with far less chance of being injured, damaging products, or hurting someone else.

The exoskeletons in use in industry today reflect their military beginnings. Look for the capabilities and appearance of these devices to change in the future to look more like the exoskeletons shown in movies such as *Aliens* (https://tinyurl.com/krhh8b5k). The real-world examples of this technology (see the video and article at https://tinyurl.com/4wbsf7ea as an example) are a little less impressive but will continue to gain in functionality.

Exoskeletens can enhance people's physical abilities in downright amazing ways. For example, a Smithsonian article discusses using an exoskeleton to enable a child with cerebral palsy to walk (https://tinyurl.com/nyb5p3kd). Not all exoskeletons used in medical applications provide lifetime use, however. For example, an exoskeleton can help a person who experienced a stroke walk without impediment (https://tinyurl.com/439syr72). As the person regains skills, the exoskeleton provides less support until the wearer no longer needs it. Some users of the device have even coupled their exoskeleton with other products, such as Amazon's Alexa (see https://tinyurl.com/tp3kyxfk for details).

IMAGINING THE DARK SIDE OF EXOSKELETONS

Despite an extensive search online, few nefarious uses for exoskeletons turned up, unless you consider the military applications negative. However, destroying is easier than creating. Somewhere along the way, someone will come up with negative uses for exoskeletons (and likely every other technology mentioned in this chapter). For example, imagine high-stakes thieves employing exoskeletons to obtain some sort of advantage during the theft of heavy objects (`https://tinyurl.com/46tfte7c`).

Even though this book is about clearing away the hype surrounding AI and presenting some positive uses for it, the fact remains that the smart individual does at least consider the dark side of any technology. This strategy becomes dangerous when people raise an alarm without any facts to support a given assertion. Yes, thieves could run amok with exoskeletons, which should provide incentive to properly secure them, but it also hasn't happened yet. Ethical considerations of potential uses, both positive and negative, always accompany creating a technology such as AI.

Throughout the book, you find various ethical and moral considerations in the positive use of AI to help society. It's definitely important to keep technology safe, but you also want to keep in mind that avoiding technology because of its negative potential is truly counterproductive.

REMEMBER

The overall purpose of wearing an exoskeleton isn't to make you into Iron Man. Rather, it's to cut down on repetitive stress injuries and help humans excel at tasks that currently prove too tiring or just beyond the limits of their body. From a medical perspective, using an exoskeleton is a win because it keeps people mobile longer, and mobility is essential to good health.

Addressing a Range of Physical Abilities

The creation of highly specialized prosthetics and other devices, many of them AI-enabled, has been a game changer for many people. For example, these days, some people can run a marathon or go rock climbing, even if they've experienced paralysis or the loss of a limb (`https://tinyurl.com/ce958ms9`). Then again, some people are using exoskeletons for an arguably less-than-productive use (`https://tinyurl.com/tt9rvxdj`).

THE GRIT AND PERSEVERANCE BEHIND THE AI DEVICE

The people you see online who are especially adept at having an amazing life with assistance from prosthetics or other devices have usually worked really hard to get where they are now. Using an AI-enabled device can get you a foot in the door, but to enter, you must be willing to do whatever it takes to make the device work for you, which usually requires hour upon hour of therapy. This chapter doesn't seek to make light of the incredible amount of work that these amazing people have put into making their lives better. Rather, it spotlights the technologies that help make their achievements possible. If you want to see something extraordinary, check out the ballerina at `https://tinyurl.com/37vn8bfd`. The article and its video makes plain the amount of work required to make these various technologies work.

REMEMBER

It's a fact of life that just about everyone has some challenge in terms of capabilities and skills. At the end of a long day, someone with 20-20 vision might benefit from magnifying software to make text or graphic elements larger. Color-translation software can help someone who sees the full spectrum of human color take in details that aren't normally visible. As people age, they tend to need assistance to hear, see, touch, or otherwise interact with common objects. Likewise, assistance with tasks such as walking could keep someone in their own home for their entire life. The point is that using various kinds of AI-enabled technologies can significantly help everyone to have a better life, as discussed in the sections that follow.

