IUMELA
The Inception of an Intelligent Modular Education Learning Assistant

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Abstract: University College Dublin has made an unprecedented transition from its once traditional educational metaphor to a modularised education framework, the first of its kind in Ireland. This paper questions whether students, who are unfamiliar with the concepts of modularisation, can successfully make informed decisions, ensuring success from specifically tailored module combinations. It presents IUMELA, an intelligent modularised-education learning assistant for use in a mobile context to aid in this career-making decision making process. Using multi-agent systems and their associated expert systems, it recommends appropriate modules based on the students own requirements. Proclaimed as a new departure, the ubiquitous multi agent systems technologies are capable of transcending the boundaries of the traditional into a world of innovative intelligent mobile learning, where software components embedded with intelligent learning assistants can enhance the third level students academic career.

1 INTRODUCTION

"Just as technology can be used to strengthen different forms of intelligence, so too can it target different learning styles." (Snowman et al. 2006) IUMELA is an acronym for Intelligent Ubiquitous Modularised Education Learning Assistant. It uses multi-agent systems (MAS) technologies to create an intelligent learning assistant that can support students in their choice of modules based on their learning preferences, academic abilities and personal preferences. The learning assistant uses expert systems analysis functionality to recommend and predict potential outcomes through the investigation of the students' learning styles and comparative analysis of similar past student's achievements. A wireless device can support the functionality of a MLE and IUMELA has been designed for use on the XDA Mini S. It was chosen because studies have shown that third level students tend to purchase a vast array of mobile phone technologies and upgrade these devices more frequently than other consumer groups within the market. Mobile devices enable student's opportunities to connect their academic queries to data in a real time setting thus reducing many administrative overheads (McGovern, 2005). The remainder of this paper is structured as follows: Section 2 provides a description of current research in the areas of mobile intelligent learning applications and learning styles theory. Section 3 presents the internal structure of the IUMELA application. Section 4 presents the results of the software's feasibility study. Finally, the conclusions and future developments are discussed in Section 5.

2 RELATED WORK

2.1 The Mobile Device

A wireless device is any form of networked hardware that can communicate with other devices without being physically attached to them (Tarasewich, 2002). IUMELA has been designed to run using the smart phone technologies available on the XDA Mini S. This smart phone combines integrated personal information management facilities as well as mobile phone capabilities (Ballagas, et al. 2006). IUMELA's preliminary findings suggest that providing third level students with access to modularised education learning assistant via smart phone technologies, as well as via traditional means, ensures that the resources are being provided in an on-demand, an anytime,

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anywhere manner. Previous studies have shown that the XDA class of mobile computing devices provides flexibility, connectivity, pro-activity, cost-efficiency and multimedia capabilities that its users have expressed as essential to the successful completion of their computing activities (Doe, 2006).

Microsoft Windows Mobile 5.0 drives the XDA Mini. This is a scaled down version of Microsoft Windows that has been specifically designed for PDA's and smart phone technologies (Doe, 2006). The operating system provides a familiar platform to students ensuring its ease of use and simplistic integration with the Managed Learning Environment (MLE) installed at the University. Active Sync technologies enable the XDA to synchronise with the university's MLE, ensuring that IUMELA's student case base is kept current and relevant.

In past research, it was evident that students were using mobile device as a graphing calculator, word processor, database, test prep tool, and as a means of accessing resource. These devices have afforded students with "opportunities to connect questions and investigations to the data in a real time setting that enhances "systematic investigations, critical thinking and cooperation" (Staudt, 1999) Additional research suggests that these facilitate group work, the immediate analysis of data particularly during laboratory exercises or when conducting scientific investigations in the field (Belanger, 2000).

2.2 Modular Education at UCD

UCD Horizons is the flagship of modularised education in Ireland. Modular education in UCD has provided a structured modular and credit-based taught degree programme. It has been designed to be more flexible than its traditional counterpart and enables students to individualise their academic career. They are required to undertake some core modules and have the opportunity to elect some optional and free choice modules also. This, in theory, enables them to adapt their degree programme based on their own study preferences and strengths (Nolan, 2006).

A primary motivation behind developing IUMELA was that, although there is enhanced freedom of choice in a modularised education, students entering third level education are often poorly equipped to deal with such freedom. They subsequently make misinformed module choices, frequently resorting to poor decision-making metrics.

