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INTELLIGENT AGENTS PARADIGM AND ITS ETHICAL, SOCIAL, TECHNICAL AND LEGAL PROBLEMS

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Abstract - The aim of this study is to discuss and critically review the Intelligent Agents (IA) and their recent developments. The report will particularly focus on the area of Intelligent Agents and information retrieval and how this technology is aiding users of databases. This report commences with a discussion of what Intelligent Agents are and it reviews the qualities they are generally expected to have and settles on the definition of an intelligent agent as a software entity. IA possess basic qualities such as autonomy, co-operation and learning. Then the report critiques the current state of IA technology by examining the technological, social, ethical and some of the legal issues. It further examines the implications of this technology for the reason that computer and information professionals have already recognised that there are a number of problems and issues surrounding the IA terminology and technology which must be resolved as soon as possible in order to acquire the utmost benefit from this technology. Although the Agents offer substantial advantage to users, the very nature of the IA paradigm leads to a number of ethical, social, technical and legal problems, common to all agent-based applications.

Keywords - Information Retrieval, Intelligent Agents, Artificial Intelligence, Information Storage and Retrieval, Databases, Information Management, Computerized Servants, Agent-based Computing.

INTRODUCTION

Intelligent Agents are sophisticated computer programs that imitate human thinking and actions. For example, researchers have created an Intelligent Agent called Steve to help train maintenance workers on US Navy Vessels. Usually, maintenance is given top priority on military ships. The faster maintenance workers can be trained, the better for the ships in question. Steve acts as a virtual teacher and takes the form of a human figure or a hand on a computer screen, guiding students through a Navy training program. [21] In this case, the agent teaches itself by acquiring the knowledge needed to assist the user. Accordingly, Intelligent Agents can be described as computerized servants, which are software, that communicate, cooperate and negotiate with each other. Hedger [11] says Intelligent Agents have a limited ability to take over human tasks and interact with people in human-like ways. Furthermore, he emphasizes that they are bringing technology into a new dimension, simplifying the use of computers, allowing humans to move away from complex programming languages and creating more human interaction.

Furthermore, agent-based computing has been hailed as “the next significant break through in software development,” [18] and the new revolution in software. Currently, agents are the focus of intense interest on the part of many sub-fields of computer science and artificial intelligence. Intelligent Agents have the potential to be extremely useful, because of their “intelligence.” That is, the agents can learn user actions and performances and they can respond correctly as the user performs a similar action. In other words, these Intelligent Agents have the capability to learn by example.

THE DEFINITION OF INTELLIGENT AGENTS

Unfortunately, there is indeed no universally agreed definition of an Intelligent Agent. Although a number of researchers have already defined what an “Intelligent Agent” is, none of the definitions are widely accepted. However, I believe that most researchers would find themselves in agreement with the following broad definitions. An Intelligent Agent is a program, which can operate autonomously and accomplish unique tasks without direct human supervision. This is similar to human counterparts such as insurance agents, real estate agents, and travel agents etc. Bentley states:

An agent is a system that can perform a task with a certain amount of “intelligence” due to some specialized skill (learning systems) or knowledge (knowledge bases). Basically Intelligent Agents do not just blindly do what they are told. They can be set up to evaluate choices and help the user to do things. [2]

However, the overall aim of agent research is to develop software, which engages and helps all types of end users. Intelligent Agent research is new and broad; it includes research in different software engineering fields such as interface design, communication and coordination, adaptation and learning algorithms etc. Therefore, a variety of researchers have already assigned different names in order to match their software engineering fields, for example, Autonomous Agents, Intelligent Agents, Knowbots, Intelligent Interfaces, Adaptive Interfaces etc. [19]

THE QUALITIES OF INTELLIGENT AGENTS

According to a research carried out by Don Gilbert and Peter Janca of IBM [20], the qualities of an Intelligent Agent can be divided into three main categories: “Agency” which is the degree of independence that the agent exhibits, “Intelligence” which is the amount of learned behaviour that an agent may have - the agent’s ability to accept the user’s statement of goals and carry out the task delegated to it. Therefore, agents contain some level of intelligence, ranging from pre-defined rules to self-learning Artificial Intelligent inference machines. The third quality is “Mobility” which is the category that makes agents useful in Internet applications, yet poses security problems. An agent can also be static or fixed and reside on one computer to manage and gather information.