Considering the software-based solutions

Many people using computers today rely on some type of software-based solution to meet specific needs. One of the most famous of these solutions is a screen reader called Job Access With Speech (JAWS) (`https://tinyurl.com/nwjn8jmb`), which tells you about display content using sophisticated methods. As you might imagine, every technique that both data science and AI rely on to condition data, interpret it, and then provide a result likely occurs within the JAWS software, making it a good way for anyone to understand the capabilities and limits of software-based solutions. The best way for you to see how this works for you is to download and install the software, and then use it while blindfolded to perform specific tasks on your system. (Avoid anything that will terrify you, though, because you'll make mistakes.)

TIP

Accessibility software helps people who live with particular challenges perform incredible tasks. It can also help others understand what it would be like to maneuver through life with that specific challenge. A considerable number of such applications are available, but for one example, check out Vischeck at https://tinyurl.com/y6z7x8xs. This software lets you see graphics in the same way that people with specific color issues see them. (Note that the site may not work well with really large images or during times of high usage rates.) It's not that people with these conditions don't see color — in fact, they see it just fine. But a given color is simply shifted to a different color, so saying *color shifted* is likely a better term, and a term like *color blindness* doesn't apply.

Relying on hardware augmentation

Many kinds of human activity challenges require more than just software to address adequately. The "Considering the use of exoskeletons" section, earlier in this chapter, tells you about the various ways in which exoskeletons see use today in preventing injury, augmenting natural human capabilities, or addressing specific needs (such as enabling a person with paraplegia to walk). However, many other kinds of hardware augmentation address other needs, and the vast majority require some level of AI to work properly.

Consider, for example, the use of eye-gaze systems (https://eyegaze.com/). The early systems relied on a template mounted on top of the monitor. A person with quadriplegia could look at individual letters, and that action would be picked up by two cameras (one on each side of the monitor) and then typed into the computer. By typing commands this way, the person could perform basic tasks at the computer.

Some of the early eye-gaze systems connected to a robotic arm through the computer. The robotic arm could do extremely simple but important actions, such as help users get a drink or scratch their nose. Modern systems actually help connect a user's brain directly to the robotic arm, making it possible to perform tasks such as eating without help (see https://tinyurl.com/hyht79z9). In addition, even newer systems are doing things like restoring a person's sense of touch (https://tinyurl.com/ddfpkcze).

Seeing AI in prosthetics

You can find many examples of AI used in prosthetics. Yes, some passive examples exist, but most of the newer visions for prosthetics rely on dynamic approaches that require an AI to perform. One of the more amazing examples of AI-enabled prosthetics is the fully dynamic foot created by Hugh Herr (https://tinyurl.com/9v253u8c). This foot and ankle work so well that Hugh can perform tasks

such as rock climbing. You can see a presentation that he gave at TED; go to https://tinyurl.com/ffpy5ff9.

WARNING

A moral dilemma that we might have to consider sometime in the future (thankfully not today) is when prosthetics actually allow their wearers to substantially surpass native human capability. For example, in the movie *Eon Flux*, the character Sithandra has hands for feet (https://tinyurl.com/k3eun74x). The hands are essentially a kind of prosthetic grafted to someone who used to have normal feet. The question arises as to whether this kind of prosthetic implementation is valid, useful, or even desirable. At some point, a group of people will need to sit down and ascertain where prosthetic use should end to maintain humans as humans (assuming that we decide to remain human and not evolve into some next phase).

Completing Analysis in New Ways

Using AI in a manner that best suits its capabilities maximizes the potential for medical specialists to use it in a meaningful way. Data analysis is one area in which AI excels. In fact, entire websites are devoted to the role that AI plays in modern medicine, such as the one at https://tinyurl.com/amanphxc.

Merely taking a picture of a potential tumor site and then viewing the result might seem to be all that a specialist needs to make a great diagnosis. However, most techniques for acquiring the required snapshot rely on going through tissue that isn't part of the tumor site, thereby obscuring the output. In addition, a physician wants to obtain the best information possible when viewing the tumor in its smallest stages.

Not only does using AI to help perform the diagnosis assist in identifying tumors when they're small and with greater accuracy, it also speeds up the analysis process immensely. Time is critical when dealing with many diseases. According to https://tinyurl.com/35umyv6k, the speed increase is monumental and the cost small for using this new approach.

