Artificial Intelligence and Applications in Medicine

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TITLE

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Abstract

The Artificial intelligence has many applications in the field of health. Its use can facilitate the daily bureaucratic interaction with the patient, the management of health data and medical records, but also the conduct of research based on medical data. The doctor, due to the huge amount of medical information at his disposal, has become increasingly imperative to use information systems with a symbolic role in the field of medicine.

Additional Keywords and Phrases: AI, Imaging, Expert System, Monitoring, Assistants, Medicine Ethics

Introduction

Artificial Intelligence is a branch of computer science, focused on the development of systems to perform tasks that normally require human intelligence. Today, artificial intelligence is one of the fastest growing branches of IT and computing with a potentially large impact on healthcare. Artificial intelligence systems and applications are based on so-called neural networks, which require large data sets (Big Data) to train the generated algorithms that will perform the requested tasks. Radiology plays a key role in the development of artificial intelligence algorithms, due to the availability of vast amounts of data from various diagnostic imaging modalities (e.g. X-ray, ultrasound, CT, MRI, etc.) that can be extracted and used to training of the relevant algorithms.

Thus, many AI-based applications have recently been developed and are being tested for their use and benefits in traditional radiology activities such as image interpretation.

The rapid expansion of artificial intelligence and its application in medical imaging, beyond current applications, is expected to lead to significant progress as it can improve work performance, help perform time-consuming and repetitive tasks, complete complex tasks, and support decision-making. However, in general, the perceptions and attitudes of medical imaging professionals regarding the introduction of this new technology, and how they see its introduction in their field, has been largely unexplored.

Benefits of artificial intelligence in medical imaging

Benefits of artificial intelligence in medical imaging and artificial intelligence systems are expected to have several benefits in medical imaging in the future. Although there is little empirical evidence, radiologists, hospital administrators and computer technology developers expect great added value from the development of artificial intelligence applications in clinical practice of more accurate and more objective diagnoses, avoiding errors and automating demanding tasks for radiologists and operational benefits such as reduced workload, time savings, consistent radiologist reporting and advanced service availability. Regarding the first category of benefits the primary driver behind the emergence of artificial intelligence in medical imaging has been the desire for greater efficiency and effectiveness in clinical care.

Both effectiveness and efficiency, but also the reduction of errors are key components of quality of care, which has been given increasing importance in recent decades.

The research presented suggests that in some cases artificial intelligence can lead to a reduction in errors, to the diagnosis of situations earlier than would be the case without the application of machine learning algorithms, to the diagnosis of situations in "difficult", i.e. inaccessible areas, etc. These results can undoubtedly contribute to the improvement of the quality of care, through early diagnosis and the application of treatment interventions in specific groups of patients.

Artificial intelligence and expert systems in medicine

According to Clancey and Shortliffe (1984), who summarized in a compendium the then current state of the art of applying artificial intelligence methods to problems in the field of medicine with an emphasis on diagnosis and treatment, they argue that Medical Artificial Intelligence (IT), is primarily concerned with the construction of AI programs that make diagnoses and recommend treatments.

Unlike medical applications based on other programming methods, such as statistical and probabilistic methods, medical AI programs are based on symbolic models (models) of disease entities and their relationship to patient factors and clinical implementations. Today, the importance of diagnosis as a goal that requires the support of IT in typical clinical situations, occupies the same position as other clinical goals.

The field of Informatics within IT, which has particularly contributed to Medicine in the last thirty years by assisting in monitoring, diagnosis, decision-making, as well as in the justification of proposals, is Expert Systems. Expert Systems (ES), together with Intelligent Agents, are today the preeminent commercial product of the IT sector [1].

They are programs which, in their attempt to deal with complex real-world problems, encode the knowledge and reasoning of a domain expert in a specialized field of science and technology. Consequently, an Expert System can be defined as a computer program, which refers to a specialized field of human knowledge and exhibits behavior analogous to that of a human expert in that field. An expert system is based on an extensive amount of knowledge, which is related to a specific problem area.

