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REVIEW ARTICLE

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Artificial Intelligence Tools in Health Information Management

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Abstract

Application of ICT in health (eHealth) has become an integral part of modern healthcare systems. Electronic health information management has proven useful in improving quality of health care, reducing costs and facilitating health research. However, the increasing complexity of healthcare and the growing demand for high quality healthcare delivery has created a need for eHealth systems with the capability of anticipating the future need for information, delivering the information timely to patients and professionals, supporting communication, facilitating coordination and enhancing the performance of decision support systems. Agent-based systems, which operate by artificial intelligence, have shown great promise to meet these challenging needs and to realize the full potential of eHealth systems. In this paper we provide a brief review of application of agent-based systems in chronic disease care.

Keywords: Agent-based Systems, Tele-medicine, Health Information Management, eHealth

Review

Contemporary health challenges such as resource limitation [1], high costs of healthcare [2] and the need for real-time access to health information for fast diagnosis and treatment [3] have made the use of e-health and tele-health services mandatory [4-9]. Electronic health information management can lead to improved quality of healthcare, reduced costs of healthcare services and faster progress of health research and education [10]. In this context, application of artificial intelligence and agent paradigm can provide unparalleled advantages and opportunities. An agent is an autonomous software entity that uses artificial intelligence (AI) to choose the best set of actions for realizing the goal specified by the user. Agents are characterized by features such as 1) ability to react timely and flexibly to unexpected and dynamic changes in environment; 2) having autonomous and independent behavior in performing the assigned tasks; 3) ability to perform proactive actions to reach the specified goals; 4) being able to communicate with users or other agents; and 5) capability of reasoning, planning and learning which allow them to have intelligent behavior [11, 12]. These features have rendered agent technology one of the most productive areas of AI use with the promise of producing practical solutions to real problems. In the healthcare domain, AI and agent-based systems have found a wide variety of applications from improving decision support systems to facilitating tele-medicine and tele-care.

Table 1 summarizes the applications of agent-based systems in health information management.

Agents can improve the performance of computerized systems in terms of interoperability, coordinating distributed data (such as patient records held in different departments within a hospital or in several hospitals) and dynamic management of distributed data and resources. They are able to communicate among themselves in order to exchange any kind of information, facilitate remote care monitoring of elderly people, provide diagnosis decision-support, improve distant medical training and gather, compile and organize medical knowledge available on the Internet [11, 12, 20, 24, 29-32, 36-39].

Of particular and widely used kinds of agent-based systems

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Table 1 Agent-based electronic health systems in health information management

System	Region of use, Year	Usage	Architecture	Objective	Medical data management [a]	Planning and resource allocation	Data monitoring	Decision support system
SAPHIRE [13, 14]	Turkey co-financed by European Commissions start : 2006, Project duration: 30 months	Chronic diseases	(a) Agent factory, (b) EHR Agent, (c) Ontology Agent, (d) Guideline Agent, (e) Monitoring Agent, (f) Alarm Distribution Agent	Providing a clinical decision support system for remote monitoring of patients at their homes and hospital to decrease the workload of medical practitioners and also reduce healthcare costs.	y		y	y
MIA (Medical Information Agents) [15-19]	Netherland, 2004-2007	Chronic disease	(a) the department agent, which manages the resources of one department, (b) the treatment agent, which schedules the treatment of one patient and is also able to make appointments with department agents and exchange appointments with other treatment agents	(a) Automatic feedback to actions that are not in line with clinical practice guidelines, (b) Automatic retrieval of medical literature, and (c) Scheduling patient treatment	y	y		
Health Agents [20-23]	EU-funded research Project, 2006-2008	Brain tumor diagnosis and prognosis	Database agent, preprocessing agents, GUI interface agents, YP agents, classifier builder agents, classifier agents, petitioner agents, EbSS agents	(1) To create a network of elements that contributes to diagnosis of new cases of brain tumors, (2) To improve the classification of brain tumors through multi-agent decision support over a distributed network of local databases, (3) To develop new pattern recognition methods for a distributed classification and analysis of high-resolution magic angle spinning and DNA data, (4) To define a method to assess the quality and usability of a new candidate local database containing a set of new cases, based on a quality score (5) To compile, evaluate and use parameters to audit classifiers and improve them periodically.	y		y	y