As impressive as the detection and speed capabilities of AI are in this area, what really makes a difference is the capability to combine AI in various ways to perform Internet of Things (IoT) data compilations. When the AI detects a condition in a particular patient, it can automatically check the patient's records and display the relevant information onscreen with the diagnosed scans, as shown in the article at https://tinyurl.com/b5p8sdsr. Now the doctor has every last piece of pertinent information for a patient before making a diagnosis and considering a particular path. (To see other amazing uses of AI in medicine, check out the site at https://tinyurl.com/275mztss.)

Relying on Telepresence

In the future, you may be able to call on a doctor to help with a problem and not even go to the hospital or clinic to do it. For that matter, you may be able to call on just about any other professional the same way. The use of telepresence in all sorts of fields will likely increase as the availability of professionals in specific areas decreases due to continuing specialization. The following sections discuss telepresence and describe how it relies largely on AI in some respects.

Defining telepresence

The term *telepresence* simply means to be in one place and seem as though you're in another. The ScienceDirect article at `https://tinyurl.com/xs2sb6sa` talks about how telepresence and augmented reality walk side by side to provide special kinds of experiences. While augmented or virtual reality exist essentially in artificial worlds, telepresence exists in the real world. For example, using telepresence, you might be able to see the Grand Canyon more or less directly without actually being there. The thing that separates telepresence from simply using a camera is that, through the use of sensors, a person experiences telepresence through their own senses. It's almost, but not quite, the same as being there in person.

If the person is also able to interact with the other environment, perhaps through a robotic-like device, many people call it *teleoperation.* A gray area exists in this case because it's hard to tell precisely where telepresence ends and teleoperation begins in many cases. However, the central idea in both cases is that it feels as though you're actually there.

Considering examples of telepresence

One of the most common uses of telepresence today is to reduce costs in hospitals in various ways. For example, a robot could monitor a patient in ways that monitoring equipment can't, and then alert either a nurse or a doctor to changes in a patient's condition that the robot isn't designed to handle (`https://tinyurl.com/ypzw52pt`). Telepresence means being able to monitor patients from essentially anywhere, especially in their homes, making nursing home stays less likely (`https://tinyurl.com/26tav7zv`). In addition, telepresence allows a patient to visit with family when such visits wouldn't be possible for any of a number of reasons.

Telepresence is also making an appearance in factories and office buildings (https://tinyurl.com/4xsnjjtt). A security guard is safer in a secured room than walking the rounds. Using a telepresence robot allows the guard to patrol the premises without getting tired. In addition, it's possible to fit a robot with special vision to see things that a human guard can't see.

Enforced use of telepresence will likely increase its use and provide an incentive to improve the technology. During the Covid-19 pandemic, many doctors also began to rely on telepresence to maintain contact with their patients as described in articles like "Teleconsultations during a pandemic" at https://tinyurl.com/macuta3e. The National Institutes of Health (NIH) also recommended using telepresence for patient-based teaching as described at https://tinyurl.com/4j9zeb6j. Isolation during the pandemic was also a problem for many people, especially the older population, as described in the article at https://tinyurl.com/ykvadwxb. All of these pandemic-enhanced uses of telepresence will likely make the technology more common and potentially reduce its cost due to economies of scale.


TIP

The capabilities of the telepresence device determine its usefulness. The site at https://tinyurl.com/y7sm2ytr shows that the robotic form comes in all sorts of sizes and shapes to meet just about every need.

Understanding telepresence limitations

The problem with telepresence is that humans can quickly become too comfortable using it. For example, many people criticize a doctor who used telepresence, instead of a personal visit, to deliver devastating news to a family (see https://tinyurl.com/3azcb7w8). In some cases, personalized human touch and interaction is an essential component of life.

Telepresence also can't replace human presence in some situations requiring senses that these devices can't currently offer. For example, if the task requires the sense of smell, telepresence can't support the need at all. Given how often sense of smell becomes an essential part of performing a task, even in a hospital, overreliance on telepresence can be a recipe for disaster. The article at https://tinyurl.com/w8pbvx78 provides some additional insights as to when telepresence may simply be a bad idea.

