Agent-Assisted Collaborative Learning
Using Agent Teamwork as a Collaborative Method to Facilitate e-Learning

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Abstract: e-Learning was a major shift in the learning medium to reach out to vast amounts of people and enable the possibility for them to catch up on lost time or acquire new skills from the comfort of their home and at the time most suitable to them. However numerous issues have been attributed to e-learning over the years amongst which is the low retention rate that sheds a shadow on its validity and effectiveness. In this paper we discuss how we propose to employ artificially intelligent agents that collaborate together and with human counterparts to optimise the medium and extract academic benefits.

1 INTRODUCTION

Learning has been a part of man ever since he has been. With time, learning has become more sophisticated and necessary. This necessity has become entrenched in society to the point that education is now considered a basic right as much as work and food. In the latter part of the last century we find forward thinkers like Paolo Freire who wedded the idea of education to politics (Freire, 2005). Fusing the idea of education into life. The way education should be delivered to learners should not take the form of dominance, or rather oppression. In his ideology the teacher's dominant, oppressive, position over the learner is removed. Freire insisted that the teacher should be a part of the learning cycle. Teacher and learner should form a synergy of continuous exchange. In this way education becomes a gift of the teacher to the disadvantaged student.

Moving into the twenty first century one is not really concerned any more about the availability of education. But now it is the delivery that has started to become an issue. In the 1960s Seymour Papert started publishing his visionary idea that computers help students understand better and achieve better (Papert, 1993). He was then heavily criticised, and cited as an elitist, by wanting to focus attention to privileged children over the rest who could not afford computers (Papert, n.d.). In his seminal book "Mindstorms: Children, Computers and Powerful Ideas" Papert explains the development of a new computer language called Logo which can be used to help students better understand abstract mathematical concepts (Papert, 1993)

Now that most governments worldwide insist that education should be a life-long process which helps people throughout all their life, the delivery of education has become an issue. More people at varying levels and ages need to be reached effectively. So now we attempt to deliver education on demand to broader masses, and it's through technology that this promise can be realised. But by delivering on-line lessons, en-masse, we have also unwittingly altered the student-teacher-class relationship. The class now is not a physical class anymore. The student is burdened with greater responsibilities, namely that of self-motivation (Rees, 2013). Consequently it has been noted that learner engagement and retention suffers (Rees, 2013). The way technology has been employed to date has done little to levitate the situation. Computers should not be used to program learners, but to assist them (Papert, 1993).

The allure of making automated teaching systems quickly caught ground, hoping to make up for sterile computer programs which are inflexible and without emotions. Researchers are reverting to *Artificial Intelligent* (AI) techniques to solve problems presented in the educational domain. AI has been proven to offer solutions that adapt to

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circumstances, even to situations that have not been encountered yet (REFERENCE). So an intelligent technology is a natural choice where one attempts to develop an approach that fits every learner according to his or her needs.

Although we shall not be concerned with the political or pedagogical aspects of education in this work, we shall attempt to offer a solution to improve learner engagement and retention. This cannot be done without understanding the forces that shape education and its delivery. So prior to delving into a computer solution, one has to understand the way humans learn. Then adapt a feasible technical solution that best facilitates learning. The rest of this paper is organised as follows. In the next section we will delve into a number of related past research avenues to identify the main issues related to the area and justify the use of agents in our proposal. Section 3 will in fact detail the formulation of the problem at hand and the section that follows will describe our proposed approach. Finally we dedicate a section on results and close the paper with our final conclusions.

2 PREVIOUS RESEARCH

2.1 Collaborative Learning

An intelligent personal environment is one that can embrace collective knowledge of many online users while adapting the aggregated content to a particular user's needs. Network and software technology available today permit the collection of information from various sources and then facilitate the presentation of material to learners of mixed abilities. Learners would be able to approach the subject with relative ease, as there would be assimilation between the users' needs and the way a course is structured. The richness of this model provides a possibility to learners of mixed abilities to come together and possibly even assist each other in learning.

The advent of e-learning has made "mass education" possible. Computers are available and powerful enough to handle the ever-growing demands we put on them. It is the techniques, which facilitate learning that normally, and understandably, lag behind. The first thing that strikes home when thinking of such a situation is the enhancement of the learning process which is able to assist students in their studies.

