

OphthoABM-An Intelligent Agent Based Model for Diagnosis of Ophthalmic Diseases

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Abstract: *The Ophthalmic diseases lack fatality, but have tendency to progress overtime (morbidity) and have more impact on daily life of the patients. Diseases like Glaucoma and Diabetic Retinopathy have chronic course which can be sight-threatening if not intervened in due course and proper follow-up. The diagnosis in such diseases, require examinations by optometry instruments following the symptoms. An integrated interpretation of these examination results are needed as they have different representation and their significance, to reach final diagnosis. Currently this interpretation is dependent on individual attributes such as, past experience and domain knowledge of the expert. Thus there arises a need of automated diagnosis free from individual attributes and can produce integrated interpretation. This paper proposes an Intelligent Agent Based Model for diagnosis of ophthalmologic diseases. The intelligent agents of the model are specialized and use advance computational techniques for deriving diagnosis from numerical data and images, thus combines autonomy and communicative characteristics of agents to reach to a final diagnosis.*

Keywords: Agent Based Model (ABM), Multi Agent System, Glaucoma, Diagnosis.

1. Introduction

Intelligent System face steep technical challenge in a number of areas. Biological systems are profoundly complicated, and a clinical decision may utilize an enormous range of potentially relevant data. In India, most of the healthcare delivery systems are based on manual record keeping, including Ophthalmology domain. In Ophthalmology, reaching a foolproof diagnosis is never an easy job for a clinician. There are various examinations to be done which produces different parameters to be analyzed and inferred to reach to final diagnosis. This paper proposes a model of intelligent system to carry out such diagnosis to ease the clinician using new technological avenues of computer science called Agent Based System or Multi Agent System.

A multi-agent system is a computerized system composed of multiple interacting intelligent agents within an environment. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent. Intelligence in case of such system may include some methodic, functional, procedural or algorithmic search, find and processing approach. Multi-agent system consists of agents and their environment. The agents in this type of system can be as efficient as robots, humans or human teams. It may contain a combined human-agent teams.[1]

2. Intelligent Agent based systems

An Intelligent Agent Based System consists of hardware and software, having intelligent features called as intelligent agent. If the agents are software, it is called intelligent software agent or software agent.

An agent has a distinct characteristic as one of its characteristics: autonomy. During his activities, An agent can interact with the environment, learn and use its knowledge to do its task without much interaction and command from computer users. This is how agent shows some degree of autonomy. An intelligent agent which has autonomy is called autonomous agent.

2.1 Characteristics of an Agent

The Characteristics of Software Agents are:[2]

- Reactive - It Responds in a timely fashion to changes in the environment
- Autonomous - It Exercises control over its own actions
- Goal-oriented - It Does not simply act in response to the environment
- Temporally continuous - Is a continuously running process
- Communicative - It Communicates with other agents, sometimes including people
- Learning - It Changes its behavior based on its previous experiences

- Mobile - It is Able to transport itself from one machine to another
- Flexible - Its Actions are not scripted
- Character - It has Believable "personality" and emotional state. e.g., A mobile Agent

2.2 Agent in Multi Agent System

A multi-agent system is a system composed of multiple intelligent agents which are interacting with each other within an environment. Multi-agent systems can be used to solve problems which are difficult for an individual agent to solve.[3] The agents in a multi-agent system have following characteristics:

- Autonomy: the agents are partially independent, autonomous and self-aware
- Local views: no agent in multi agent system has a full global view of the system. It is very difficult for an agent to make use of the knowledge of global view, as the system is too complex
- Decentralization: there is no designated controlling agent

Multi agent systems(MAS) are also called as "self-organized systems", which tend to find the best solution for their problems "without intervention". The main feature which is achieved when developing multi-agent systems, is flexibility. A multi-agent system can be added to, modified and reconstructed, without detailed rewriting of the application.

