Applying Agent and Multi-agent to Medical Field

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Abstract

The adoption of agent technologies and multi-agent constitutes an emerging area in bioinformatics. Artificial Intelligence and knowledge based systems are assuming an increasingly important role in medicine for assisting clinical staff in making decision. Multi-agent based medical diagnosis systems may improve the efficiency of traditionally developed medical computational systems like medical expert system. In this paper, multi-agent based medical diagnosis system is proposed. Naïve Bayes Classification is used for selecting the best service provider Agent in order to solve the problem effectively.

1. Introduction

Artificial intelligence and knowledge based system are assuming an increasing important role in medicine for assisting clinical staff in making decision under uncertainty (e.g. Diagnosis decisions, therapy and test selection). Furthermore, many medical procedures involve several individuals, in a number of specialist departments, whose decisions and actions need to be coordinated if the healthcare is to be effective and efficient. For example, a general practitioner (GP) may suspect that his patient has cancer. However, as he neither has the knowledge nor the resources to confirm this hypothesis, he must refer the patient to a hospital specialist who can make a firm diagnosis and he needs to consult with specialist. Having confirmed the presence of cancer, the specialist must devise a care program for treating the patient. This typically involves hospital nurses, the patient's GP, and home care organization jointly executing a series of interrelated tasks. To provide the appropriate software support for such coordinated health care management it was decide to adopt an agent-based approach.

The motivation of the use of agents for different medical problem solving consists in properties of the agents such as: increased autonomy in operation, capability of communication, autonomous learning capability and capability to interact with the environment. These properties allow to the agents to coordinate with other agents and human during different problem solving. Multiple agents cooperate with each other in order to speed up computation, to complement each other's capabilities, to share each other's knowledge and to improve the efficiency of information services.

2. Agents and Multi-agent Systems

Agent can be considered as a distinct kind of software abstraction, in the same way that methods, functions and objects are software abstractions. More specially, an agent is a high-level software abstraction that provides a convenient and powerful way to describe a complex software entity in terms of its behavior within a contextual computational environment. It differs from an object in the capability to control its own state. The notions of agents are reactive, proactive, autonomous and interact with other such entities. These properties allow to the agents to coordinate with other agents and human during different problem solving. In multi-agent systems, multiple agents interact in some overarching system architecture. Multiple agents coordinate with each other in order to speed up computation, to complement each other's capabilities, to share each other's knowledge and to improve the efficiency of information services.

3. Agents in Bioinformatics

Agent technology deals with entities typically equipped with information management and coordination capabilities. The notion of agents in bioinformatics suggests the support of integration of information by designing domain-aware information agents for knowledge management and problem-solving within a biological domain. The use of agents in computational and system biology suggest the design of agent-based systems, tools and language for modeling the biological processes themselves [3].

It is often not clear if a gene is expressed o differentially expressed. It is even more difficult to determine if an observed change is relevant for a disease. Humans are not good in ranking these findings, particularly not for complex diseases, with

many contributing factors. Feng Gu, Uwe Aickelin, Julie Greensmith [4] discussed Agent-based classification model that to access the UCI Wisconsin Breast Cancer data-set and classify the data items into two categories, which are normal and anomalous. GeneWeaver [2] is a multi-agent system aimed at addressing concerns with the management of data and analysis methods for bioinformatics. This was targeted at genome annotation.

An agent is a software entity that applies Artificial Intelligence techniques to choose the best set of actions to perform in order to reach a goal specified by the user. They have many properties to perform tasks. Multi-agent system might be defined as a collection of autonomous agents that can communicate with each other and coordinate their activities in order to solve the problem that could not be tackled by any agent individually [15].

There is a growing interest in the application of agent-based techniques to problems in the medical domain. Some of the fields in which they are already being applied are Patient Scheduling, Organ and tissue transplant management, Community care, Information access, Information sharing, Decision support, Training , Internal hospital tasks and so on.

In medical field, agent and multi-agent system can be endowed with medical knowledge. A medical diagnosis problem represents the identification of a patient's illness. Many medical diagnosis systems must have specific properties, depending on the types of the medical problems that they must be solved.

4. Related Works

John Fox, Jun Huang and N.R. Jennings [11] described the design and implementation of a layered architecture for decision support applications in general and for distributed medical care in particular. A prototype system has been developed for other specific application of distributed management of cancer patients among general practitioner, hospitals, home care organizations and pharmacies.