However, in accordance with the Artificial Intelligence point of view, an agent possesses a list of properties [23] such as

- Autonomy - agents operate without direct human intervention and have control over their own actions.
- Social ability - agents communicate through a common language to other agents and even to humans.
- Reactivity - agents perceive their environment and react to changes in it.
- Pro-activeness - agents are capable of exhibiting goal directed behaviour by taking the initiative.

In general, some agents may have additional characteristics, and for certain types of applications, some attributes will be more influential than others. However, Jennings and Wooldridge [22] believe that it is the presence of all four characteristics in a single software entity which provides the power of the agent paradigm and which distinguishes agent systems from related software paradigms such as object-oriented systems, distributed systems, etc.

DIFFERENCES FROM CONVENTIONAL SOFTWARE

At the beginning of this report it was mentioned that Intelligent Agents are software, but they are essentially dissimilar from other conventional software because of their distinctive characteristics such as

Delegation: The user entrusts the agent to tackle some or all of an activity. In other words, by definition agents act autonomously on behalf of a user or a process, without the direct intervention of humans or others.

Personalization: The user determines how the agent interacts, In many cases, the agent learns about the user and adapts its actions accordingly.

Sociability: The agent is able to interact with other agents in ways similar to interpersonal communications. This includes some degrees of give and take, flexibility and goal-oriented behaviour. For example they may communicate with the user, system resources and other agents as required in order to perform their tasks.

Predictability: The user has a reasonable expectation of the results.

Mobility: The ability to go out - usually onto the network - to accomplish the delegated task. That is, they may move from one system to another to access remote resources or even meet other agents and co-operate with them.

Cost effectiveness: The benefits gained by the user (time, information, filtering etc) should be of greater value than the cost (monetary, time, re-work, etc)

Skill: The agent has its own expertise. A simple agent may be capable of only executing a simple command containing no ambiguity. On the other hand, the agent could have the ability to effectively deal with the ambiguity in the command.

Living with constraints: This can be as simple as “find me item I want, but do not purchase it,” or become as complex as, “go only to the most likely information sources, since there is a fee for just accessing an information source.” Some information services, for example, allow the user to set the maximum amount of money to be spent on any

search. [9]

WHY WE NEED INTELLIGENT AGENTS

One of the major objectives of the agent research is to help end-users. Thus currently many research projects have been conducted through the concept of IA to develop systems that handle various aspects of activities ranging from comparatively small systems such as e-mail filters to large, open, complex mission critical systems such as air-traffic control. Nevertheless, agents are predominantly a needed entity due to the immense growth of information available on the Internet. The ability to locate information a user needs on the Web is its greatest strength and its greatest problem. The rapid growth of web pages has created an information overload that has far surpassed any attempt to organize it. Therefore, users are beginning to suffer from severe information overload.

Some agents, which are available now, can save users time by performing repetitive tasks such as gathering and posting e-mail and checking newsgroups. The users do not need to be 'driving' the computer and can compose e-mail and newsgroup posting off-line at their leisure. Nowadays if you need some information from the web, you generally sit down at the computer to fulfil your information requirements by using available search engines such as Google, Yahoo, Alta Vista etc. In this case, you may need to spend a lot of time with the computer, conceivably need to spend several hours, or even days to search relevant information tally with your requirements. Nevertheless, with the development of Intelligent Agent technology, the end users can search or gather information very quickly perhaps in a few seconds. The end users can tell the intelligent agent what they actually want and continue working on other projects or move on to more enjoyable activities. [9] Basically, time is incredibly important resource today. As such with the help of an agent, users do not have to waste their time gathering information. On the other hand, monetary savings is also a major advantage of this technology because the connect charges will decrease substantially as a result of this software entity. Harper [9] points out that it is also a very simple procedure, for the user has to tell the agent what to search for, and log-out. On the other hand, the agents will make the Internet and computers easier to use. Furthermore he mentions that the Agents can be designed to search for information from a wide variety of sources. Instead of just using one search engine, agents could look at the possible methods and select several methods, which should produce the best results. Therefore, the most obvious advantage is improvement in user satisfaction through effective search over the web. It's scale has completely outstripped an individual's ability to access and comprehend it. However, it is recognized that a poorly designed agent could severely impact both overall network performance and the performance of the servers that it does access.