Table 1 Agent-based electronic health systems in health information management *(continued)*

Palliasys [24,25]	Spain, 2004-2005	Palliative disease	Two main parts: ICT technologies, a multi agent system with 4 types of agents: the Data Base Wrapper, Doctor Agent, Patient Agent, Data Analyzer	To improve the management of clinical data of palliative patients- implement an alarm system from the collected data	y			y
K4Care [20, 26-28]	European project, 2006-2009	Elder people	Three main modules: the Knowledge Layer, the Data Abstraction Layer, the K4Care agent-based platform.	Knowledge Based Homecare e-Services for an Ageing Europe	y		y	y
M2DM Telemedicine Service [29,30]	European commission, 2002	Diabetes	Multi-access server architecture, common database management system (DBMS), multi-access organizer, communication server agent, application server agent	Merging of telemedicine with knowledge management	y		y	y
Integrated mobile information system(IMIS) [31-34]	Sweden BY VINNOVA, 2001-2002	Diabetes	Six databases: (1) for patients (2) for care providers (3) tools or instrument base (4) community network (5) laws, rules and norms applied in healthcare (6) labor division in healthcare	To integrate both healthcare providers and healthcare receivers into a web-based mobile platform in order to increase healthcare interoperability, integrity and mobility.	y	y	y	
Aingeru [35]	Spain 2004	Elder people	Five different types of components: user PDA, control centers, care centers, health centers, technical centers	Tele-assistance of elderly people by combining three technologies of intelligent software agents, semantic web ,web services	y		y	y

(MAS) in the healthcare area are multi-agent systems (MAS). A MAS is comprised of multiple agent-based systems that interact with each other to exchange information and solve difficult problems. Components of a MAS may be running in different machines, and can be physically located in many different geographical locations. Each agent is able to keep a specific part of knowledge that is required to solve the problem [37]. Multi agent systems have the potential to improve the health care system performance, where the main cause of errors are failures in communications [21]. Multi agent approaches apply in different fields in health care such as medical data management, decision support system, planning and resource allocation, tele-care, education, simulation, robotics, medical image processing, and bioinformatics [20].

As described in Table 1, in the area of chronic disease care, agent-based systems have proven exceptionally useful. For example, use of Integrated Mobile Information Systems (IMIS) for diabetic health care has demonstrated that agents can positively affect the quality of patient care. Based upon a coordination mechanism that allows for the agents to interact with each other, IMIS agents are capable of information sharing, organization coordination, and task delegation.

Another successful agent-based system for chronic disease care is M2DM. Knowledge agent in M2DM system combined different analytical approaches to monitoring diabetic data. The system has shown marked capabilities for identifying intensity of abnormality, providing users with the results of data analysis, providing real-time feedback to patients, allowing patients and physicians to predict future risky situations and prevent them [29-32, 39].

The ability of anticipating the events based on current information and proactively and autonomously interfering in the process make agent-based systems invaluable tools for improving patient safety and reducing medical errors.

Development of ICT in healthcare industry has provided costumers with easy and cost-effective access to information they need [13, 40]. Huge volume of information as well as the necessity of coordination and communication among health services professionals with different skills contribute to high complexity of health care environment [36]. This complex situation entails use of effective health information management systems that allow for appropriate data management and timely access to reliable information, and facilitated organization, storage, retrieval and dissemination of data [41]. Central to these capabilities is the use of agent-based systems; studies show that usage of intelligent agent-based systems in various areas of health is growing. [10, 24, 36, 42-44].

Conclusions

Dynamic health environments are dependent on speedy access to real-time health information and high interoperability among different providers with various skills. These requirements make the use of eHealth and information management system imperative for achieving high performance healthcare delivery. In this context, agent technology and artificial intelligence facilitate taking full advantage of eHealth systems. Agent-based systems can improve interoperability, maintain the autonomy of the collaborating participants, facilitate health information, provide expert knowledge management, and improve e-learning.

Authors' Contributions

The authors equally contributed to reviewing the literature and preparing the manuscript.

Competing Interests

The authors declare that there are no competing interests.

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