The model that shall be proposed in this short essay is based on the seminal idea propositioned by Professor Matthew Montebello (Montebello, 2014). Professor Montebello argues that crowd sourcing is a valuable tool to assist a learner in his journey of instruction.

Essentially a learner needs to interact with his environment, whether it is another person, a software agent or a machine. Learning would be greatly enhanced by interaction. So the proposed system should be able to:

- Support interaction;
- Assist in scaffolded learning;
- Transform data into relevant knowledge.

Interaction with an artificial environment requires the solution of multiple problems. The most suited approach to the situation will be the utilisation of software agents. Multiple software agents can be employed to interact with each other and human operators.

2.2 Why Use Agents?

When applying computer systems to assist real life situations the interaction between various variables can be complex and at times unfeasible to model in traditional ways. This becomes especially true when human interaction is involved, and computer systems assist, in a very ubiquitous way, humans through the task.

Agents are generally designed to be small, disjoint programs that work in tandem to solve a complex situation. Their simplicity and collaborative features makes them more adept to such studies. In situations where distributed computation or communication between components are required agents fit the bill perfectly. Moreover agents are capable of *reasoning* about their environment (AgentBuilder, n.d.).

2.3 Standards

Standards help developers build products which are interoperable. In the case of agents interoperability is a mandatory feature as communication is necessary between each agent.

Currently there are two popular standards, FIPA and OMG-MASIF. FIPA (Foundation for Intelligent Physical Agents) was set up in 1996 specifically to produce standards for agent systems. It seems to be that FIPA is the leading standard. FIPA focuses on agent architecture and interoperability (Cao & Das, 2012).

OMG-MASIF was formed a year after FIPA. The Object Management Group (OMG) released a document in 1997 called Mobile Agent System Interoperability Facilities (MASIF). This document proposes a specification for communication between agents (Cao & Das, 2012).

In this work the FIPA standard shall be followed. This decision was taken on the basis that many tools are FIPA compliant.

2.4 Agent Building Tools

When it comes to building agents there are a lot of tool kits that can be of assistance. There are many toolkits that can be used to develop multi-agent systems. The use of tool kits will allow focus on the domain of application rather than the building of the agent itself. It is rather difficult to choose between the different tool kits as can be attested through Wikipedia.com (Wikipedia, 2015). The choice was then narrowed down by choosing FIPA compliant tools. The Foundation for Intelligent Physical Agents (FIPA), an IEEE organisation was formed in 1996 to produce software standards for heterogeneous and interacting agents and agent-based systems (FIPA, n.d.).

In order to reduce interfacing complexity the JADE toolkit shall be chosen as the preferred toolkit. The Java Agent Development Framework (JADE) was purposefully developed in Java to ensure cross-platform compatibility of the package. Agent development occurs through middleware and a graphical user interface. Moreover implementation can be distributed across different machines running different operating systems. JADE is free to use under the Lesser General Public License version 2. It boasts of a large community of developers backing it up. Telecom Italia are the copyright holders of the software (JADE, 2015).

2.5 Reasoning Mechanisms

Computational agents require rational behaviour to be of some use as autonomous agents in a system. The approach to simulate rationality is naturally a complex task (Rao & Georgeff, 1995). Much of what we have today bases itself on the study of human organisation. One of the most popular models in use today is the belief-desire-intention model. The belief-desire-intention is a very popular model of *reasoning*. And many of the models in place today are either faithful implementations or base themselves in it.

The model was developed by Michael Bratman as a way of explaining the future-directed intention by humans (Bratman, 1999). It has its roots in philosophy where one tries to understand practical *reasoning* in humans. Practical *reasoning* is directed towards actions. This is a process where one has to figure out what to do. Practical *reasoning* comprises the weighing of considerations, sometimes antagonistic, against the beliefs, desires and values one has (Wooldridge, 2000). Cognitive science forms the basis of the approach to *reasoning* and as a result human awareness can be analysed and translated successfully into a BDI framework that can be used by software agents (Dunin-Keplicz & Verbrugge, 2013).

The BDI model was first developed as a model for understanding human *reasoning*. But it found its way into computer science and is actively used in programming software agents (Georgeff, et al., n.d.). It focusses on beliefs, desires and intentions as a way of solving problems that face an agent. Each action performed by an agent, human or otherwise, can be separated into two parts. A planning part, and a doing part. In BDI the planning part of the action is separated from the doing aspect of the same action. Agents programmed using this framework are able to balance the time spent in planning against the time spent doing (Bratman, 1999).

