LearneA
Design and Functionalities of a Hybrid Personalized Learning Electronic Assistant

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Abstract: Throughout the last decade a number of Personalized Learning Environments have been proposed encompassing various personalization techniques, in order to provide learning material adapted to the specified user's requirements. In this study, we illustrate the design and enumerate the basic functionalities of LearneA, a Hybrid Personalized Learning Electronic Assistant. LearneA practically revisits the way other existing personalized environments implement the various proposed personalization mechanisms, but furthermore incorporates a number of innovative characteristics, which have not been implemented yet in any other learning environment. Our aim is a smart Hybrid Personalized Learning Assistant which will eventually offer a completely different learning experience. Additionally, a review of previously proposed Learning Environments is presented with respect to the personalization techniques which they embrace in order to provide personalized learning content for the user.

1 INTRODUCTION

Although the World Wide Web encompasses of an extensive number of learning systems, it is however extremely difficult for someone to isolate and select the suitable learning material which fits his needs. Most learning systems offer raw educational material categorized in chapters which are divided into sections, and present the specified material in a modest static way without integrating any kind of adaptation to the specified user's requirements.

A number of e-learning systems have been proposed throughout the years, with many of them widely adopted and successfully used. Later on, several researchers investigated the prospective of proposing a personalized e-learning system which adapts the learning material offered, to the learner's specified needs and characteristics (Dolog, 2004; Chen, 2005; Huang, 2007). A personalized learning assistant should provide a flexible and functioning learning environment which combines specified personalization techniques and a number of supporting services.

Traditional e-learning systems were widely embraced by the academic community throughout the last decade, due to the necessity of providing an online heterogeneous learning environment for students with different learning styles and capabilities (Dung, 2012). The implementation of a number of e-learning environments circumvented many limitations of the classical teaching-in-classroom (Garrison, 2011; Hsieh, 2011), approach (formal teaching, tutors' teaching style, students' learning capabilities and absorbency of the material delivered) thus presenting a learning way without the restrictions of the typical class. Moreover, the applicability of personalization techniques to the classic e-learning systems led to personalized learning environments which include personalized techniques that fit to the learners' preferences and needs.

This report records all the necessary requirements and specifications of LearneA, our proposed hybrid personalized **Learn**ing **e**lectronic **A**ssistant and presents a design architecture for this assistant. Moreover, all the necessary components which comprise the overall mechanism are thoroughly explained and all the personalization techniques are signalized for both their mechanism and usage within the assistant.

LearneA practically revisits the way other existing personalized systems propose and implement the various personalization mechanisms which are found in the literature and industry. The hybrid model of the assistant which we propose comprises of a number of dynamically evolving characteristics and components which combine a number of personalization techniques endorsed in

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literature (e.g. ontology-driven profile personalization, context-aware personalization, query personalization and recommendation techniques).

To the best of our knowledge, there isn't any Personalized Learning Assistant with the functionalities which are hereby proposed. Our aim is a smart hybrid Personalized Assistant which will eventually offer a completely different learning experience for anyone who wishes to expand his knowledge perspectives in various learning areas combined with personalization mechanisms which will lead him throughout the entire offered course.

In Section 2 we present and categorize related work, according to the main personalization technique utilized. In Section 3, we present the architecture and in Section 4 the functionality of our proposal, while in Section 5 we present conclusions arising from this work and we briefly discuss future plans.

2 RELATED WORK

Throughout this section we summarize and present a number of personalization techniques which are encountered in literature. Emphasis is given on the distinct characteristics proposed and the personalized mechanism each one of them promotes.

An attempt to review Personalized Learning Assistants with the characteristics that our system encompasses was made, but there exist no Personalized Assistants directly focused on learning material which directly combine wholly the techniques we propose. Therefore a review is presented here which includes a number of Personalized Systems (not Learning Assistants) and the basic functionalities which they provide regarding personalization mechanisms, namely the way these systems provide personalized content after performing their selected techniques.

Subsequently throughout this section background material is presented, classified into 4 distinct categories (i.e. personalization techniques) and a comparison table is given, highlighting the distinct characteristics each system delivers in contrast to our proposed Personalized Learning Assistant.

2.1 Personalization and Context-aware Systems

Recently a number of context-aware Learning Systems have been proposed with a number of them encompassing the idea of a recommendation strategy which adds the notion of adaptivity and seeks to present personalized results to the learner using their system.

