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Artificial Intelligence in Surgery: Dawn of New Era

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IMPORTANCE Artificial intelligence is rapidly reshaping science and healthcare. Approximately 37% of organizations have implemented some sub-entity of AI in their daily workings which include social networking, airplanes, robots, and deep learning computers and surgical science is no exclusion. This article aims to review and summarize major aspects of artificial intelligence (AI), along with its practical implementation, limitation, and potential in the field of surgery.

METHODS Published multidisciplinary literature search was conducted on artificial intelligence in medical science to recognize different techniques and prime concepts that are bringing about innovation across multiple industries, including surgery. Barriers and challenges of working with AI were also scrutinized.

RESULTS & DISCUSSION The major dimensions of AI include: (1) Machine learning, (2) reasoning, (3) problem solving, (4) perception, and (5) language. Their current role and future implementation in surgical practice were introduced including big data sets and systems that aid in medical decisions. Besides this, the duty of surgeons in promoting and facilitating this technology to optimize clinical effectiveness was also brought into consideration.

CONCLUSION AI carries the potential and aptitude to revolutionize the way surgery is being taught and practiced over the past years. The surgeons themselves are eager and well-positioned in integrating AI into modern practice, however, in order to attain this, they require the expertise of data scientists.

Keywords: artificial intelligence, surgeons, machine learning, reasoning, problem solving, perception, language, computer, machine, analysis, integration.

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Review Article

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By definition, "AI is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings[4]." It aims to develop a system endowed with the intellectual characteristics of humans such as reasoning, generalization, discovering meaning, or simply to learn from past experiences[5]. AI is significant mainly not only because it can give enterprises insights into their operation that they might have not known earlier, but also can complete the assigned task efficiently, with relatively few errors along with its ability to perform and analyze certain detailed tasks better than humans. We can practically see this with the help of a few examples like iRobot which uses AI to analyze, identify and remember efficient routes to keep the room clean, Hanson robot i.e Sophia an advanced robot that while using AI can communicate in natural language and can convey human-like emotions through facial expressions[6]. Another example can be seen in the form of a virtual nursing assistant which guarantees its availability throughout the day, guides patients about their problems and directs them to the best healthcare setting with which they can save a huge amount of money annually. These advancements demonstrate that although machines are notorious yet are not only accepted but are also in high demand. From incorporating machines into our day-to-day work to the consequent industrial revolution, machines and AI have played a massive role in improving the quality of life[2]. Therefore, surgeons should know the basics and impact of AI on the healthcare system and should consider possible ways in which they can interact with this technology.

DIMENSIONS IN AI

AI is a part of a lot of disciplines including philosophy, psychology, linguistics, statistics, robotics, maps, etc. Major advancements in computer science such as better speed and power led to the advent of AI and also contributed to

the growing popularity that helped it in venturing a capital investment worth $ 5 billion dollars in 2016[7].

The gist of AI, its subfields are discussed below:

A. Machine learning: Amongst the different forms of learning the simplest and commonest is learning by trial and error[2]. For instance, a computer tries a method, observes if it works in case it does not work, it tries a new method until a solution is reached. The program might then store the solution with the position so that the next time the computer encounters the same information it would recall the solution automatically. This basic act of memorizing individual items is known as "rote learning" which is relatively easier to implement on a computer[8]. With other AI applications machine learning has been enhanced to a supreme level that helps in solving major problems in no time.

B. Reasoning: It simply is to draw inferences that are apt according to the situation. Inferences can either be deductive or inductive[4,9]. An example of deductive reasoning is that "all spiders have eight legs. Since Tarantula is a spider, therefore, it has eight legs[10]." The example of inductive reasoning is "Mary and Jim are left-handed and use left-handed scissors since Bill is also lefthanded therefore he uses left-handed scissors as well[11]. These examples show that in the deductive case, the truth of premises guarantees the truth of the conclusion and is used in mathematics and logic whereas, inductive reasoning is a general conclusion from a set of specific observations[9].Therefore, inductive reasoning is more common in science where data is gathered, and tentative models are built[4].

These inferences have been a success, especially deductive reasoning; however, true reasoning is more complex than this as it involves drawing inferences relevant to the solution of the problem, which is a challenge in itself[4].

C. Problem-solving: Regarding AI, it systematically deals with a range of possible actions in order to reach a solution. It consists of two types a) special purpose and b) general purpose[5]. The special-purpose method deals with a distinct problem and frequently exploits specific features of the situation in which the problem is deep-rooted[4] e.g., in UBER that gives the user the nearest link to its driver. In contrast to this, general-purpose uses a technique that is applicable to a wide range of problems on the basis of signal input for example a robot that has the ability to move forward or backward[4].

