Review

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Artificial Intelligence in Medicine

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Abstract

Artificial intelligence (AI) is the science of creating intelligent computer programs. The aim of AI is to help doctors in clinical diagnosis and treatment and to reduce the rate of medical error. The main AI methods used extensively are expert systems (ESs), fuzzy logic, genetic algorithm, and artificial neural networks (ANNs). ESs make inferences with patient data in cause and effect relationships and make recommendations to the doctor. Fuzzy systems aim to produce scientific expressions and approximate results from uncertain data such as those in the field of medicine. ANNs contain neurons that mimic the biological nervous systems. A network is obtained by connecting these neurons in various ways. AI methods continue to evolve even if medical field use has been tested many times. In the present study, a brief evaluation has been made regarding the methods mentioned.

Keywords: Artificial intelligence, expert systems, artificial neural networks, fuzzy logic

INTRODUCTION

Artificial intelligence (AI) was first used by John McCarthy in 1955. It was defined as "the science and engineering of making intelligent machinery." At the same time, in 1956, McCarty and colleagues organized a conference on AI in the United States to give rise to a new interdisciplinary field of research. Thus, an intellectual framework was established for all subsequent computer research and efforts (1).

Artificial intelligence is a computer science that deals with the design of intelligent computer systems. The Intelligent Computer System is a system that is comparable to the intelligence of human behavior. Similar systems of the thinking ability of humans can be established with AI. Its areas of application include robotic, expert systems (ESs), automatic translation programs, meaning analyzers for natural languages (e.g., understanding questions in certain areas and understanding text), natural language sentence production (e.g., abstract poetry writing, story writing, and making computer art/music), audio analyzers (e.g., recognizing certain words in a speech and determining the boundaries between sound units), game programs (e.g., chess and bridge), and theorems proving/problem solvers (2). Although significant progress has been made in the field of AI in recent years, the efforts of researchers to develop new inventions and programs are ongoing.

Expert Systems

Expert systems is the most important application area for AI. It is a computer program that aims to replicate the expertize of a specialist on a computer. A well-developed ES has the ability to imitate processes that can be performed by specialists, such as designing, planning, diagnosing, interpreting, summarizing, generalizing, controlling, and making recommendations (2). The data base and inference mechanism are the most important features that distinguish ES from other decision support systems (3).

Conventional Programs→Algorithm+Data Base

Expert Systems→Inference Mechanism+Data Base

Data base is the most central element of the ES. It contains all the information, data, rules, relationships, definition of problems, solutions, and information on how to proceed with the solution.

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It is organized by the knowledge engineer as a result of the interviews conducted by experts (4, 5).

Expert system's core includes an inference engine. It provides the analysis of data and rules stored in the data base. It communicates to the user and enables the solution to be achieved by providing reasoning to the system (5).

ESs in Medicine

Medical ES might be defined as the ES developed to provide structural questions and solutions in the fields of medicine. It is developed in accordance with the recommendations of one or more medical experts. Thus, it is ensured that accurate results are produced by taking into consideration the most appropriate questions. The goal of the medical ES is not to replace the physician but to provide advice to the physician based on the patient's data.

MYCIN is the first and most well-known medical ES developed for the diagnosis and treatment of bacterial infectious diseases at Stanford University (3). It also aimed to reduce the use of antibiotics. It takes patient data, laboratory results, and symptoms and makes diagnosis, prescribes, and performs treatment planning functions.

MYCIN is a computer program that informs the patient's physician about the diagnosis of meningitis and the diseases caused by bacteria in the blood. However, it provides the method of diagnosis and treatment to a specialist in that field only. It is the most well-known of the ES ever developed. Since most of the articles prepared on the ES focus on MYCIN, this ES has played an encouraging role in further studies in this area. The doctor who wants to use MYCIN at Stanford University hospital answers the questions asked by MYCIN. These questions include the patient's symptoms of discomfort, general information about the patient (e.g., age and gender), and analysis results. In the meantime, when MYCIN asks for information about a test whose results have not yet been obtained, the doctor is able to answer "not known yet" since MYCIN is able to continue to make decisions with incomplete information similar to a specialist. In conclusion, MYCIN reports the diagnosis and recommends the treatment method to the doctor (6-8).