Barna Laszlo Iantovics [8] proposed the development of a medical diagnosis system capable of solving difficult diagnosis problems. The medical diagnosis system is a heterogeneous system with human and artificial agents members specialized in medical diagnosis and assistant agents. The proposed diagnosis system can solve difficult medical diagnosis problems that cannot be solved by doctors or artificial systems specialized in medical diagnoses that operate in isolation. The problem solving by the diagnosis system is partially based on the blackboard-based problem solving.

Barna Iantovice [10] described a novel cooperative hybrid medical diagnosis multi-agent system called CMDS. The cooperative problem solving by the proposed system combines the physicians and artificial agents' advantages in the medical diagnosis elaborations, by using the medical knowledge that are distributed between the members of the system. Medical multi-agent system called MASM [6, 7] is proposed by Barna Laszlo Iantovics and that can help physician in their work. This system is complex but increase the accuracy. The system cannot describe the classification method used to classify the diseases. Iantovics Bl also presented ICMA "Intelligent cooperative mobile Agent Architecture" in [9]. The proposed mobile agent architecture allows the creation of mobile agents, which can solve intelligently difficult problem like medical diagnosis problems in insecure network. Advantages of ICMA mobile agents are versus some of the communication capability, protection possibility and intelligence.

The integration of intelligent agents in a multi-agent architecture that supports the provision of telemedicine services for the intelligent management of diabetes mellitus is described by A. Garcia, Enrique J. Gomez, M.Elena Hernando, F.Javier Perdices, Francisco del Pozo and V. Torralba [1]. The combination of different methods to analyze blood glucose monitoring data and insulin data makes possible to extract relevant information about the patient metabolic state under different situations of data completeness. The result of the statistic and the rule-based analysis can be presented to users in a very intuitive way. But it can lead to errors under a situation of missing data.

5. Multi-agent based Medical Diagnostic

The power of the agent technology comes from the coordination and cooperation among the agents. The solutions fall into one of the two broad categories: the broadcasting based solutions and the middle agent based solutions. The Contract Net protocol (Reid G. Smith (1980)) [16] is an example of the broadcasting based solutions. The middle agent based approach is very flexible and is suitable for small and large agent systems alike. Three types of middle agents are identified [5], namely the matchmakers, the brokers, and the mediators. A matchmaker serves the role similar to that of the yellow page. A broker agent works in a different way. When it receives a request from the service consumer agent, it finds a (ideally the best) service provider to execute the task(s), and then returns the results of the execution back to the service consumer agent. A mediator works in a way similar to the

broker but it does more. Most of today's middle agents perform service matching only based on service descriptions. As a result, the agents that are most appropriate for the given request may be discovered and selected. There is actually a third type of solutions, the blackboard-based solutions Xiaocheng Luan [17].

The proposed system for multi-agent based medical diagnosis system is shown in figure1. It is built by using Vertical architecture. This system also built on middle agent architecture. There are some steps to develop the multi-agent based medical diagnosis system. First, need to identify the agent's roles. Secondly, need to identify the responsibilities and services for each role. Thirdly, need to determine the goal and plan to achieve the goals. We define initial agent to interact with the user, coordinator agent to send the problem to desired agent and to perform some interactions between the lower level agents and top agent and assistant agents to perform diagnosing the problem. In proposed system coordinator agent uses Naive Bayes classification method for classifying the general problem. Then it will match the result of the classification and service or capabilities of the assistant agents in the system and sends the problem to one of the assistant agents.

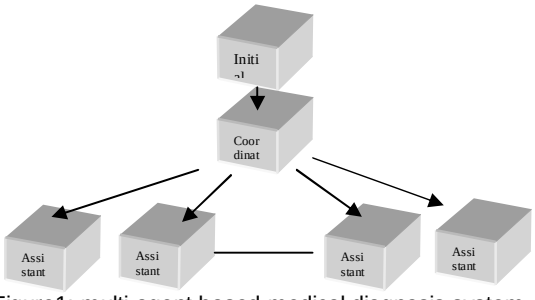

Figure1: multi-agent based medical diagnosis system

5.1. Naive Bayes classifier

A naive Bayes classifier is a term in BayesiIsan statistics dealing with a simple probabilistic classifier based on applying Bayes' theorem with strong (naive) independence assumptions. A more descriptive term for the underlying probability model would be "independent feature model". In simple terms, a naive Bayes classifier assumes that the presence (or absence) of a particular feature of a class is unrelated to the presence (or absence) of any other feature. In paper [13] discussed the Simple Bayesian Classifier The main purpose of this paper was to show how the Simple Bayesian Classifier (SBC) actually works and how it performs in practical situations. Some test results *were* discussed in detail. By using Naïve Bayes classification method for classifying, it will improve the performance of the total multi-agent system.