One of the most notable proposed systems which comprises of the ideas of context-awareness but also includes a recommendation module in order to give personalized courseware recommendation for the learner is (Wang, 2011). The authors developed a u-learning environment where the user of the system can use a mobile device with RFID technology in order to connect to the Learning Management System. The u-learner later on transmits back the contents of the course to the device, which are enriched with recommended content with the aim of the recommendation module. The overall design of the system is satisfactory and according to the t-test performed, the results obtained showed a significant time difference.

Another noteworthy Context Aware Ubiquitous Learning Environment was proposed in 2006 in (Yang, 2006) which eventually illustrates and supports P2P collaborative learning. The use of ontologies with the aid of Protégé for learner ontology and service ontology is highlighted in the construction of the profiles. Both learner and service ontologies contain surrounding context-awareness parameters i.e. QoS, environment profile and device capabilities all part of the so called context acquisition. Later on context detection and extraction support the P2P learning environment presented. The authors demonstrate the use of their proposed system with a carefully designated scenario.

Furthermore, another two context-aware adaptive learning systems were proposed in (Chen, 2012) and (Yaghmaie, 2011). In the first one, the ubiquitous concept is mainly demonstrated again with the aid of RFID tags, whereas the overall design architecture primary consists of 3 distinct modules, the U-Learning Module, the Teaching Materials Management Module and the Examination and Evaluation Module. A series of experiments were conducted in classrooms and in the Atayal u-Museum in Taiwan. In the latter one, the proposed context-aware system is based upon a well-known open source LMS with the aid of ontologies and Agents, where 4 types of Agents reside in the overall system architecture (i.e. Context Management, Content Selector, Content Organizer and Content Presenter Agent).

2.2 Personalization and Ontologies for Describing Profiles or Courses

The use of ontologies is a widely recognized technique for a number of web applications as well

as other systems. E-learning systems which are built upon ontological profiles or courses on a learning system which are described semantically with the aid of ontologies are frequently encountered.

One of the many examples of applying intelligent techniques and semantic web technologies in e-learning environments is the work (Gladun, 2009). The main idea is the ontologies which are built by the tutor (reference ontology) and by the student (discipline-related ontology) which is later on compared to the referenced one. Furthermore, a Semantic Web prototype entitled M(e)L, is presented which is supported by a number of Agents -Tutor, Student(s) and Informational- which interact with each other. Essentially, the Tutor Agent and Student Agent are not communicating directly but rather via a broker Agent, the Informational one, giving promising advantages to the whole learning experience.

Another noteworthy example of the use of ontologies in a personalized web search environment (not a learning one) is described in (Sieg, 2007). Even though this approach does not directly embrace the notion of an e-learning environment, the use of ontological user profiles in order to describe user context as well as the re-ranking of the results obtained based on the interest scores in the user profile, characterizes this attempt for personalized web search as a noticeably promising one. The same approach with slight differences is described in (Mohammed, 2010) where the ontological profiles are constructed by semantic analysis of the log files.

Finally, another significant methodology which combines the use of ontologies and recommender system is the architectural model proposed in (Shishehchi, 2010). The recommender system described, consists of two subsystems and their underlying modules. The use of ontological and OWL rules demonstrates the rule filtering recommendation technique.

2.3 Query Personalization

Another interesting approach for providing personalized results in a learning system is query re-writing with the aid of a specified user profile, which is updated dynamically including the user context and interaction of the system. Such approach was described for a Learning Management System in (Paneva, 2006) and in (Koutrika, 2004) for Database Systems.

For the first one, the authors define a specific sequence of Learning Objects (LO) and activities which are tailored to the tutor (rather than the learner) and moreover introduce the notion of query personalization by filtering and ranking the results which are returned by a specific query using the pre-defined user profile.

In the latter one, the authors present the conception of query re-writing (query personalization) by transforming the original query applied by the user internally (with the aid of their personalized engine) into another query. For this purpose they use preferences which are supplied by the user at an earlier stage and are stored into the user's profile. Later on, the extraction of the set P_k of top-K preferences take place, derived from the user profile. These preferences along with the initial user query are used in a preference selection algorithm, formulating another personalized query, thus obtaining different results adaptive to each user.