Devising New Surgical Techniques

Robots and AI routinely participate in surgical procedures today. In fact, some surgeries would be nearly impossible without the use of robots and AI. However, the history of using this technology isn't very lengthy. The first surgical robot, Arthrobot, made its appearance in 1983 (see https://tinyurl.com/48bshu29 for details). Even so, the use of these life-saving technologies has reduced errors, improved results, decreased healing time, and generally made surgery less expensive over the long run. The following sections describe the use of robots and AI in various aspects of surgery.

Making surgical suggestions

You can view the whole idea of surgical suggestions in many different ways. For example, an AI could analyze all the data about a patient and provide the surgeon with suggestions about the best approaches to take based on that individual patient's record. The surgeon could perform this task, but it would take longer and might be subject to errors that the AI won't make. The AI doesn't get tired or overlook things; it consistently views all the data available in the same way every time.

Unfortunately, even with an AI assistant, surprises still happen during surgery, which is where the next level of suggestion comes into play (https://tinyurl.com/dw3f5m4e). According to the article at https://tinyurl.com/2zpuhywm, doctors can now have access to a device that works along the same lines as Alexa, Siri, Google Home, and Cortana (the AI in devices you may actually have in your own home). No, the device won't take the doctor's request for music to play during the surgery, but the surgeon can use the device to locate specific bits of information without having to stop. This means that the patient receives the benefit of what amounts to a second opinion to handle unforeseen complications during a surgery. Mind you, the device isn't actually doing anything more than making already existing research, which was created by other doctors, readily available in response to surgeon requests; no real thinking is involved.

Getting ready for surgery also means analyzing all those scans that doctors insist on having. Speed is an advantage that AI has over a radiologist. Products such as Enlitic (https://www.enlitic.com/), a deep-learning technology, can analyze radiological scans in milliseconds — up to 10,000 times faster than a radiologist. In addition, the system is 50 percent better at classifying tumors and has a lower false-negative rate (0 percent versus 7 percent) than humans. Another product in this category, Arterys (https://arterys.com/), can perform a cardiac scan in 6 to 10 minutes, rather than the usual hour. Patients don't have to spend time holding their breath, either. Amazingly, this system obtains several dimensions of data: 3-D heart anatomy, blood-flow rate, and blood-flow direction, in this short time.

WORKING IN THIRD-WORLD COUNTRIES

Frequently, people perceive that none of the amazing technologies relied on by medical professionals today actually make it to third-world countries. Actually, though, some of these technologies, such as products from Caption Health (`https://captionhealth.com/`), are meant specifically for third-world countries. Doctors used the resulting technology in Africa to identify signs of Rheumatic Heart Disease (RHD) in Kenyan children. During a visit in September 2016, doctors used the Caption Health equipment to scan 1,200 children in four days and spotted 48 children with RHD or congenital heart disease. Without AI, the equipment couldn't exist; it would never be small or easy enough to operate for use in these environments because of a lack of consistent energy sources and economic means.

Assisting a surgeon

Most robotic help for surgeons today assists, rather than replaces, the surgeon. The first robot surgeon, the PUMA system, appeared in 1986. It performed an extremely delicate neurosurgical biopsy, which is a nonlaparoscopic type of surgery. Laparoscopic surgery is minimally invasive, with one or more small holes serving to provide access to an organ, such as a gall bladder, for removal or repair. The first robots weren't adept enough to perform this task.

By 2000, the da Vinci Surgical System provided the ability to perform robotic laparoscopic surgery using a 3-D optical system. The surgeon directs the robot's movements, but the robot performs the actual surgery. The surgeon watches a high-definition display during the surgery and can actually see the operation better than being in the room performing the task personally. The da Vinci System also uses smaller holes than a surgeon can, reducing the risk of infection.

The most important aspect of the da Vinci Surgical System, though, is that the setup augments the surgeon's native capabilities. For example, if the surgeon shakes a bit during part of the process, the da Vinci Surgical System removes the shake — similarly to how anti-shake features work with a camera. The system also smoothes out external vibrations. The system's setup also enables the surgeon to perform extremely fine movements — finer than a human can natively perform, thereby making the surgery far more precise than the surgeon could accomplish alone.

