Review

New Horizons of Artificial Intelligence in Medicine and Surgery

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Abstract: Ideas about Artificial Intelligence appeared about half a century ago, but only now is it becoming an essential element of everyday life. The data provided is getting bigger and bigger and, in this case, we need artificial intelligence that helps us with superhuman powers. The interaction with medicine is getting closer and closer, medicine being a field that continues to be perfected. Machine learning, deep learning, neural networks, computer vision are some of the mechanisms that are already applied in medicine, becoming a trend in healthcare worldwide. Artificial intelligence will be the thing that will change contemporary medicine. Developed countries such as Japan, France, Germany have already implemented artificial intelligence in their medical systems. The help is in medical diagnosis, patient monitoring, personalized therapy, and workflow optimization. Artificial intelligence will help surgeons to perfect their skills, to standardize techniques, to choose the best surgical technique. The goal is to predict complications, reduce diagnostic time, diagnose complex pathologies, guide the surgeon intraoperatively and reduce medical errors. We are at the beginning but the potential is enormous.

Keywords: artificial intelligence; surgery; machine learning; healthcare

1. Introduction

Artificial intelligence is the capacity of a computer to imitate brain functions such as analysis, studying, planning and imagination. Some of the artificial intelligence technologies are over half a century old. The increasing digital power, the large amount of electronic information and new processing technologies have led to the advancement of artificial intelligence in recent times. Artificial intelligence has become a main component of the digital revolution of humanity and has become one of the basic priorities for the European Union [1]. Often considered by people to be a field of computer science, artificial intelligence has broad connections from arithmetic to information science, philosophy, biology, etc. Major changes will be brought by artificial intelligence applications, but even so it has entered our everyday life, without us feeling it. Artificial intelligence systems use techniques such as deep learning, machine learning, and rules. Machine learning algorithms bring electronic information to artificial intelligence systems by using statistical techniques to approve artificial intelligence systems to learn. Over automatic learning, artificial intelligence systems are becoming continuously more capable to give solutions, without having to be especially programmed to do it. The utility in medicine could be enormous if all physicians tried to interact with artificial intelligence and understood that this is the future.

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2. Discussion

Artificial Intelligence Includes Three Categories:

1. *Artificial narrow intelligence*, also called "weak artificial intelligence", is defined as the goal-oriented version. This kind of artificial intelligence is a reproduction of a human limited intelligence. Narrow artificial intelligence is fixed on achieving individual tasks, but is limited to specific cases. "Siri (from Apple), Alexa (from Amazon), Google Search" are illustrations of narrow artificial intelligence.
2. *Artificial general intelligence*, also named "powerful artificial intelligence". It represents a type of artificial intelligence that can understand and learn all tasks just as a human would do them. The way of thinking, examining and solving artificial intelligence does not differ from that of a being in some cases. Faced with an unfamiliar task, the artificial general intelligence system could find a solution.
3. *Artificial superintelligence* is considered the most advanced, powerful, and intelligent type of artificial intelligence. This is, in the hypothesis, at this level of intelligence, it not only performs and act like human nature but also becomes aware that it exists as an entity.

Artificial intelligence uses advanced algorithms to process information. It learns from data patterns or characteristics by combining large sets of information with appropriate algorithms. To understand how artificial intelligence actually works, its various subfields must be explained [2].

- Machine learning - train a machine how to decide on, by learning from past experiences. Their main idea is that systems can learn with minimal human involvement and make different decisions. Supervised learning and unsupervised learning are two of the most popular machine learning methods. "Supervised machine learning" is based on labelled input and output information, while "unsupervised learning processes" in based on unlabelled or untreated data.
- "Deep learning" - imitates the functioning of the intellect in processing information and builds different models to then use them in solutions choice. "Deep learning" is a subgroup of "machine learning" in artificial intelligence. It can learn unsupervised through networks, from random information, that has no structure. Deep learning is used in detecting volumetric bodies, understanding, converting sounds, translations and choosing solutions.
- "Neural networks" mimic human intelligence by containing a base of algorithms that try to recognize relationships in a data set. "Neural networks" resemble the connections between human brain cells - neurons having the same principles.
- "Natural language processing". It is a function through which a machine can read, understand and interpret a language. The computer understands what the user communicated and can respond accordingly.
- "Computer vision". Computer vision decomposes the image into thousands of parts and studies it in detail through certain visualization algorithms. Through this, the computer uses thousands of images making associations, learns and can give a result based on the accumulated experience.
- "Cognitive computing". "Cognitive computing algorithms" imitate intelligence, similar to a human being, analyze the environment, sounds, images and give an answer. Cognitive computing in theory is an equal interaction between man and machine [3].