The success of MYCIN in the treatment was compared with the experts and it was observed to be more successful. But despite all its features, it has never been used in practice due to ethical issues (for example, who would be responsible if an error was made).

ES Examples Used in the Medical Field (9)

Rule-based systems: MYCIN, the most well-known ES mentioned above, encodes its information in approximately 500 rules based on the IF-THEN structure. It consists of two parts: data base and inference engine. Data base contains data on the field of expertize, whereas inference engine is more general purpose. In other words, when the content of the data base is changed, the inference engine can still function. This distinction is called EMYCIN and allows the development of similarly structured data-based systems in other subject areas both within and outside of medicine. BLUEBOX and HEADMED can be presented as examples developed in the field of psychopharmacology, and PUFF in the field of pulmonary diseases. In addition, ONCOCIN is an example of MYCIN derivative systems that support oncologists.

Causal models: CASNET is prepared for the diagnosis of glaucoma eye disease. Diseases are defined as a network of causes and consequences. The system is performed close to a specialist physician.

Hypothesis-based systems: PIP has been developed for the diagnosis of edema, and ABEL for the regulation of acid-base and electrolyte balance.

Fuzzy ESs

Fuzzy ES helps to make logical solutions and inferences within the framework of fuzzy logic rules of fuzzy inputs and outputs in systems with insufficient data. Fuzzy sets and subsets are the basis of fuzzy reasoning. In a classical set theory, an entity is or is not an element of the cluster. If this state is expressed mathematically, "1" is the element of the cluster, and "0" is not the element of the cluster. Clusters in fuzzy reasoning are expanded forms of classical clusters. Each entity in the fuzzy entity cluster has a membership degree. The membership degree of entities can be any value ranging from 0 to 1. In other words, fuzzy logic is a logic system that uses the changing gray levels from the true-false dilemma in order to overcome the challenges occurring while working with indefinite data and results of the symbolic logic (10). Most concepts used in medicine are fuzzy. The fuzzy logic method is suitable for medical applications due to the imprecise nature of medical concepts and the relationships between these concepts. Indefinite medical conditions can be defined with fuzzy sets. Fuzzy logic proposes methods of generating solutions with approximate results.

Artificial Neural Networks

Artificial neural networks (ANNs) constitute direct, complex, and nonlinear models where the inputs, the independent variables of the system, are associated with the outputs, dependent variables of the system (11). ANN is powerful in computing and information processing. It derives this power from its parallel structure and its ability to learn and generalize. Generalization is the ability to generate appropriate responses to the inputs that the ANN has not encountered in the education or learning process. All these features show that the ANN is capable of solving complex problems. Neuron, the main process element of the ANN, is nonlinear. Therefore, ANN that is formed by the combined cells is also nonlinear, and this feature is spread over the whole network. With this feature, it has become the most important tool in the solution of these nonlinear complex problems (12). In addition, in many problems, it can make more accurate decisions than human specialists. However, when asked, it cannot provide clear responses as an ES does. Another problem of ANN is that it requires an expertize level of use. This situation has prevented the widespread use of ANN in medical practice (7).

CONCLUSION

Artificial intelligence has evolved over the years and has made significant progress in medicine. The fact that the AI does not overlook any details and does not forget any information, and that it will review all the possibilities makes it successful. Among these, although ES is preferred since it makes the cause and effect relationship clearer, more complex systems should be created by integrating ANN with fuzzy reasoning in order to overcome the deficiencies.

In addition, it is not possible to create an ES based on senses. For example, it is both difficult and relative to express the senses, such as taste and smell. The decision to eliminate all diagnostic and therapeutic decisions to the ES still remains unanswered as it brings the question of who will be responsible for the errors.

In the present study, it should be emphasized that the purpose of the use of AI in the medical field is not to replace the physician directly but to facilitate the diagnosis and treatment procedure for the physician. However, with the benefits and achievements of health care studies, it is inevitable that it will open a new era in medicine and shed light on more advanced diagnosis and treatment methods. Thus, it can be said that the target will be achieved more quickly in the diagnosis and treatment. Therefore, the cost will decrease.

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