3. Agent based systems in medical diagnosis

Over past few years time Artificial Intelligence (AI) field has observed an increasing interest for research particularly for integration of different computing techniques such as fuzzy systems, Genetic Algorithms (GAs) and ANNs to generate hybrid systems which are more efficient. The objective of hybrid systems is to provide flexible information processing systems which can make use of the tolerance for uncertainty, approximate reasoning and partial information to achieve robustness and close resemblance with human like decision making (Pal et al 2000). Computer aided medical diagnosis integrates computer science, image processing, pattern recognition and AI techniques and its performance and reliability depends on a number of factors including segmentation, feature selection, reference database size, computational efficiency etc(Bin Zheng2009). Computational intelligence (CI) was seen as a comprehensive framework to design and analyze intelligent systems with a focus on all fundamentals of autonomy, learning, and reasoning (Duch 2007). A key issue in CI is adaptation of behavior as a strategy to handle changing environments and deal with unforeseen situations. CI exhibits interesting links with machine intelligence (Mitchell et al 1997), statistical learning (Tibshirani et al 2001) and intelligent data analysis and data mining (Berthold and Hand 2006), pattern recognition and classification (Duda et al 2001), control systems (Dorf and Bishop 2004), team learning in robotic soccer (Geetha Ramani 2009) and operations research (Hillier and Lieberman 2005).

The capability of an agent consists in the specializations that the agent can use in the problems solving. A problem solving specialization represents a problem solving method. The capacity of an agent defines the resources that the agent can use in problem solving. The systems composed from more agents are called multiagent systems. Many difficult problems solving

is a naturally cooperative process, whose solving implies a cooperative multiagent system. Motivations of the use of cooperative multiagent systems in problem solving consists in the limited capabilities and capacities of individual agents. uations, the symptoms of an illness may or cannot be interpreted properly.

In the medical domains many medical diagnosis systems are used that operate in isolation or cooperate . One of the most recent research direction is represented by the agent-based medical diagnosis. Many difficult medical diagnosis problems must be solved cooperatively by more agents, members of a multiagent system, endowed with different medical knowledge. Some of the recently developed medical multiagent systems act as assistant of the physicians during medical problem solving. A motivation of cooperative solving of difficult medical diagnosis problems by multiagent systems consists in the limited knowledge and resources of the individual agents.[4]

4. Diseases in ophthalmology

The disease conditions in ophthalmology can be broadly classified as inherited diseases, age related diseases, allergies & infection induced diseases, systemic diseases etc. There are two systemic diseases included for explanation, as diagnosis of these two diseases are the primary objective of the proposed model.

4.1 Glaucoma

Glaucoma is a condition that causes damage to your eye's optic nerve and gets worse over time. It's often associated with a buildup of pressure inside the eye. Glaucoma tends to be inherited and may not show up until later in life.[5]

The increased pressure, called intraocular pressure, can damage the optic nerve, which transmits images to the brain. If damage to the optic nerve from high eye pressure continues, glaucoma will cause permanent loss of vision. Without treatment, glaucoma can cause total permanent blindness within a few years.

4.1.1 Types of Glaucoma

There are two main types of glaucoma:

(a) Open-angle glaucoma : Also called wide-angle glaucoma, this is the most common type of glaucoma. The structures of the eye appear normal, but fluid in the eye does not flow properly through the drain of the eye, called the trabecular meshwork.

(b) Angle-closure glaucoma : Also called acute or chronic angle-closure or narrow-angle glaucoma, this type of glaucoma is less common but can cause a sudden buildup of pressure in the eye. Drainage may be poor because the angle between the iris and the cornea (where a drainage channel for the eye is located) is too narrow.

For most people, there are usually few or no symptoms of glaucoma. The first sign of glaucoma is often the loss of peripheral or side vision, which can go unnoticed until late in the disease. Occasionally, intraocular pressure can rise to severe levels. In these cases, sudden eye pain, headache, blurred vision, or the appearance of halos around lights may occur.

Glaucoma cannot be prevented, but if it is diagnosed and treated early, the disease can be controlled. At this time, loss of vision caused by glaucoma is irreversible and cannot be restored. However, successfully lowering eye pressure can help prevent further visual loss from glaucoma. Most people with

glaucoma do not go blind as long as they follow their treatment plan and have regular eye exams.