The initiation of artificial intelligence hospital systems is one of the most crucial tendency in medicine worldwide. Artificial intelligence technology brings important changes to the healthcare, becoming a necessity that more and more hospitals will need. It is already used in the development of new drugs, improving the quality of healthcare services, reducing costs for these services.

The initial diagnostic application of an artificial intelligence algorithm was approved in 2018 by the "Food and Drug Administration" in the USA - a program that automatically analyzes fundus images to assist in screening for diabetic retinopathy [4].

The adoption of artificial intelligence in healthcare continues to grow with varied implications in pathological anatomy, imaging, cardiology and others, but it is important that medical personnel in every field interact with these technologies in order to provide safer, more cost-efficient and more productive medical care [5].

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Globally, there is a significant increase in the application of artificial intelligence in healthcare. Currently, some of the countries that are using Artificial Intelligence extensively in the medicine include the United States of America, China, Japan, the United Kingdom, Germany, and France. These countries have made significant progress in using artificial intelligence in a ample area of medical applications, such as medical data analysis, patient monitoring, medical diagnosis, personalized therapy and more. However, many other countries, including those in Central and Eastern Europe, are making efforts to implement artificial intelligence in their medical systems to increase the quality and performance of medical services [6].

In the first quarter of 2022, private firms invested billions of dollars in healthcare. A third of this amount was allocated to one of the most promising fields in medicine - the integration and development of artificial intelligence [7].

Some models of using artificial intelligence in medicine:

- Medical diagnosis: Artificial intelligence can help identify symptoms and formulate a diagnosis. Artificial intelligence technologies can be trained to recognize patterns and signs that indicate certain diseases, thus helping to make an accurate and rapid diagnosis.
- Patient monitoring: Artificial intelligence can be used to monitor the condition of patients and detect any changes in their health status. For example, in intensive care unit or cardiology.
- Personalized therapy: Artificial intelligence can be used to create personalized therapies for patients based on their genetic profile and medical history. This can help choose the best treatments for patients, reducing the risks of side effects and increasing therapeutic efficiency.
- Optimizing Workflow: Artificial intelligence can be used to optimize workflow in hospitals, reducing waiting time and increasing the efficiency of medical processes.

Artificial Intelligence in Surgery

Surgeons spend a lot of time in the operating room to perfect their skills, analyze and participate in thousands of operations to learn different techniques and apply them in everyday practice, but human capabilities are limited. In this case, artificial intelligence comes to their aid, which has the ability to absorb an enormous amount of information in some seconds. By learning from thousands of different surgeries, artificial intelligence can help choose the best surgical techniques, giving both surgeons and patients better experiences. This can lead to standardized techniques with better results [8].

The advantage of using artificial intelligence is to increase the diagnostics percentage of complex pathologies, reduce the risk of medical errors and decrease time to diagnosis, because what artificial intelligence does perfect is build a standardized assessment to take out personal subjective perception. Already due to his results that it presented, it was found that the technologies based on artificial intelligence will be more and more advanced in the following times [9].

Preoperative Risk Prediction

It is well known that with surgical intervention there are some risks. According to statistics, around 20% of operations have simpler or more complex complications [10]. The patient always wants to know what risks he is subject to before surgical intervention. Risk prediction would greatly help both the decision to operate and to predict possible postoperative complications for the benefit of the patient.

Over time, various risk calculators and decision algorithms have appeared. Most of them address and prognosticate the "risk of major cardiac events". It includes specimens like the "Revised Cardiac Risk Index (RCRI)" [11], "Perioperative Risk for Myocardial Infarction" or "Cardiac Arrest (MICA)" [12]. One of the most well-known risk calculators is the "American Society of Anesthesiologists score (ASA)". It is often used in intensive care units but it has a high degree of built-in subjectivity [13].

In 2013 the "American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP)" published a "risk calculator". They utilized data from 393 hospitals (1500000 subjects)

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to produce a "generalized linear mixed model to predict the risk of mortality and various complications". They obtained great results [14].

In the past, all "risk calculators" applied traditional linear and additive models. Once the development of artificial intelligence began to use machine learning techniques, such as random forests, for example. The University of Florida has created "MySurgeryRisc". Data from electronic medical records were used. After their app interacted and received feedback from doctors, it managed to learn and adjust continuously [15]. Another prospective, nonrandomized pilot study of twenty physicians correlated the helpfulness and preciseness of preoperative risk estimation between doctors and "MySurgeryRisk". It has been shown that "*implementation of a validated, MySurgeryRisk computational algorithm for real-time predictive analytics with data derived from the electronic health records to augment physicians' decision-making is feasible and accepted by physicians*" [16].

Researchers at Duke University developed the Pythia risk calculator by extracting and managing data from large local institutions using 3 machine learning methods: "logistic regression", "random forest models", and "extreme gradient boosted trees". The result was patterns with high prognostic performance. Patterns can be applied in daily work as a tool for identification of patients with high-risk, current assessment and treatment management [17].