This knowledge is organized in the form of a set of rules, which allow the system to draw conclusions from the available data. This methodology, for solving problems, does not follow the conventional form of a program, Artificial Intelligence, Intelligent Agents and Applications in Health Informatics data and algorithms, but has an architecture that has as cores a knowledge base (Knowledge base) and an extraction engine inference engine.

If we want a more complete description of expert systems, we can use the definition given by the British Computer Society (The British Computer Society's Specialist Group on Expert Systems). An expert system is considered to be the integration into a computer of a knowledge-based component from the skill of an expert, in such a form that the system can offer intelligent advice or make an intelligent decision about some operation processing. An additional desirable feature, which many would consider fundamental, is the system's ability, upon demand, to justify its course of reasoning in a manner readily understandable to the questioner.

It is worth mentioning that expert systems belong to decision support systems. They are mainly used in the role of consultant (consultant, advisor), but also in the role of critic or tutor. All these roles involve a dialogue between the user and the system. Therefore, expert systems belong to dialogic systems. The quality of the interface between the system and the user is a critical factor. A domain expert and a knowledge engineer must work together to develop an expert system. The domain expert is specialized in an area of human activity, whose knowledge about that area will be transferred to the system.

A knowledge engineer is a computer scientist specializing in artificial intelligence and expert systems. The knowledge engineer collaborates with the expert in his field in order to make the most of his experience-knowledge.

Based on the results of this collaboration, he designs the system and the structure of knowledge and then follows its implementation. The field of artificial intelligence that deals with the development of expert systems is called knowledge engineering. The expert system solves problems using a model of the expert's logic and reaches the same conclusions that the expert would reach if faced with a similar problem. Expert systems exhibit behavior that we would characterize as intelligent, in specific domains and processes, analogous to that of a human expert in the same domain. The expert system fully emulates the inference ability of a human expert, i.e. acting in all respects like him, and not partially simulating. The integrated expert system is used by the end user.

Remote patient monitoring devices

In recent years, the technological development in IT has brought to the fore small-sized devices that work like sensors. These devices are attached to the patient's body and send signals to a host computer via wired or wireless networks.

The doctor can see the signals in real time or after an interval. As in the case of Telemedicine, this possibility concerns specialties such as cardiology and pulmonology. Today there are tiny defibrillators that are implanted in patients prone to developing ventricular tachycardia.

These devices sense the occurrence of arrhythmia and act in milliseconds, literally saving lives. The discovery of new sensors that capture signals from a person's biological activity will enable the use of such devices by other specialties as well. It is very likely that in the near future devices of small size, with low energy requirements, will be implemented which will record brain activity. Such small electroencephalographs will be able to be placed by neurologists rather than neurosurgeons and will be able to send signals from the brain's electrical activity to a central computer when it shows some qualitative change in its activity. These devices may be passive or active, actuating a drug infusion pump or other device to stimulate or suppress abnormal brain activity [2].

Also, researchers in New York are working on a new artificial intelligence program which they are feeding with hundreds of thousands of clinical notes and other data on actual patient cases such as blood draws, biopsies and doctor observations and other important applications in Medical science. This program is gradually being trained to read this huge amount of medical data. The goal of the researchers is to create computer models that will be able to analyze the course of each patient's disease, the relationship of his disease with other patients and its possible evolution in the future.

In addition to being fast, diagnoses with such systems are also accurate. In particular, artificial neural networks have shown that they are able to accurately detect certain diseases such as malignant melanoma.

Figure 1 Remote patient monitoring devices (via www.globalenterprise.com)

HEART ASSISTANTS

The latest developments in pacing mean that the pacemaker is incredibly tiny and can be implanted in the heart with a simple catheterization. This operation takes less than half an hour and the lifespan of the pacemaker is approximately 10 to 13 years. It is also just as easily removed for recharging.

There is no need to surgically create a space under the skin, as is currently done with the classic pacemaker, nor does it have electrodes that connect the pacemaker to the heart, thus avoiding the possibility of contamination of the surgical wound or the electrodes [3].

But the evolution of pacing continues. Research has been published in the journal Nature Biotechnology that portends an even more impressive future for pacing. Specifically, the biological-cellular pacemaker is prepared. It has to do with the creation of pacemaker cells, i.e. cells that can generate electric current by themselves.