4.2 Diabetic Retinopathy

Diabetic retinopathy is the most common diabetic eye disease and a leading cause of blindness in adults. It is caused by changes in the blood vessels of the retina.[6]

In some people with diabetic retinopathy, blood vessels may swell and leak fluid. In other people, abnormal new blood vessels grow on the surface of the retina. The retina is the light-sensitive tissue at the back of the eye. A healthy retina is necessary for good vision.

If a person has diabetic retinopathy, at first he may not notice changes to his vision. But over time, diabetic retinopathy can get worse and cause vision loss. Diabetic retinopathy usually affects both eyes.

Often there are no symptoms in the early stages of the disease, nor is there any pain. Blurred vision may occur when the macula—the part of the retina that provides sharp central vision—swells from leaking fluid. This condition is called macular edema.

If new blood vessels grow on the surface of the retina, they can bleed into the eye and block vision.

5. Proposed Agent based system in ophthalmology diagnosis

The diagnosis in ophthalmology compared to other domains involve significant amount of analysis though advanced investigating equipments, producing minute examination data. The type of data required to be processed can be numerical data or an image. The degree of accuracy required for such processing calls for use of agent based system with specialized agent for processing different types of data.

The proposed agent based system is useful to the optometric technician who performs primary examinations at various local clinics or remote clinics which uses telemedicine. It is also useful to clinicians for second opinion.

The system has different agents for specific functionalities. The name and functionality of each agent is listed below.

5.1 Types of Agents and functionalities

The agents are broadly classified in two types of agents:

- Preprocessing Agents
- Diagnostic Agents

5.1.1 Preprocessing Agents

- FundusPreprocessingAgent : Preprocess the Fundus Image by applying filtering, Smoothing and thresholding
- OCTPreprocessingAgent : Preprocess the OCT Image by applying smoothing and filtering for edge detection
- OCTFuzzyPreprocessingAgent : Preprocess the numerical parameters to be used by neurofuzzy classifier, Decision Tree Classifier

5.1.2 Diagnostic Agents

- FundusDiagnosticAgent : Diagnosis of pathology by finding exudates or detection of change in thickness of blood vessels or optic disc
- OCTDiagnosticAgent : Diagnosis of pathology by thickness of boundary of retina in OCT image
- OCTNeuroFuzzyDiagnosticAgent : Diagnosis of pathology by classification after identification of

abnormal parameter values and their significance in pathology

- CoalescingDiagnosticAgent : Provides final diagnosis by evaluating the outcomes from different diagnosis agents

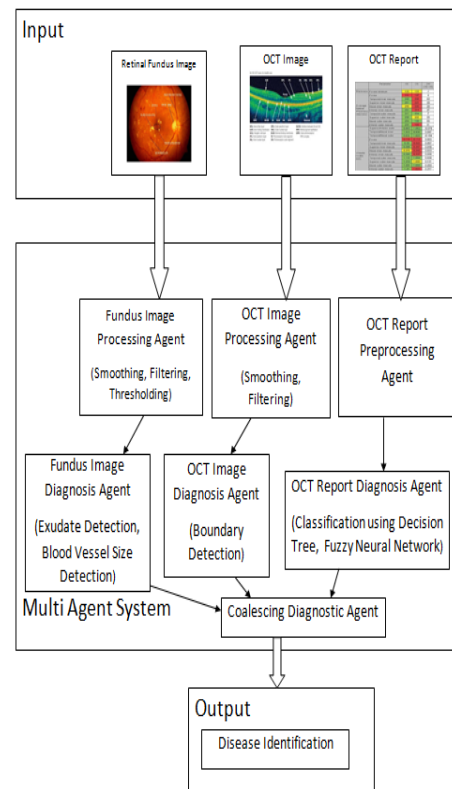


Figure 1: OphthoABM-An Intelligent Agent Based Model

The Preprocessing agents apply various suitable techniques to preprocess the data and extract the required useful parameters, which are used by various diagnostic agents to diagnose respective pathology of eye. The inference of each diagnostic agent is processed by coalescing diagnostic agent and final diagnosis will be done. As an output accurate disease identification is predicted.

6. Future Scope

The proposed model with modification can be extended for implementation in distributed environment to span a large geographical area. It can also be integrated with telemedicine to reach remote areas.

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