2.3 Learning Styles & Teaching Strategies

Psychologists agree that intelligence is an ability. Significant resources have gone into developing an understanding of how students use these abilities for the purpose of education, otherwise known as learning styles theory. Learning styles are considered to be preferences for dealing with intellectual tasks (Snowman et al, 2006). It is possible to adopt different learning styles as the need arises. Kagan found that some students seem characteristically impulsive, while others are reflective (Morgan, 1997). Witken (Witken et al. 1977) theorised that individuals can be influenced by their surrounding context and that there are two groups of learners: field dependent and field independent. Sternberg's (Sternberg, 2001) styles of mental self –government theory describes thirteen styles that fall into one of five categories. There are functions, forms, levels, scope and learning. This concept supports the belief that IUMELA would assist students by suggesting appropriate modules based on their preferred learning styles.

Educators often use various instructional methodologies to engage any number of styles of learning at one time or another. They are required to use various test formats to measure accurately what various students have learned. IUMELA measures those classes in which students consistently participate well, through the inclusion of an expert agent. IUMELA's expert agent defines each teachers style based on one of several well-documented behavioural approaches; constructivist, humanistic and social (Bloom et al. 1956), (Krathwohl et al. 1964), (Simpson, 1972), (Adams & Engelmann, 1996). IUMELA, as a learner-centric intelligent assistant, can link concepts to every day experiences, guide students in their problem solving processes and encourage learners to think analytically when reasoning in a humanistic manner.

Historically, assessment involves measuring how much knowledge and skills a student has and its acceptability based on the teachers' eventual goals. The summative and formative techniques are two popular methods of evaluation. Teachers use a variety of means to evaluate, either summarily or formatively, a student's knowledge or skills level. A vast array of methodologies - including written assignments, short answer tests and e-portfolios - are frequently used by lectures in UCD and so have been incorporated into IUMELA expert agents reasoning abilities and knowledge base

Software systems are becoming increasingly more complex and online information spaces are growing exponentially. Kay (Kay, 1990) highlights

how the use of MAS has resulted in a transition from the traditional direct manipulation of a system to indirect human-intelligent agent interactions. Agents have enabled the delegation of the mundane and tedious. Shneiderman (Shneiderman, 1979) considered user confidence and agent autonomy as areas that required consideration. MAS should have the overall effect of reducing the users workload (Collier, 2001).

3 IUMELA – THE AGENT ARCHITECTURE

IUMELA conforms to FIPA specifications (FIPA, 2001). The multi-agent system (MAS) was developed using Agent Factory (Collier, 2001) toolkit, using Java as the programming language. In particular, the Assistant Agent runs on a XDA Mini S. The high-level communication protocols have been implemented using ACL messages, whose content refers to the IUMELA ontology. The GAIA methodology was used to identify the agent structures, roles and interactions within IUMELA (FIPA, 2001) and can be identified in figure 1.

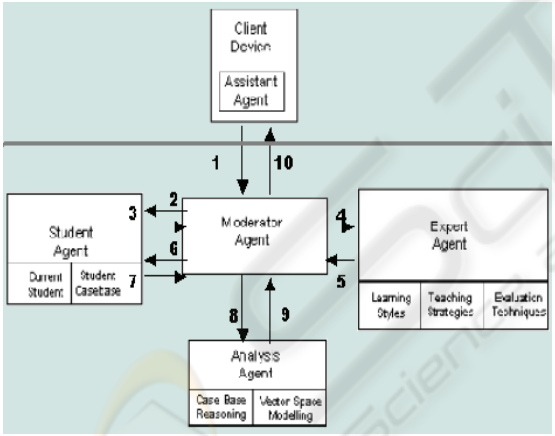

Figure 1:The Agent Architecture.

IUMELA uses a FIPA compliant MAS architecture, displayed in figure 1, to fulfil the task of an intelligent application capable of autonomous human computer interaction for communication, event monitoring and the performance of higher order cognitive tasks. IUMELA consists of a community of five agent types: assistant, moderator, learning agent, expert agent and analysis agent.

3.1 The Assistant Agent

The assistant agent resides on the student's client device and is responsible for the seamless interaction between IUMELA's MAS and the student. The effectiveness of interface agent technologies as a means of facilitating human-computer interactions ensures that they remain a prevalent research area within the fields of artificial intelligence (AI), human-computer interaction (HCI), and user modelling. It is considered a mechanism by which the mundane and tedious can be altered or delegated. Each of these research domains reflects upon a unique facet of the agents' capabilities, rating its effectiveness in terms of their own requirements.