ORGAN TRANSPLANTATION

Transplants are one of the most important medical achievements of the 20th century. Despite this, the lack of donor organs still remains a key issue internationally, with the result that the wait for a transplant often lasts months or even years. But thanks to the use of new technologies and the gradual progress of medicine, mainly in the field of regenerative medicine, promising prospects for the creation of organs appear. In this way, there will no longer be a wait for an organ transplant.

BONES

These are implants that replicate the simple structural work of skeletal tissue. For example, joints made of metal and plastic materials which are mainly used due to rheumatoid arthritis.

There is also the possibility to replace teeth, hips and even discs of the spinal column which are properly adjusted to fit the patient and be comfortable. A 3d printer is usually used to make the bones. As for the material, they are made of porous polymer, a material that is almost as strong as the real thing. Artificial bones are the most easy body parts to build, but not as perfect as natural ones.

DEPARTMENT OF NERVOUS SYSTEM

Parts of our nervous system can already be replaced by electronics. The cochlear implant, which is a specialized device that converts sound into electrical stimuli, is widely used. It is microsurgically placed on the side of the skull behind the ear. The electrodes of the implant are inserted into the cochlea where they stimulate the auditory nerve with electrical impulses.

It is activated through a small device, the speech processor, which is placed externally on the patient's head and is programmed for each person personally.

Therefore, the restoration of hearing with the cochlear implant is a medical and technological miracle. Another example is the bionic eyes that are slowly coming to market. It is a camera that receives images and immediately converts them into an electronic signal, which is transmitted wirelessly to a special microchip that is implanted behind the eyeball. The microchip's electrodes decipher the signal that will pass through the nerves to the brain, which can perceive certain patterns of light and shadow spots, depending on which electrodes have been stimulated [4].

These implants can help people with severe vision problems see normally. In order to improve them, however, it is necessary to gain a better understanding of how the brain works

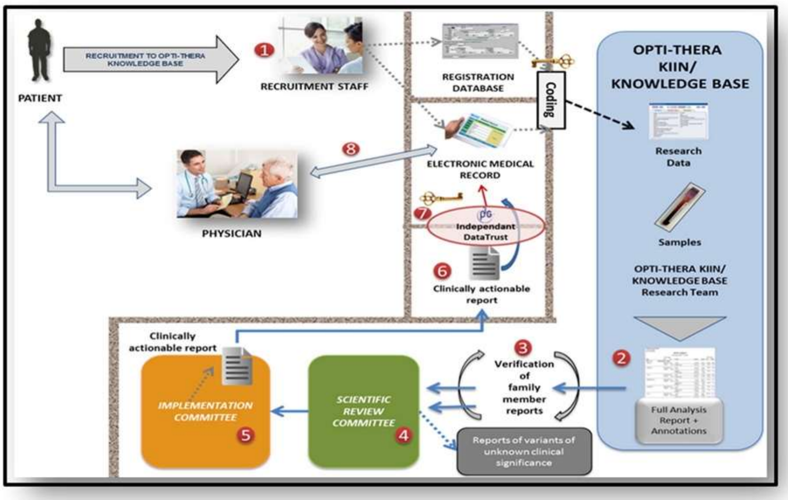

Figure 2: Full Analysis of Medicine Exams (via www.metabolism.com)

CELL REGENERATION

Thanks to stem cells, or more simply, by cultivating normal cells, it is possible to grow almost any type of tissue. In fact, scientists have managed to create complete organs from scratch. Nevertheless, the development of more complex organs with not so simple blood vessel systems is very difficult. Artificial organs such as artificially growing cysts have been able to change the lives of patients with scintiroids. In the past, a complete liver with blood vessels had been constructed but was not fully functional.

EXTREME

With the rapid development of technology, the replacement of the lower and upper extremities is mainly done by robotic replacements. Now there are hands and feet that look more and more like the real thing.

This shows that we are slowly entering the bionic age. Synthetic limbs that predict the movements of the person using them and look real are expected to be released soon. New technologies offer greater strength and flexibility to the user and artificial skin sensitive to the touch. In addition, researchers are preparing limbs that become one with the body, work perfectly with bones, tissues and the nervous system and are controlled by the brain. It is very possible that in the future those with extra limbs will be faster and stronger than able-bodied people thanks to the continuous improvement of technology.