D. Perception: In this, the environment is analyzed and interpreted with the help of various sensory organs, be it real or artificial. The analysis, however, is complicated by the fact that an object may appear differently depending on various factors like the angle from which it is viewed, and the intensity and direction of light present at the scene[4]. Machines in AI have different types of perception devices like cameras, mic etc. The camera assesses the object and a huge network of chipsets evaluates it and gives further commands according to the predefined dataset stored in its memory, for example, the self-driving mode in a car which assists in driving the car.

E. Language

It is a way of communication through vocals and signals both via which a person or robot can communicate with its surroundings. An important characteristic of human language is its productivity[4]. Similarly, a computer can communicate in innumerable ways like light signals, sound, written sentences, pictorials, etc. A developmental milestone in AI, SIRI can communicate with its user verbally on the basis of a vast datasheet and can fulfill the user's desires.

COLLABORATION OF AI WITH OTHER FIELDS

AI believes in combining its subfields with elements of computing such as database management and signal processing. The increasing popularity of AI in surgery due to synergy is parallel to that of other technological advancements for example mobile phones, fast computers, internet which have resulted from the use of hardware and software interchangeably[7]. BIXBY, a virtual assistant developed by Samsung electronics responds to its owner due to a combination of demesnes by means of various ways like pictures, songs, vocals, etc. Clinical application of this vast network led to the invention of various applications that helped dermatologists in diagnosing skin lesions with the help of memory stored in computers. Johns Hopkins University successfully developed STAR (smart tissue autonomous robot), which is programmed to perform bowel anastomosis in animal models[7]. Realistically, robotic surgery is out of scope for now, but with the progress and potential of AI, autonomous surgery is not far away from being practiced. Therefore, surgeons should engage in assessing the quality and applicability of AI advances to ensure minimal error in incorporating AI in the field of surgery.

Limitations of AI: As with any new technology, AI is subjected to unrealistic expectations from the media hype that can lead to utter disappointment and disillusionment

in the future[7]. As for now, AI depends upon the dataset stored in its program and cannot answer every query as expected by the media. Besides this, traditional procedures and methods can still outperform AI today in various ways as AI is not fully discovered and is a little too complicated to be understood[12]. The main factors responsible for its limitations are enlisted below:

1. Limited data set
2. Poor algorithms
3. Limited sources
4. Fear of AI
5. Automated clinical interpretation[2].

IMPLICATION FOR SURGEONS

There are a lot of possibilities and ways with which a surgeon can utilize AI in their clinical practice. Sound knowledge of AI by surgeons can lead to good decision-making and better pre-operative, per-operative, and postoperative outcomes with more accuracy[7]. Surgeons can be trained to perform surgery for specific commands prior to actual surgery by 3D surgery trainer applications, where a surgeon can program different scenarios that he/she may encounter while performing actual surgery. Moreover, automated analysis of clinical data can provide more patient-specific risk score assessments that can have better post-operative results. AI applications can also monitor patients at their homes after surgery, which is better as it is with them and is in the surgeon's diary the entire day. Nowadays, scientists are gathering videos of various surgeries to store in a dataset of AI, so that it can perform autonomous surgeries in the future[7]. Such collection of datasets can lead to evidence-based practice and can create disruptive innovation in the field of surgery.

The role of surgeon: Surgeons are uniquely positioned and are talented enough to help drive these innovations further rather than just passively wait for the technology to become useful on its own[4]. Surgeons should seek opportunities in building partnerships with data scientists so that they can collect data that is required for AI, for the incorporation of AI into their field[6]. This, however, is only possible if the complete record of the patient is kept and is included in the dataset of AI. Surgeons hold immense importance in guiding scientists about different sets of questions that are required to examine the patient, as this can aid in better decision making, hence, better outcomes. A collection of huge data, advanced technology, and automated assessment can help surgeons in treating patients efficiently. The collected data can create 'collective surgical consciousness' that can lead to real-time technology augmented clinical decision support regarding pre-operative, intra-operative, and postoperative complications.

CONCLUSION

The world is entering the dawn of AI, which is not only integrated into the business, telecom, and other fields but also assimilated into the fields of surgery and medicine. With expanding databases and sound knowledge, surgeons may have the power in the future to treat complicated cases that are currently untreatable. But, in order to reach such a stage surgeons should join hands with scientists to help them build a legacy that could be carried on in the future. This, however, is only possible with proper data recording and keeping along with encompassing AI into the server.

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