TECHNICAL STUFF

The da Vinci Surgical System is a complex and extremely flexible device. The FDA has approved it for both pediatric and adult surgeries of the following types:

- Urological surgeries
- General laparoscopic surgeries
- General noncardiovascular thoracoscopic surgeries
- Thoracoscopically assisted cardiotomy procedures

The point behind including all this medical jargon is that the da Vinci Surgical System can perform many tasks without involving a surgeon directly. At some point, robot surgeons will become more autonomous, keeping humans even farther away from the patient during surgery. In the future, no one will actually enter the clean room with the patient, thereby reducing the chances of infection to nearly zero. You can read more about the da Vinci Surgical System at `https://tinyurl.com/4h44vtyy`.

Replacing the surgeon with monitoring

In *Star Wars,* you see robotic surgeons patching up humans all the time. In fact, you might wonder whether any human doctors are available. Theoretically, robots could take over some types of surgery in the future, but the possibility is still a long way off. Robots would need to advance quite a bit from the industrial sort of applications that you find today. The robots of today are hardly autonomous and require human intervention for setups.

However, the art of surgery for robots is making advances. For example, the Smart Tissue Autonomous Robot (STAR) outperformed human surgeons when sewing a pig intestine, as described at `https://tinyurl.com/aezx65u3`. Doctors supervised STAR during the surgery, but the robot actually performed the task on its own, which is a huge step forward in robotic surgery. The video at `https://tinyurl.com/p3dswzyx` is quite informative about where surgery is going. You can see a more technical video at `https://tinyurl.com/3dr4xbkk`.

Performing Tasks Using Automation

AI is great at automation. It never deviates from the procedure, never gets tired, and never makes mistakes as long as the initial procedure is correct. Unlike humans, AI never needs a vacation or a break, or even an eight-hour day (not that many in the medical profession have that luxury, either). Consequently, the same

AI that interacts with a patient for breakfast will do so for lunch and dinner as well. So at the outset, AI has some significant advantages if viewed solely on the bases of consistency, accuracy, and longevity (see the sidebar "Bias, sympathy, and empathy" for areas in which AI falls short). The following sections discuss various ways in which AI can help with automation through better access to resources, such as data.

Working with medical records

One major way in which an AI helps in medicine is with medical records. In the past, everyone used paper records to store patient data. Each patient might also have a blackboard that medical personnel use to record information daily during a hospital stay. Various charts contain patient data, and the doctor might also have notes. Having all these sources of information in so many different places made it hard to keep track of the patient in any significant way. Using an AI, along with a computer database, helps make information accessible, consistent, and reliable. Products such as DeepMind, now part of Google Health (`https://tinyurl.com/yskwcm72` and `https://health.google/`) enable personnel to mine the patient's information to see patterns in data that aren't obvious.

Medicine is about a team approach, with many people of varying specialties working together. However, anyone who watches the process for a while soon realizes that the various specialists don't always communicate among themselves sufficiently because they're all quite busy treating patients. Products such as CloudMedX (`https://cloudmedxhealth.com`) take all the input from all the parties involved and perform risk analysis on it. The result is that the software can help locate potentially problematic areas that could reduce the likelihood of a good patient outcome. In other words, this product does some of the communicating that the various stakeholders would likely do if they weren't submerged in patient care.

Predicting the future

Some truly amazing predictive software based on medical records includes Autonomous Health, which uses algorithms to determine the likelihood of a patient's need for readmission to the hospital after a stay. By performing this task, hospital staff can review reasons for potential readmission and address them before the patient leaves the hospital, making readmission less likely. Along with this strategy, Zephyr Health (`https://tinyurl.com/3782d8rp`) helps doctors evaluate various therapies and choose those most likely to result in a positive outcome — again reducing the risk that a patient will require readmission to the hospital.

In some respects, your genetics form a map of what will happen to you in the future. Consequently, knowing about your genetics can increase your understanding of your strengths and weaknesses, helping you to live a better life. Deep Genomics (https://www.deepgenomics.com/) is discovering how mutations in your genetics affect you as a person. Mutations need not always produce a negative result; some mutations actually make people better, so knowing about mutations can be a positive experience, too. Check out the video at https://tinyurl.com/fjhs638b for more details.