INTELLIGENT AGENT APPLICATIONS

There are several orthogonal dimensions along which agent applications could be classified. They can be classified by their type, by the technology used to implement the agent, or

by the application domain itself. [13] Industrial applications of agent technology were among the first developed IAs in early 1987. [13] Today agents are being applied in diverse aspects of industrial applications such as process control, manufacturing, air-traffic control etc. It is also widely applied in the field of medicine and health care. Hung et. al. [12] describe a prototypical agent-based distributed medical care system. This system is designed to integrate the patient management process, which typically involves many individuals. In the entertainment field, it is often not taken seriously by the computer professionals. [12] However Wavish et. al. [20] describe a number of applications of agent technology to computer games. For example, they have developed a version of the popular Tetris computer game, where a client should try to make a wall, out of irregularly shaped falling blocks. The agent in this particular game takes the part of the user, who controls where the blocks fall.

Commerce is almost entirely driven by human interactions; humans decide when to buy goods, how much they are willing to pay and so on. For this purposes IA technology helps buyers, sellers and intermediaries to do their task sophisticatedly. Medical informatics is also a major growth area in computer science since new applications are being found for computers every day in health industry. Therefore, that agent technology has been applied in this domain, for tasks such as patient monitoring, pharmaceutical controlling, etc.

IMPORTANCE OF IA IN INFORMATION RETRIEVAL CONTEXT

Taking into consideration the information retrieval context, an agent is specially designed for query processing. In this case, Intelligent Agents have processing power in order to perform planning and query processing. According to their knowledge of themselves, they know what information they have to access and they know what other agents to ask for information regarding keywords. An agent may also enter domain models or information source models if the agent is connected with a structured domain, especially relational database. [10] In addition to being self-reliant and knowledgeable of their environment, Intelligent Agents coordinate and cooperate with each other to achieve the satisfaction of the particular query. They use numerous ways for doing this task. [17] In a specification sharing agent system, a single agent decomposes the problem and assigns sub goals to other agents. Each agent knows what every other agent's needs and capabilities are. There is no "master" agent. Whichever agent receives the query subdivides it among the group of agents. It is assumed that any agent will perform a task requested from it and they all work together as sequels to achieve a solution. [10]

THE INTERNET AND INTELLIGENT AGENTS

In this context, one important category of Intelligent Agents used for searching agents is in particularly designed to locate information available from an assortment of sources on the WWW. These agents mask the complexity of the Information superhighway and filter the exploding amount of information available [6]. By using this technology the users can

search for any kind of information. For example, it may be product information, weather information, travel information, or any kind of information available on the Web in any mode, such as text, image or sound formats. Belfourd and Furner [1] suggest that as a radical solution to the problem of information overload, IAs are smarter than average search tools for two reasons:

- An IA acts with autonomy by making decisions on the basis of data it acquires about environment, rather than as a result of direct instruction from the user.
- An IA has the facility to learn about individual personnel preferences so that gradually it is able to predict the likelihood of items that will be of interest to the user.

However, Search Intelligent Agents, which can be used for information searching on the Web, are still in its infancy. [11] Nevertheless, a number of web Intelligent Agents can be identified in the field of web technology, for example,

Web Interfaces: this creates a buffer between user and Web to alleviate the necessity of performing low-level searching tasks. They allow a user to make high-level request, which is then performed by the Web interface agent.

Web Shoppers: The number of online shopping facilities grow as the WWW grows. It would take great deal of personal time to visit various online stores one by one to find the best price for a single product. If a group of agents could perform this, the result would be both a timesaving and possibly, a monetary saving task for the shopper.

DISTRIBUTED PROBLEM SOLVING

The task of information gathering in a distributed setting can be viewed in general terms as either distributed processing or distributed problem solving. Distributed problem solving can be characterized by the existence of interdependencies between sub problems assigned to individual agents, leading to a need to cooperate extensively during problem solving. [15] Usually they extend communication to detect and exploit these interdependencies between sub problems. At the start, normally they have only partial and imperfect views of global solution requirements. [15] On the other hand it is based upon the idea that a goal or a problem can be split into sub goals or sub problems and is concerned with how a problem can be divided among a number of agents to achieve a solution. In this case, Intelligent Agents can make united solutions by breaking the main problem into sub problems due to their unique expertise. Subsequently these sub problems will be merged into a complete solution. In considering the information retrieval, this implies the splitting of a query into sub queries. An agent who knows something about a particular sub query may take on the task of fulfilling that sub query. [10] For example, if the query is “qualities of the Internet and the World Wide Web,” and there is an agent associated with an entire database about Internet, then this particular agent may offer to take on the sub query of “qualities of the Internet” and “qualities of the World Wide Web,” finally the findings are merged and conferred for the user. Using agents, the query is split into sub queries and the results of all sub queries are re-combined to obtain the information “solution” to the entire query. [10]

