Expert Systems with Applications 42 (2015) 1825–1834

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Expert system for medicine diagnosis using software agents

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ARTICLE INFO

Article history:
Available online 25 October 2014

Keywords:
Software agents
Bayesian Network
Ontology

ABSTRACT

In order to simplify the information exchange within the medical diagnosis process, a collaborative software agents framework is presented. The human body systems (e.g. respiratory, cardiovascular) are embedded into distinct software agents. The holistic perspective is given by the all connected agents exchanging information. The purpose of the framework is to allow the automated information exchange between different medicine specialists. The key factor of the exchange is sharing concepts between the areas of expertise. Each human body system expert will act over his concepts (evidences, causes, effects), however the information from other systems will be assimilated as well. The framework has three key components: knowledge management, uncertainty reasoning and software agents. The ontology is chosen to address the management of human body systems knowledge. The Bayesian Network is the graphical model for probabilistic knowledge representation and reasoning about partial beliefs under uncertainty. The software agents, as collaboration framework, are in charge of the belief propagation between system instances.

1. Introduction

According to the United Nations (UN) Population Division, during the next 45 years, the number of persons in the world aged 60 years or older is expected to almost triple. This triggered the need for delivering better and more efficient healthcare services like fast and reliable medical diagnosis and eHealth system.

Most of the health problems are caused by the combination of diverse factors (e.g. environment, genetic, lifestyle). These can affect different systems of the human body (e.g. respiratory, cardiovascular, digestive), thus a complex diagnosis is required. This process involves different healthcare professionals that need to share patient information.

In order to simplify the information exchange and to reduce the complexity within the medical diagnosis process, a collaborative software agents framework is proposed. Each human body system specialist has an assistant software agent facilitating the communication of patient diagnosis data and automatic update of his domain with other related external system information, see Fig. 1. Each assistant agent has a dependants external systems list given by the provisioned knowledge in the database. After an internal evidence update (the doctor set the evidences gathered after his diagnosis) the assistant agent dispatches information to this list of agents. This information represents the belief of an entity shared between at least two systems (e.g. smoking entity is part of both respiratory and cardiovascular systems). If no dispatch operations occur anymore between agents the diagnosis process terminates, the systems having entities with belief values above a threshold value will labeled as awareness during diagnosis result.

2. Related work

Some of the researches in this direction has been summarized as follows:

- Bayesian Network (BN) decision model for supporting diagnosis of dementia, AD and Mild Cognitive Impairment (MCI) (Seixasa, Zadroznyb, Laksc, Concia, & Saadea, 2014); the network structure was built based on current diagnostic criteria and input from physicians domain experts; the network parameters were estimated using a supervised learning algorithm from a dataset of real clinical cases.
- Workflow-based Clinical Decision Support System (El-Fakdia, Gameroa, Melndeza, Auffretb, & Haigronc, 2014) designed to give case-specific assessment to clinicians during complex surgery or Minimally Invasive Surgery; the software will use a Case-Based Reasoning methodology during the perioperative workflow to retrieve similar past cases from a case base to provide support; the graphical user interface allows easy

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http://dx.doi.org/10.1016/j.eswa.2014.10.026
0957-4174/

navigation through the whole support progress, from the initial configuration steps to the final results organized as sets of experiments easily visualized in a user-friendly way.