In particular, the "defective" instruments will simply be replaced by new ones. One method for creating artificial organs, which is still in an experimental stage, is the 3D printing of living tissues, or bioprinting. An organ made from the patient's cells could also solve the problem of transplant rejection if it comes from another donor. The university's scientific team will start tests on it to print human cells with the ultimate goal of printing bones and skin. Another innovative action carried out thanks to a 3D printer is the creation of a copy of the matrix. Now known as synthetic matrices.

Artificial Intelligence framework of both Bioethics and Medical Ethics.

Despite the multiple benefits, the introduction of AI systems is accompanied by serious ethical issues. The state of urgency under which new technologies were used during the covid-19 pandemic, for example, raises ethical questions concerning individual and political liberties, equality and autonomy. Digital data from mobile phone apps, Bluetooth connections, social media, wearables, etc. were used to power smart systems and trace contacts of potential cases, monitor symptoms, monitor compliance with quarantine and model the flow of virus spread.

This may temporarily deprive citizens of their rights with no guarantee that they will be restored when normalcy returns. On the positive side, the speed of algorithmic decisions far exceeds the capabilities of the human brain and therefore allows the creation of systems capable of autonomous decision-making, such as diagnostic systems for diabetic retinopathy, which do not require human intervention. The possibility of using such systems promises greater accuracy in diagnosis, lower costs and improved patient access to health services.

AI systems are based on machine learning and neural network design: an initial set of "nodes" entries are connected to intermediate sets called hidden layers (they work like interconnected neurons in the brain), and each node is connected to a generated output. As the configurations become more and more advanced and the available data more, the algorithm breaks down into sub-steps (intelligible to humans) the intermediate steps, which would be practically impossible to trace, even by experts. In this sense, maximum accuracy makes transparency more difficult.

Furthermore, under current law, algorithms are only patentable if the steps they follow are part of a natural mechanism. This adds to the ambiguity, as creators and companies are reluctant to reveal details about the design of the algorithms, lest they be copied by potential competitors.

The overriding concern is that algorithms are designed by humans, who are prone to error and bound by personal values and inherent biases. Moreover, the existing patterns of inequalities, e.g. the limited access of minorities to health services permeates TN systems, and thus prejudices are entrenched. As a result, TN models may be disproportionately harmful because they will predict low response to treatments or higher mortality in groups that are not adequately represented in existing data. For example, part of the general population does not use smartphones or smart applications, which power IT systems.

The lack of transparency, especially in self-training machine learning models, also raises questions about who is to blame for a misdiagnosis. At the institutional level, the effects of machine learning algorithms on decision-making processes are becoming even more apparent. Consider the following scenario: when an algorithm turns out to be flawed and systematically suggests the wrong treatments due to poor methodology or a limited number of model training samples, the healthcare organization pushes to follow the system's recommendations, and the clinician is the one who ultimately has to decide, has responsibility the company that created the algorithm? In cases like this, each of the parties involved has contributed to the "medical malpractice", but none of them is fully responsible. Decisions based on poor models can mean the difference between life and death, e.g. determine who will have access to a ventilator. AI systems are not moral entities, so the new era in health services may require models of collective responsibility.

In the end, the introduction of AI in health services must be done with careful and judicious steps, and only after extensive discussion in the context of both Bioethics and Medical Ethics.

Conclusion

Artificial intelligence is one of the newest research fields. In the approach of artificial intelligence with the laws of thought, the emphasis was on the correct derivation of conclusions. In this way, it aims to study ideas that allow a computer to appear intelligent. Among the most important applications of artificial intelligence are intelligent agent systems. Intelligent agents have some additional features that make them stand out from simple programs and these are their characteristics such as autonomy, sociability, responsiveness and initiative. Intelligent agents have a large and growing class of applications to demonstrate as well as an intense research activity.

Artificial intelligence is revolutionizing human affairs and may become the most important innovation in human history.

With artificial intelligence and data analysis there is rapid development in many fields such as education, finance, national security, health sector has already benefited humanity by improving health as well as its applications in science.

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