SEARCH UTILITIES AND INTELLIGENT AGENTS

Intelligent Agent technology can also be applied to many areas within the computing field such as user-interface, information filtering, etc.

Today, search utilities incorporate Intelligent Agents. Indeed, many of the powerful features offered by search utilities, such as language independent searching, filtering, automatic refinement of results and document summaries, active hyperlink of query words and live highlighting of search terms are possible because of the nature of Intelligent Agents. [8] Unlike a standard software program that will execute specific functions within clearly defined parameters, agents are:

- Adaptive, that is they can interpret monitored events to make appropriate decisions.
- Self-organizing, that is they assimilate both information and experience.
- Communicative with both the user and other agents. [8]

Agents can search across a wide range of document types and formats. They can provide a uniform interface for search queries across different sources and are true “infomediaries” in that they can identify and search appropriate resources that may or may not be known to the searcher. The adaptive element of Intelligent Agents is central to the functionality of many search products that incorporate agents. The following popular search utilities, which all contain agent technology, are available as free downloads and as more comprehensive paid versions one can Mata Hari, Bulls Eye Pro, Copernic, etc. [8]

DRAWBACKS OF INTELLIGENT AGENTS

Intelligent Agents have their doubters, skeptics as to their use, in that there are a range of social and ethical problems and some legal issues, which are looming over head.

Even if the Intelligent Agents have already given the explosion of information accessible on the Internet, it also presents an interesting problem. The problem is that if many users have news searching Intelligent Agent tools constantly searching for information on the internet, is it not likely that the internet may be clogged up by too many of these searching tools? It is likely that each person would have quite a number of these programs running, in order to get a wide variety of information. To further complicate this picture, there is also the possibility that these Intelligent Agents will be programmed with the capability to spawn other agents. Imagine if one of these Intelligent Agents had an error built in which caused the program to continuously spawn agents to search the Internet. What if each one of these spawned programs also spawned other programs to search the Internet?

Furthermore, it is conceivable that a certain number of the Intelligent Agents searching the Internet for information would get lost, that is, they would not return with the requested information to the entity, which spawned them. Thus, one can begin to see the bottlenecks on the already crowded Internet.

Recently, the agency concept has been applied in the area of information retrieval. For example, Yahoo’s My Agent and Microsoft’s Agent have publicized agent-based information

retrieval facilities. The drawback to these commercial agents and those proposed in the literature is that they do not integrate the agency concept with other technologies, which are needed by the user. Consider a user who wants to retrieve information from a distributed heterogeneous environment such as the Internet. Previously proposed agents can only retrieve the information. They do not have the capability to filter, analyze or synthesize the information. [19]

Unfortunately, Intelligent Agents also have the potential to harm human beings. First, if human beings rely too much on Intelligent Agents, they may possibly lose too much of their freedom. This is a problem with technology and computers in general. Lanier [14] describes that confining oneself to an artificial world created by some human programmer(s) does limit human potential. This argument, though, lends itself more to the development of children's minds rather than human beings in general. Another objection he raised is that human beings end up degrading and lowering themselves when they accept computer programs as Intelligent Agents. Although some individuals are perfectly knowledgeable on the subject of Intelligent Agents, some do not know precisely about this technology. On the other hand several persons included in these two categories may not be aware of the harms and limitations of the IA technology, and they rely too much on them believing that computers actually possess intelligence and autonomy. These are the people who Lanier suggests will be psychologically harmed by Intelligent Agent terminology. When individuals begin to think of computers as actually possessing intelligence and autonomy, they will begin to treat the computers like people rather than tools, which they are intended to be. The result of treating computers like people will actually be that people begin to view themselves and others around them as computers. "As a consequence of unavoidable psychological algebra, the person starts to think of himself as being like the computer." [14]

Keeping trust and assigning responsibilities to Intelligent Agents are also major dilemmas of this technology because they may perhaps abuse the authority given to them. The agent may strike a balance between continually seeking guidance and never seeking guidance. Then what will happen? For example, if I have given my authority to the Intelligent Agent to pay my credits on behalf of me, how do I ensure that the agent does not run any mistake or run up a huge credit card bill on my behalf? Therefore, when we dedicate the responsibility to them we have to be more careful about the risk and the kind of authority, which is being transferred.