Along with the evolution of artificial intelligence, prognostic scores have also evolved. In the future, doctors could use tools for objective, and more exact, prognosis of subject issues.

Diagnostics

One of the most important uses of artificial intelligence is the diagnosis of pathologies. Advances in imaging in recent years have provided so much data that only AI can process it.

An example would be the studies that tried to approach endoscopy for gastric cancer. Scientists have tried to apply artificial intelligence to aid in the endoscopic investigation of gastric malignancy, because about 10% of upper gastrointestinal tumors are not identified by endoscopic examinarions [18]. A convolutional neural network was applied to automatically recognize malign and benign zones under endoscopic exam with an efficiency of 86-92,5%. The role of artificial intelligence in the endoscopy of gastric malignancy is not only to find it, but also characterize it (ex: depth of wall invasion) [19–21].

Another study was performed on patients undergoing colorectal cancer screening or surveillance in eight centers (Italy, United Kingdom, United States of America). They underwent 2 consecutive colonoscopies on the same day, with or without artificial intelligence. 230 subjects were admitted in the study research. Artificial intelligence has achieved good results. The colorectal cancer omission rate has halved. This pleads for the benefit of artificial intelligence in reducing failures in identifying small, subtle lesions in standard colonoscopy [22].

A study from Japan tried to diminish unnecessary resection. Their model built with aid of artificial intelligence must identify T1 colorectal tumors at risk for metastasis to lymph nodes. A machine-learning artificial neural network was developed. They use information on subjects' age and sex, malignancy volume, affected area, histology type and grade, lymphatic and vascular invasion. The artificial neural network surpassed protocols in diagnosing subjects with T1 colorectal cancers with invasion in lymphatic nodes. This model can be helpful to identify subjects who require supplementary surgery after colonoscopic T1 resection [23].

Intraoperative Applications

Computer vision, a computer science discipline that utilizes artificial intelligence techniques such as deep learning to process and analyze visual data. Artificial intelligence, over computer vision, enables PC to understand viewable steps and connect with the us in real time [24]. With enough exercise and the adding in system of hundreds of surgical interventions, artificial intelligence can advise all along surgery. To acquire images, laparoscopic cases are used because of the ease with which images are obtained. In the beginning, a lot of work was done for the standard stages.

1. Recognition of the Surgical Phase

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Surgical phase (or stage) recognition is one of the most frequently investigated utilization of machine learning to intraoperative video analysis. The surgical interventions have their specific steps. The experience of surgeons can be utilized to train artificial intelligence and test the classification accuracy of neural networks [25].

2. Recognition of the Instrument

Surgical instrument recognition is another application. From the detection of the chosen instrument we can obtain indications on the surgical stage and an analysis of the complexity of the interventions.

3. Gestures and Error Recognition

The recognition of gestures and movements is a more complex phase that unites the other two previously mentioned. The deep learning tried to classify the participants according to the skills in 3 levels of professionalism (beginner, intermediate and expert). So artificial intelligence can be a good evaluator of professional surgical skills [26].

4. Recognition of Anatomical Landmarks

A recent addition to machine learning in intraoperative application is the capability to find surgical anatomy. Applying laparoscopic cholecystectomy procedures, Madani et al. try to find and train artificial intelligence models that can differentiate safe and unsafe areas of dissection and recognize anatomical landmarks in the time of laparoscopy (cholecystectomy). Artificial intelligence models were developed on "2627 random frames from 290 laparoscopic videos". They managed to demonstrate that technology can guide us in real time and reduce the risk of intraoperative errors. The efficiency of identifying the safe and unsafe areas was 0.94 and 0.95, respectively [27].

Currently, the American Society of Gastrointestinal and Endoscopic Surgeons is making great efforts to convoke an international accord on guidelines for video images collect for analysis with machine learning and computer vision. The future phases will introduce the development of live-surgery "decision support". As artificial intelligence accumulates more and more cases and intraoperative video images, it will have excellent surgical intelligence that will be able to assist any surgeon in any corner of the world with best surgical care.

5. Conclusions

We wished to show that artificial intelligence is already involved and will increasingly intervene in medicine and more precisely in the management of surgical cases. Artificial intelligence and its application is at the beginning of development, although important advances are being made by artificial intelligence. This theme is in a continuous exploration and progress. As with any new technology, critical evaluation of new studies, software, and equipment is necessary to adequately assess the impact on peoples care and surgical evaluation. However, in the present, the data on the potential applications of artificial intelligence in surgery has been promising. We think computers will not ever fully replace the physician or surgeon, but I can individually and collectively augment physician performance.

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