- Microaneurysm segmentation based on a multi-agent system model (Pereiraa et al., 2014).
- Ontology driven decision support method as an automated procedure for diagnosing Mild Cognitive Impairment (MCI) through Magnetic Resonance Imaging (MRI) (Zhanga, Hub, Maa, Moorec, & Chena, 2014); specialized MRI knowledge is encoded into an ontology and construct a rule set using machine learning algorithms, both are applied to automatically distinguish MCI patients from normal controls (NC).
- Web-based Decision Support System driven by Fuzzy Logic for the diagnosis of Typhoid Fever (Samuel, Omisore, & Ojokoh, 2013).
- Web-based expert system for nutrition diagnosis (Chena, Hsua, Liua, & Yangb, 2012) by utilizing the expert system techniques in Artificial Intelligence. The research implements Nutritional Care Process and Model and integrate the nutrition diagnosis knowledge from dietetics professionals to establish the basics of building the rule-based expert system with its knowledge base (KB); KB contains the nutrition diagnosis rules which can be updated or added by a knowledge engineer; the program will make inference to the rule base and make nutrition diagnosis after dietetics professionals enter patients basic data.
- Home care (Batet, Martínez, Valls, & Gibert, 2009), the particular case of home care studied and developed in the EU K4Care project, is presented. The automatic customization of an agent-based medical system is approached by means of ontologies. The customization is achieved by means of generating individual versions of a reference ontology, called Actor Profile Ontology, which defines the behaviour of the actors in the multiagent system. The main goal of the project is to develop an intelligent web platform for providing e-services to health professionals, patients and citizens involved with the care of elderly patients living at home.
- The Ontology-based Holonic Diagnostic System (OHDS) (Ulieru, Hadzic, & Chang, 2006), sets up on knowledge discovery from ontologies, such as medical issues, health matters, disease factors, DNA etc and knows who is doing a particular type of research, what work has been done and which research group has the most up-to-date results, which database on the web is needed, what is in it, what is the value of the information in that database, where it fits into the specific disease knowledge and how to access it, whose work is related to each other, overlapping with or complementary to each other.
- DITIS (Pitsillides et al., 2006), is a system that supports dynamic Virtual Collaborative Medical Teams dealing with the home-healthcare. It supports the dynamic creation, management and co-ordination of virtual medical teams, for the continuous treatment of the patient at home. DITIS provides a distributed web based database with direct wireless connectivity and mobile agents linking all members of the virtual medical team.
- Multiagent system Generic Human Disease Ontology based (GHDO) (Hadzic & Chang, 2005), GHDO was created by merging and aligning existing medical ontologies. The concepts of the GHDO are organized into the following four dimensions: Types, Symptoms, Causes and Treatments of human diseases. The multiagent system uses the common GHDO ontology for query formulation, information retrieval and information integration. The aim was to develop a methodology to access, extract and manipulate information from various information resources.
- Agent Cities (Chair, Moreno, & Nealon, 2002), is a multiagent system composed of agents that provide medical services. This contains agents that allow the user to search for medical centers satisfying a given set of requirements, to access his/her medical record or to make a booking to be visited by a particular kind of doctor.
- Holonic Diagnosis System for e-Health applications (Ulieru, 2003), is a synergy of Soft Computing – Internet – Multi Agent Systems in developing technologies for remote diagnosis, prediction and ubiquitous healthcare. A medical holarchy is a

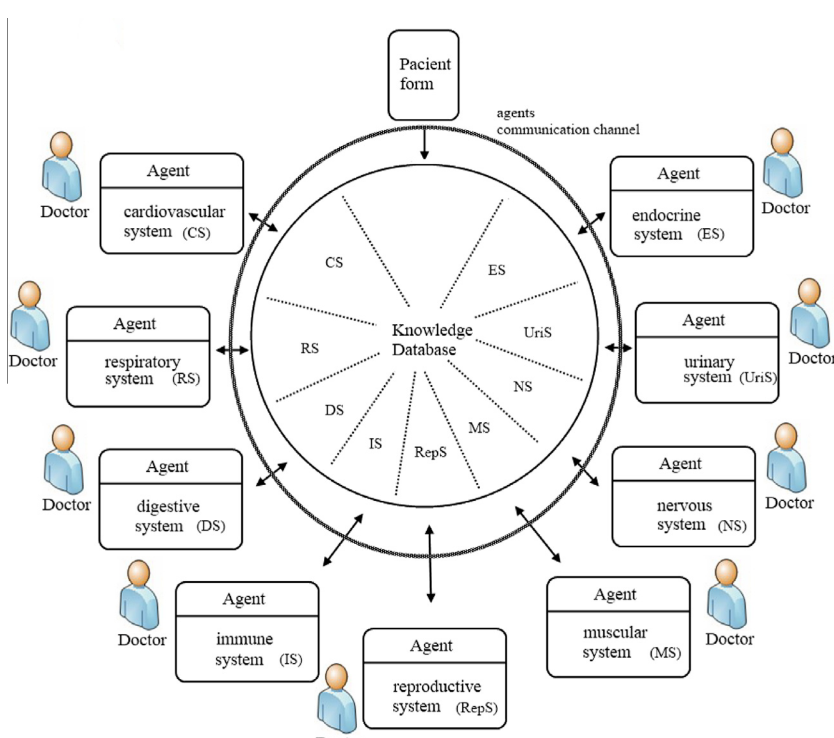

Fig. 1. Framework high level view.