AI research has afforded the assistive interface agent with knowledge representation skills, learning heuristics, and reasoning abilities. HCI research in interface agents has ensured attentiveness to the user, focusing on that which the user requires. In order to effectively display personalized information to the student, a user modelling functionality is required (Harrington, et al. 1996). Deploying IUMELA on a mobile device ensures that the manner and location of the student-agent interaction will differ significantly from that which occurs when taking place via the traditional desktop metaphor. Enabling the student to interact with IUMELA in a ubiquitous manner ensures that their learning experience can be transformed into a larger context, incorporating it into every aspect of their third level academic career. It is the task of the assistant agent to interact with the student and the other agents within the MAS in order to provide appropriate assistance based on context. Adaptive personalization was considered as the mechanism that would best assist students.

To correctly aid the student, the assistant is required to be aware of several fundamental variables: their degree program, level, current stage, preferred learning style, academic history, and preferred teaching strategy. The application is capable of using a multitude of web-based technologies ensuring that the student's information could be displayed in an appropriate and discernable form.

3.2 The Moderator Agent

The mediator agent family is composed of three basic agent patterns: the broker, the matchmaker, and the mediator. They act as intermediaries between any number of other agent types. Similar to the broker and mediator agents the moderator

arbitrates interactions between the other agent types. In addition to this, it also maintains an acquaintance model based on past interactions. The moderator can interpret the requests received and, based on a combined analysis of the stored acquaintance model and current context it acts accordingly. However, further to this the moderator can also seamlessly interact with resources external to the IUMELA MAS, this functionality was necessary in order to enhance its communicative capacity. Assistant and expert agents inform each other of actions preformed via the moderator agent.

3.3 Expert Agent Technologies

The student agent enables all other agents in IUMELA to connect to the student case base and to access the administrative data of the analysed student. It provides a single, generic method by which other agents can interact with the student data while, simultanelosuy, ensuring student confidentiality. It has an ability to examine incoming messages and retain and return information based on the senders clearance level. It can then match action requests to the appropriate agent role controlling the student case base.

IUMELA aims to help students to achieve their ultimate academic goals by assisting them in devising competent and obtainable academic goals while traversing through a specially tailored module schema. The student agent enables students to envision a potential overview of their academic journey based on the student's current profile and previous academic achievements.

The fundamental role of the expert agent is to accurately depict the teaching strategies of the module. So too, is it the task of this agent to retrieve all potential evaluation techniques for each module, ensuring that any prediction or recommendation made is based on 100% current information. Within IUMELA, the expert agent maintains a knowledge base of all possible teaching strategies used within the university. It is then linked to a list of all potential learning strategies within each module offered. It is the task of the expert agent to maintain this directory of all available modules, the lecturer directing it, and their preferred teaching style and examination technique.

The analysis agent maintains a knowledge base that predicts all plausible academic outcomes based on the information it receives from the student and expert agents. Although it maintains several potential recommendation algorithms, it will proactively choose an appropriate reasoning model based on the students prior knowledge, their academic history, and their chosen degree program and current level. This is achieved through the knowledge-reasoning centre that enables it to autonomously choose an appropriate reasoning algorithm. This agent type is capable of adapting its current reasoning strategies and assimilates new and improved ones, therefore ensuring that IUMELA's recommendations are constantly improving, becoming more accurate.

3.4 The Agent Interactions within IUMELA

Figure 2:Sample HCI with IUMELA.

Upon logging on to IUMELA for the first time, the student is required to complete an initial survey. To do so is necessary to enable the multi-agent system (MAS) to assist the new student in choosing their preferred learning style, teaching strategy and examination procedures. To ensure that IUMELA is useful from the onset, a student will be unable to navigate through the application without having completed the survey beforehand.

The student enters their UCD email address and student number, which will suffice as their unique student identifiers within IUMELA. The assistant agent submits them to the moderator agent via the getSurvey() message, which adheres to the FIPA compliant IUMELA ontology. The moderator receives the message and, using its internal reasoning abilities, forwards it to the appropriate student agent. The student agent, responsible for maintaining the knowledge base for all students, creates a new entry for the student, retrieves the question to be posed and returns it to the assistant agent for display, see figure 2. When there are no more questions to be answered, the assistant agent

affords the student the opportunity to review the survey, and update any answers he so wishes.