Legal issues are also a key problem in the field of Intelligent Agent technology, for example what if my Intelligent Agent gives a bad advice to other peer agent, for example, paying a huge amount of money for a particular purchase rather than the actual amount which should be paid for the particular company. Then the problem is who should be responsible for the actions of agents? If agents cause problems, is the user to be held responsible, or should it be the software designer and developer? These questions are still debating issues, [3] consequently it is very difficult to decide. It may be cause for a legal action, which would end up with an extremely difficult decision.

In fact, although the Intelligent Agent technology has an important role to play in the development of innovative computer applications, it should not be oversold. Jennings and

Wooldridge [13] argue that most applications that currently use agents could be built using non-agent techniques. Thus the mere fact that a particular problem domain has distributed data sources or involves legacy systems does not necessarily imply that an agent-based solution is the most appropriate one or even that it is feasible. Moreover they point out that usually an agent-based solution may not be appropriate for domains in which global constraints have to be maintained, in domains where a real-time response must be guaranteed, or in domains in which dead-locks or liveness must be avoided.

In accordance with the weaknesses of the Intelligent Agents Eichmann [4] has pointed out a number of ethical concerns, which must be addressed carefully with the development of agents, such as they must:

- Identify themselves.
- Limit their search to appropriate servers.
- Share information with others.
- Provide accurate and up-to-date services.
- Respect the authority placed on them by server operators.

In addition, Etzioni and Weld [5] have proposed some qualities of which they should encompass, such as:

Safety, that is the agent should not destructively alter the world.

Thrifty, that is the agent should limit its consumption of scarce resources.

Tidiness, that is the agent should leave the world as it found it.

Vigilance, that is the agent should not allow client action with unanticipated results.

FUTURE OF INTELLIGENT AGENTS

Some basic Intelligent Agent based examples, basic Interface Agents that are purely based on the IA technology such as mail filtering or calendar scheduling agents should be more common in the popular market in the near future. More basic mobile agent services would also be provided in the short term. Also, many vendors would claim that their products are agent-based even though they most certainly are not.

The long term agents which approximate true smartness, in that they can collaborate and learn, in addition to being autonomous in their settings. They would possess rich negotiation skills and some may demonstrate what may be referred to, arguably as emotions.

Some researchers project a future in which people will have very little direct interaction with the WWW [6]. Instead, they will have agents to take care of all their searching and arranging of schedules through the network. This would require a system of agents, which can deal with independencies among sub problems, assigned to each of them [16]. An example of such a system would be a multi-agent-based travel-agent system. A user would call upon a travel agent to investigate possible transportation arrangements, hotel reservations, car reservations, etc. For an example, an agent would be assigned to each of the aspects of a potential vacation or business trip, and an additional agent would be used to check the whether information. These agents would intercommunicate their information in order to concoct an overall plan for the trip.

CONCLUSIONS

Intelligent Agents have been around now for a number of years. But even though this technique is still young, it looks promising already. One of the conclusions that can be drawn from the trend and developments is, that users will be the ultimate test of the success of Intelligent Agents. Users will also drive agents' development; that is something that seems to be certain. In summary, Intelligent Agents must be capable of autonomous, customised, goal-oriented behaviour in some environment that acts as a personal assistant to the user. For example, for dynamic search (information retrieval) and textual analysis, in order to allow the agent to be goal-oriented, cooperative and customised, we can adopt a machine learning approach based on previous work in textual analysis. [17]

In addition, while Intelligent Agents technology has potential to be useful to mankind, many fundamental problems remain to be solved. These problems are both technical, social or ethical in origin and require careful thought and consideration by those who are in the process of developing them. Intelligent Agent technology has made some progress but has much further to go before it can and should be accepted as a tool to improve the quality of life.

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