

Multi-agent clinical decision support systems: A survey

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Abstract

Agent-based clinical decision support systems are important to the medical industry and they can be used to improve the healthcare quality in various ways. These systems assist doctors and nurses to make diagnosis, prognosis and treatment, gathering medical data, and remote monitoring the elderly or patient people at home. This paper reviews some existing applications of multi-agent clinical decision support systems in medical and clinical workflows and problems.

1. Introduction

Decision making in medical areas is vital most of the time and have always been accompanied by mistakes due to big data management problems, incomplete or low amount of data or lack of knowledge and experience in nurses and primary care physicians who are in charge of initial physical examinations [1]. Clinical decision making follows a complicated multi-stage process, that includes data collection, diagnosis, prognosis and treatment suggestion and planning [2]. Clinical decision support systems (CDSS) are typically designed to integrate a medical knowledge base, patient data and an inference engine to generate specific advice for decision making [3]. Recently, agent-based systems has been hailed as a new method for intelligent software systems. Multi-agent CDSSs allow doctors and nurses to gather sufficient information from distributed data sources in a short time and process the data in different ways in order to help with medical and clinical decisions and enhance the decision's accuracy. The areas these systems can help in is diverse from storing and retrieval of medical records and data management to patients history and X-Ray analysis for the purpose of diagnosis and gathering and examining real-time data from monitors. In this paper we survey existing research in multi-agent CDSSs to review current trends in this area and investigate the capability of multi-agent models to provide support for the clinical needs.

2. Basics of multi-agent CDSS

In this section we briefly explain agents, multi-agent models and how they are used in medical sector. Then we discuss clinical decision support systems and their general role in assisting clinicians.

2.1 Agents

The word agent has many definitions in intelligent systems but the more common definition is that an agent is a system that can autonomously interact with, perceive, and act upon the information it perceives from the environment

[4]. Therefore, some commonly used characteristics of an intelligent agent are reactivity, autonomy, learning, cooperation, reasoning, communication and mobility.

2.2 Multi-agent systems

Multi-agent system (MAS) is a loosely coupled network of agents that cooperate with each other to solve the problems that are beyond the individual capabilities or knowledge when there is no global control system. Therefore, to solve a specific problem, different agents have to focus on a different area or can only solve a specific part of a problem. In these systems, typically there is a core agent which is in contact with all other agents and coordinate agent activities.

2.3 CDSS

To improve health care, clinical decision support systems (CDSSs) support clinicians, staff, patients, or other individuals with knowledge and specific information or intelligence at appropriate times. The CDSS possibly will provide suggestions, but the clinician have to filter the information, review the suggestions, and decide whether to take action or what action to take.

3. Applications

Multi-agent systems has been widely integrated with DSSs to support medical and clinical decision making. Multi-agent CDSS (MA-CDSSs) can help in various areas which we are going to explain in this section.

3.1 Data repository management and data mining

One of the important applications of MA-CDSSs is to benefit non-specialist users providing easy access to clinical data. Having access to more data make the decision making process easier and more accurate. Therefore, to gather useful information, there are several steps that must be taken such as securely connecting a network of clinical centers and gathering distributed data [5,6], sharing data, data synthesis and pre-processing,

data mining [7,8], and feature extraction [9] which can be done by MA-CDSSs.

3.2 Diagnosis, prognosis and treatment

A specific type of CDSSs are diagnostic decision support systems (DDSS) which are developed to provide potential diagnosis, prognosis and treatment corresponding to given signs and symptoms. Applying multi-agent models in CDSSs, common decision making mistakes made by less experienced nurses in history and physical examination (H & P) processes [1], incomplete inputs, and primary care Physicians [10] can be eliminated. Moreover, in diagnosis of some sort of disease, that requires the combination of many different types of data including family and patient histories, laboratory results, imaging results and physical findings, such as Cardiac disorder [3,11] and variants of brain tumors [12,13], multi-agent CDSSs have shown to be successful. Moreover, machine learning has been integrated with MA-CDSSs in innovative ways. As an example in IMASC systems, a distributed CDSS has been proposed to assist physicians in diagnosing a certain disease by using supervised learning techniques [3].

3.3 Patient remote monitoring

A cornerstone technology in remote monitoring elderly and patient people is the decision support systems. These systems can generate risk detection decisions by gathering (e.x. via sensors which are attached to the patient), and analyzing data and finally sending the decisions to a remote monitoring center to take action when there is a real threat. There are various ways to use DSSs to improve the remote health care procedure such as encapsulating specific DSSs in intelligent agents that can exchange knowledge and intelligence, ALISA project, QuoVAD project [14], and AGALZ as an autonomous agent to guarantee that the Alzheimer patients assigned to the nurses are given the right care [15].

4. Conclusion

This paper has presented a survey of recent research on the multi-agent clinical decision support systems to support decision making in clinical and medical problems. Multi-agent CDSSs can assist in different ways such as data gathering, management and information retrieval, diagnosis and treatment, and patient remote monitoring. Researches on using these systems for diagnosis and treatment is more extensive and most of CDSSs are merely used to retrieve information and assist physicians and nurses to discover new patterns. In none of the previous researches attempts were made to reduce the decision making time but mostly attempt to increase the decision quality. In most of the papers, the researchers tries to give innovative ideas rather than investigating and assessing their efficiency which makes it difficult to compare different methods.

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