5.2. Components of multi-agent based medical diagnosis system

5.2.1. Initial Agent. Initial agent is an agent to accept the problem and initiate the processing and send this problem to the coordinator agent to solve. The user only needs to interact with initial agent which is a member of the system.

5.2.2 Coordinator Agent. It is likely to the broker agent or middle agent. When it receives the problem, it will identify the problem by using Naive Bayes method based on its own general knowledge of the problem. Identifying the problem in advance and sending to a certain agent can save time. Then it will match the required service that is result from the Naive Bayes and the agent's service and then sends the problem to the desired agent. The coordinator agent will send back the result to the initial agent whatever the result value is. The capability of the coordinator agent is the essential part of the proposed system.

5.2.2.1. Coordination Algorithm for CO. The coordinator agent performs as broker agent or middle agent. It has some knowledge about the problem and some the capabilities or services of the assistant agents in the system. In the following algorithm for coordinator agent is shown.

```
{
   ACLMessage msg=new (ACLMessage.Inform);
   If(checkcase()==1)          //type one disease
  {
                msg.addReceiver(newaAID("Ag1",AID.ISLOCALNAME));
                msg.setlanguage("English");
                msg.setcontent("Dataset");
                send(msg);
  }
  If(checkcase()==2)                    //type two disease
  {
                msg.addReceiver(newaAID("Ag2",AID.ISLOCALNAME));
                msg.setlanguage("English");
                msg.setcontent("Dataset");
                send(msg);
  }
  If(checkcase()==3)                    //type three disease
  {
                msg.addReceiver(newaAID("Ag3",AID.ISLOCALNAME));
                msg.setlanguage("English");
                msg.setcontent("Dataset");
                send(msg);
  }
  Else
  {
                for all Agi ε AG //composite agents
                msg.addReceiver(newaAID("Agi",AID.ISLOCALNAME));
                msg.setlanguage("English");
                msg.setcontent("Dataset");
                send(msg);
  }
}
```

5.2.3 Assistant Agents. They actually process the problem. They have own knowledge to process the certain problem. They use Naive Bayes classification

and are trained with training datasets. If one of the assistant agents can solve the problem, processes itself and sends the result to the middle agent. If none of the assistant agents can solve the problem, the result of the problem may be NULL.

To implement operational behavior among agents, it is needed to implement interactions among agents. Coordination between multiple agents is the art of managing interaction and dependencies of activities. To communicate agent with each other, special language is needed. Agent Communication Language let heterogeneous agents to communicate with each other.

6. Analysis of the proposed system

The proposed system will process the desired problem faster than the traditional multi agent based system. Each agent has different knowledge and they will perform the processing with their own knowledge. In our proposed system, the coordinator agent will use Naive Bayes classification method using the knowledge about the problem and agents' capabilities in the system for sending the problem to a certain subordinate assistant agent (AG). If the agent can solve the problem, it will return the solution to the coordinator agent. If not, the result will be NULL.

In traditional multi agent based system, the coordinator agent sends the problem to one of the agents. If that agent can solve the problem with its own knowledge, it will return the solution to the coordinator agent. If not, it will send the problem to other same level agent. This process may continue until no other agent found. Therefore, this may be time consuming if the problem is not solved immediately.

The theoretical time complexity for learning of Naive Bayes is O(ni), where n is the number of features and i is the number of instances and the time complexity for classifying of Naïve Bayes is O(nc), where n is the no. of features and c is the no. of classes. If the proposed system is used in medical diagnosis such as classification of cancer using Bayesian classifier, time complexity difference between proposed system and traditional multi agent based system will exist as before. Time complexity using Bayesian classification in multi-agent system for cancer classification is shown in figure 2.

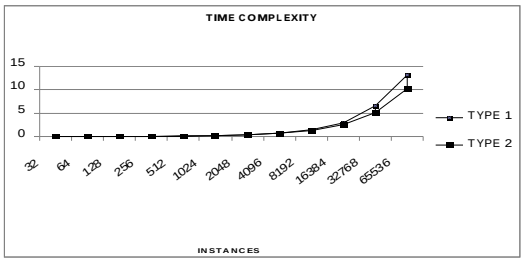

Figure2: Time complexity for proposed system and traditional system

7. Conclusion

Solving the medical diagnosis problem is a complex task that may require the cooperation of more than one physician or expert system. For solving the problem, multi-agent architecture is appropriate for medical diagnosis system. Agents can perform the activity effectively in isolation or coordination. This paper proposes the system for multi-agent based medical diagnosis system. The proposed system uses Naive Bayes classification method for classifying the general problem and for classifying the cancer. The proposed system is simple to use .

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