It is worth remaking that this model, developed in the 80's is considered dated. Moreover Michael Georgeff argues that it cannot reach the rigour of modern day demands (Georgeff, et al., n.d.). But despite this, the BDI model is still extensively used in frameworks. Unless the outcome from our research dictates otherwise, this work shall be based on this model. Primarily because of its extensive use and the availability of the number of frameworks that support it.

3 PROBLEM FORMULATION

3.1 The Current Situation

When one follows through the evolvement of learning it cannot be said that nothing has been done through the ages. But until 30 years ago learning has not been exclusively limited to obligatory school in many countries. Many a government, both locally and abroad, have realistically emphasised that learning is a life-long process.

It would be fitting at this point to start off with defining an important point, that of the meaning of

learning. Chen and Wei state, "learning is an active, interactive and constructive social process" (Chen & Wei, 2004) It entails a synergy between a number of activities that facilitate the acquisition of new skills or knowledge. Ultimately learning can also be understood as that activity a person does to acquire new skills mostly through interaction with others. Thus making collaboration with teachers and peers an essential part of the process. This has been seen to be concomitant with the actual pedagogy of the process of knowledge transfer itself. Interaction actually places the learner within a context of knowledge application. Technology seems to ably remove the interaction concept and consequently reduces student retention (Montebello, 2014).

Technology has the ability to greatly assist learning (Chen & Wei, 2004). But despite this, learning through technology has not yet reached its full potential. If one takes a look back in time, it can be noted that the use of technology to assist learning is not an innovative idea (Papert, n.d.). But technology was mainly used to increase the spread of learning further. The advent of radio, and subsequently that of television, has inspired many to introduce programmes that help people acquire skills such, as the learning of new languages, at their own pace. None are apparent today, and the success of such initiatives is dubious (Rees, 2013). But the seed of using technology to bring learning closer to more people was sown. Later on in the 90's with the advent of the Internet, that permitted global connectivity, the idea of distance education started to surface again. E-learning started to become a buzzword and has been embraced by many educational institutions. This enabled institutions to reach far beyond the limitations of their physical capacity. Material took the form of videos, sound clips and soft text. Once more results from various studies are being to show that despite the technology is promising, the end results are not (Rivard, 2013).

e-Learning should have given the student more freedom, but it also burdened him with more responsibility. Commonly teaching material would just be converted from standard printed material to a digital form and making them available to all. Material is in no way customised to suit different learning styles. Normally a one-size-fits-all situation is delivered. This, although convenient and very cost effective, is not ideal.

3.2 Tools

The most common tools in use today for the support of e-learning environments are typically, e-mail, material presentation packages, and social media and chat rooms/blogs. Taking a closer look at these tools one can identify a potential issue. They are very able at delivering material but they cannot adapt to the learner's style or wants. And mostly remove a crucial element that of collaboration. In other words the student is not being engaged in a normal, or rather, natural way within his learning environment.

The Social Learning theory, expounded by Albert Bandura, suggests that people learn expressly by interacting with their surroundings. A learner follows on by observing things that happen around him. He picks up ideas, shares them and develops them further. This action of collaboration then helps to develop the identity of the learner by interacting with the environment that projects roles and values on the person. Finally identity construction helps motivate social participation (Bandura, 1971), (Paul, 2012), (Orit, et al., 2015). As a corollary what has just been said, learners are demotivated and leave. Hence the low retention rate when students are exposed to an isolated, one-size-fits-all environment (Rivard, 2013).

4 PROPOSED WORK

Artificial Intelligence is not a new proposal to education, especially e-learning. But it must be added that the impact on e-learning has not been significant (Corbett, et al., 1997). This may be due to the fact that the personal adaptation of knowledge is still in its infancy.

The proposed research shall study the collaboration capabilities of independent multi agents and their capacity to solve problems as a team within an e-learning environment. Moreover the human element in this design shall be taken into account. Collaboration comes as a result of commitment from each participating agent, human or otherwise, sharing similar beliefs, desires and intentions.

4.1 Objectives

The environment selected for the study shall be an e-learning environment which will entail close cooperation between a system of agents and a human actor. Naturally we have to ensure that there is a binding factor between human and artificial agents which will lead to *teamwork*. The loop in this study will close when team work will eventually facilitate e-learning.