The task of the expert agent is similar to that of the student agent in that it maintains a registry of the user information. Instead of maintaining that of the student, however, it stores all information relating to the modules available at the university. Including, but not limited to, the current lecturer, their preferred teaching strategies and examination procedures. It is the task of the analysis agent to analyse all information received. It combines these with past student histories to predict all plausible academic outcomes based on the possible module combinations currently available.

4 AN EVALUATION OF STUDENTS CURRENT DECISION MAKING STRATEGIES

The purpose of the initial IUMELA user trial was two fold; the first was to determine if the agent architecture was robust enough to display returned stored student information, to retrieve information entered by the student via the assistant agent and to store this information in a meaningful and cohesive manner for later reuse. The second purpose of these initial user trials was to obtain an initial knowledge base from the current degree candidates and to offer them module opportunities not previously considered.

This trial took the form of a survey to be undertaken, via the XDA Mini S, by the general student body at University College Dublin. By enlisting a broad range of students across the university's campus it was ensured that a wide variety of students with varying interests and academic backgrounds as accounted for. The participation levels varied from faculty to faculty; 21% of the participants were from the Faculty of Arts and Humanities, 25% were from the Faculty of Engineering, 17% were from Law and 28% were from the Faculty of Science.

The First set of questions required the students to submit information pertaining to their academic history via the assistant agents interface. This information was retrieved by the assistant agent sent, via the appropriate ACL, for unbundling by the moderator agent. The moderator agent analysed the received data and determined, using its internal reasoning capabilities, to which agent the messages should be sent. Results showed that the moderator agent was safely abstracting necessary information and accurately identifying its content for sending to either the student or expert agent 100% of the time.

The information received by the student agent was specific to the students learning styles and their perceived understanding of modules currently being undertaken. The students were required to enter a difficulty rating and relevance rating for each module that they were attending. The results displayed that 83 % of the students believed that one or more of the modules taken was out of their difficulty comfort zone. Furthermore, 42% of these students indicated that one or more of these modules were not relevant to their degree course.

The aim of the final section was to store, in the student case base, the students personal characteristics; interests, abilities, values, personality and motivations. Its aim was also to indicate how students were incorporating their personal characteristics into their module decision-making. The survey indicated that only 31% of the students surveyed considered extra curricular activities they enjoy to partake in, with 62% of these indicating that the influence of television and media played a major role.

Regarding the student's academic abilities, 26% of them felt that their academic scores were higher than their classmates and 17% felt that their scores were significantly lower. Of the latter, 88% had previously indicated that one or more of the modules taken had a high difficulty rating. This indicated to the student agent that these students had poor to fair module decision-making strategies.

Furthermore, 37% of the participants indicated that their moral values and principles had played a significant role in deciding upon the modules they were currently undertaking. And finally, an overwhelming 87% had indicated that their personality had played a considerable role in their decision to undertake a particular degree programme, but only 45% of these had used the same belief set in choosing their modules. In many cases students were empowering others to indicate modules that should be undertaken; 37% received assistance from their family members, 33% from their peers and 22% from academic authorities, the remainder had chosen their academic courses alone.

With regards the feasibility of constructing an intelligent learning assistant to aid modular students in their academic decision making in a mobile context, 82% of those surveyed considered the applications structure and navigation functions enabled them to access and utilize IUMELA's survey function and vicariously enabled them to consider modules in a way not previously done.

5 CONCLUSIONS AND FUTURE WORK

It was the intention of the IUMELA feasibility study to ascertain whether there was a requirement for an intelligent learning assistant to aid students in their modularised education decision making strategies as UCD transitions from a traditional to a modularised educational framework. Research into educational psychology determined that, not only could students learning styles be categorised into discreet forms, but so too could lecturers teaching strategies be identified. By assimilating these and the university's current examination procedures into MAS based application, an intelligent agent capable of autonomous human-computer interactions could be developed. The results from the initial user trial indicated that students at University College Dublin are unfamiliar with modular education and the required decision-making strategies required in choosing third level academic modules. Even student's, who had demonstrated significant ability at choosing their degree programs had failed to do so based on their learning styles, preferred teaching strategies, evaluation procedures and personal considerations. In such a myriad of academic modules, students were not averse to receiving modular course recommendations from a multi-agent systems based learning assistant via a mobile device. In future work, the role of the analysis agent will be examined and a comparative study of reasoning algorithms used will be undertaken.

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