Making procedures safer

Doctors need lots of data to make good decisions. However, with data being spread out all over the place, doctors who lack the ability to analyze that disparate data quickly often make imperfect decisions. To make procedures safer, a doctor needs not only access to the data but also some means of organizing and analyzing it in a manner reflecting the doctor's specialty. One such product is Oncora Medical (https://www.oncora.ai/), which collects and organizes medical records for radiation oncologists. As a result, these doctors can deliver the right amount of radiation to just the right locations to obtain a better result with a lower potential for unanticipated side effects.

Doctors also have trouble obtaining necessary information because the machines they use tend to be expensive and huge. An innovator named Jonathan Rothberg decided to change all that by using the Butterfly Network (https://www.butterflynetwork.com/). Imagine an iPhone-sized device that can perform both an MRI and an ultrasound. The picture on the website is nothing short of amazing.

Creating better medications

Everyone complains about the price of medications today. Yes, medications can do amazing things for people, but they cost so much that some people end up mortgaging homes to obtain them. Part of the problem is that testing takes a lot of time. Performing a tissue analysis to observe the effects of a new drug can take up to a year. Fortunately, products such as Strateos (https://strateos.com/) can greatly reduce the time required to obtain the same tissue analysis to as little as one day.

Of course, better still would be for the drug company to have a better idea of which drugs are likely to work and which aren't before investing any money in research. Atomwise (https://www.atomwise.com/) uses a huge database of molecular structures to perform analyses on which molecules will answer a particular need. In 2015, researchers used Atomwise to create medications that would make Ebola less likely to infect others. The analysis that would have taken human researchers

months or possibly years to perform took Atomwise just one day to complete. This scenario also played out in the Covid-19 pandemic (see https://tinyurl.com/ut2fh5fa).

Drug companies also produce a huge number of drugs. The reason for this impressive productivity, besides profitability, is that every person is just a little different. A drug that performs well and produces no side effects on one person might not perform well at all for another person, and could even do harm. Turbine (https://turbine.ai/) enables drug companies to perform drug simulations so that the drug companies can locate the drugs most likely to work with a particular person's body. Turbine's current emphasis is on cancer treatments, but it's easy to see how this same approach could work in many other areas.


TIP

Medications can take many forms. Some people think they come only in pill or shot form, yet your body produces a wide range of medications in the form of microbiomes. Your body actually contains ten times as many microbes as it does human cells, and many of these microbes are essential for life; you'd quickly die without them. Pendulum Therapeutics (https://pendulumlife.com/) is using a variety of methods, including machine learning and various forms of data science (https://tinyurl.com/387n554c), to make these microbiomes work better for you so that you don't necessarily need a pill or a shot to cure something.

Some companies have yet to realize their potential, but they're likely to do so eventually. One such company is Recursion Pharmaceuticals (https://www.recursion.com/), which employs automation to explore ways to solve new problems using known drugs, bioactive drugs, and pharmaceuticals that didn't previously make the grade. The company has had some success in helping to solve rare genetic diseases, and it has a goal of curing 100 diseases in the long term (obviously, an extremely high goal to reach).

Combining Robots and Medical Professionals

Semi-autonomous robots with limited capabilities are starting to become integrated into society. Japan has used these robots for a while now (see https://tinyurl.com/5x5u5va8). The robots are also appearing in America in the form of RUDY (see https://infrobotics.com/). In most cases, these robots can perform simple tasks, such as reminding people to take medications and playing simple games, without much in the way of intervention. However, when needed, a doctor or other medical professional can take control of the robot from a remote location and perform more advanced tasks through the robot. Using this approach means

that the person obtains instant help when necessary, reducing the potential for harm to the patient and keeping costs low.


REMEMBER

These sorts of robots are in their infancy now, but expect to see them improve with time. Although these robots are tools to assist medical personnel and can't actually replace a doctor or nurse for many specialized tasks, they do provide the constant surveillance that patients need, along with a comforting presence. In addition, the robots can reduce the need to hire humans to perform common, repetitive tasks (such as dispensing pills, providing reminders, and assisting with walking) that robots can perform quite well even now.