4.2 Research Questions

From the research objectives the following questions are placed:

- How can commitment be negotiated between software agents in order to improve group interaction and problem solving capabilities?
- Could agents adjust properly to human commitment to the same task?
- What will happen if the values of a software agent will start to differ from that of a group?

5 RESULTS

5.1 Expected Outcome

Most of the work shall comprise the building of a multi-agent environment and testing it out to see whether the above research questions can be met. The data collected from the experiments set up will be analysed using discrete event simulation modelling techniques.

This study is expected to reach two goals. The primary goal is that of studying collaboration between agents and its outcome. In this case the collaboration of agents is elicited through their beliefs, desires and intentions. The formation of teams will happen only if the BDI are close enough to make an agent co-operate. For this study, BDI will not be restricted, but an agent will have to form its own data set as part of its experience. Hence it may be harder to have agents to cooperate without "forcing" them to do so.

The second goal is tightly coupled with the first. Can human learning really be improved if a closely knit group of agents collaborate with a human?

5.2 Overview of the Proposed Model

As stated earlier agent interaction shall be studied within an e-learning environment. In order to adapt the educational content to the learner one has to be aware of a number of situations, namely:

- The profile of the learner;
- The domain of knowledge being experienced;
- The needs and wants of the learner.

The resultant outcome should be the intersection of relevant material presented in such a way as to satisfy the learner. The domain of knowledge can be sought through a variety of sources, through interaction with human players or computer sources.

In essence when collaborating, a learner should not be bound to the medium delivering responses. First we shall start by describing a system of agents that needs to be set up. The idea is to have a set of agents that need each other's support to work properly. There will be more than one agent for each of the types listed below. Our system of agents shall comprise the following:

- Knowledge Agent has knowledge in a particular area.
- Knowledge Server Agent stores, retrieves, and manages knowledge; answer queries; and provides information by inferring or *reasoning* using the stored knowledge bases.
- Interface Agent serves as an interface to learners, monitors and learns from the user's actions, and then functions as an intelligent assistant.
- Coach or Tutor Agent provides guidance to assist in the learning process.
- Mediator Agent coordinates the activities of other agents and resolves conflicts between them.
- Knowledge Management Agent provides the high-level coordination of knowledge activities, such as creation, assembly, manipulation, and interpretation of knowledge, within either an individual or a collective project.
- Information Search Agent searches for specific information and sends the results back to learners.
- Directory Agent points to an appropriate agent, service, or resource.
- Mentor Agent is envisaged as acting in a rather analogous way in the learning environment, as a kind of coach for the higher-level strategies of learning.

(Chen & Wei, 2004)

5.3 Comparison to Actual Implementations

Corbett et al, in their article "Intelligent Tutoring Systems" propose a model that may be used to help the design of such a system (Corbett, et al., 1997). Moreover, they singularly cite a successful project that has been undertaken in Scotland called SCHOLAR. The model divides a system into four areas, each taking care of distinct parts of the learning system. This model can be followed on, but a more dynamic approach to the learning system will be taken.

Contrary to what we are trying to attain in this

work the material developed for SCHOLAR was manually assembled. In our case an agent will be allowed to form its domain. The creators of this project claimed that they observed a correlation between SCHOLAR use and attainment of results. Moreover they also claim that there has been an observed improvement in autonomous learning. Students who used the software in the evenings and weekends have achieved better results than peers who used the software exclusively in class with their teacher. Curiously the report waters down its claims as the authors defend themselves by saying that it cannot be said that all the achievement can be attributed to the use of SCHOLAR.

But much can be taken from this study which really attempts to involve students by giving them a system which helps them through their studies. In this work we attempt to show whether *artificial intelligence* can really come to the rescue of e-learning.

6 CONCLUSIONS

In essence interaction is an integral part of learning. People interact, and exchange ideas and grow intellectually through this process. Removing interaction greatly reduces interest and motivation. So in order to improve the chances of success technology has to be able to maintain interaction while also being able to transform data into knowledge. The information has always been there, in some form or other. Digitally it is now even more accessible. The only remaining issue is that of transforming data into knowledge in such a way as it engages and retains the learner (Camilleri P., 2015). In this work we are going to seek technical solutions that address this issue properly. (Rivard, 2013)

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