2.4 Personalization and Recommendations in Learning Systems

Finally, a number of proposed architectural models and the implementation of them embrace the notion of recommendation. One of the models proposed upon the SCORM Learning Management System is the recommendation model LORM (Personalized Learning Object Recommendation Model) described in (Wang, 2007). The use of ontologies is present in the model, in order to identify the Learning Objects (LO) for the course tailored to a specific learner's needs and build a Learning Repository. Later on, a personal preference pattern is built for each learner which consists one part of the recommendation engine, where the second part is the recommendations based on neighbours' suggestions. A thorough and comprehensive survey of personalized recommender systems, including a number of learning personalized systems is given in (Adomavicius, 2005), where in (Khrib, 2008) an automatic personalization approach is presented, with the aim to provide recommendations for learners. The model consists of two modules, an off-line builder for the models of learner and content, and an on-line module, which is used to recognize the student's needs and apply the various recommendation techniques.

All the aforementioned papers embrace a number of personalization techniques (i.e. context-awareness, query personalization, ontological user profiles and recommendation algorithms) for Personalized Learning Systems (Figure 1).

Features/Authors	Wang 2011	Yang 2006	Chen C.C. 2012	Yaghmaie 2011	Gladun 2009	Sieg 2007	Mohammed 2010	Shishehchi 2010	Paneva 2006	Koutrika 2004	Wang 2007	Khrib 2008
Context-awareness	x	x	x	x		x	x					
Query Personalization									x	x		
Ontologies and/or User Profile		x		x	x	x	x	x	x	x	x	x
Recommendation algorithms	x							x			x	
Ubiquitous capabilities	x	x	x									

Figure 1: Comparison table for personalization features and the aforementioned papers.

3 ARCHITECTURAL MODEL

A considerable number of Personalized Learning Environments have been proposed and implemented during the last decade, with each one of them applying a number of personalization techniques (as already summarized in Figure 1). Our proposed architectural model revisits the beforehand mentioned environments in a significantly different way, adding functionalities which are not yet encountered in a Personalized Learning Assistant.

Our vision is to implement an Assistant similar to requirements and functionalities of the well-known assistants from Apple Inc. Siri. (Aron 2011) and Microsoft Cortana (Warren T, 2014). However, the functionalities of our Assistant will focus on learning for particular courses.

Indicatively, the **three basic characteristics** which differentiate the architectural model proposed are as follows:

- The Personalized Learning Assistant we envision uses a **text/speech recognition engine** (initially for the English language), where simple/basic voice commands are recognized and interpreted by the Assistant. The built-in mechanism of the speech recognition software "translates" these commands into basic functionalities for LearneA. In that way, the learning experience resembles the use of Digital Assistants like Siri and Cortana, adding supplementary functionalities to the Learning Assistant.
- The learning flow is uninterrupted, accessible by any device the user may possess. The user is able to continue from the point he stopped with the aid of the **Synchronization Component**. This functionality would be supported by a web/cloud-based service which is synchronized by the device which is currently in use and concurrently synchronizes all the devices connected to the service. With the support of this service, the user would be able to continue his learning experience with all the material being adapted to the limitations and capabilities of his device.
- The Personalized Learning Assistant connects to the user's life retrieving information and data from various daily activities. LearneA's **Behavioural Component** will connect to any social network managed by the user, to his calendar and mail, thus retrieving all tasks, appointments and social interaction the user performs. In that manner, the Assistant is interrelated with the user's personal life making recommendations for the learning progress in an energetic way (use of automated scripts).

4 FUNCTIONALITY OF THE COMPONENTS

The overall proposed architecture which is depicted in Figure 2, incorporates all the necessary basic components of the design. The main differences from any other Personalized Learning Environment have been stated in Section 3 and are namely the text/speech recognition engine, the Synchronization Component and the Behavioural Component. All these characteristics have not yet been implemented to any other Personalized Learning Assistant, thus making our proposed model unique and innovative. A significant role in the overall design of LearneA is played by the **ontological user profile component.** The ontological profile is initially constructed automatically with basic features of each individual user (i.e name, age, gender etc.) but is later on dynamically updated with any useful information the Assistant captures. Any interaction with the Learning Assistant is analysed and logged in order to be integrated into the profile. The use of ontologies for the modelling and construction of the user profile is preferred than any other profile model, since it has been previously selected in many other research studies and implementation of Personalized Learning Environments.

Furthermore, the key part of the whole architecture which plays an essential role in the personalization mechanism is the **Personalization Component** which comprises of 3 distinct

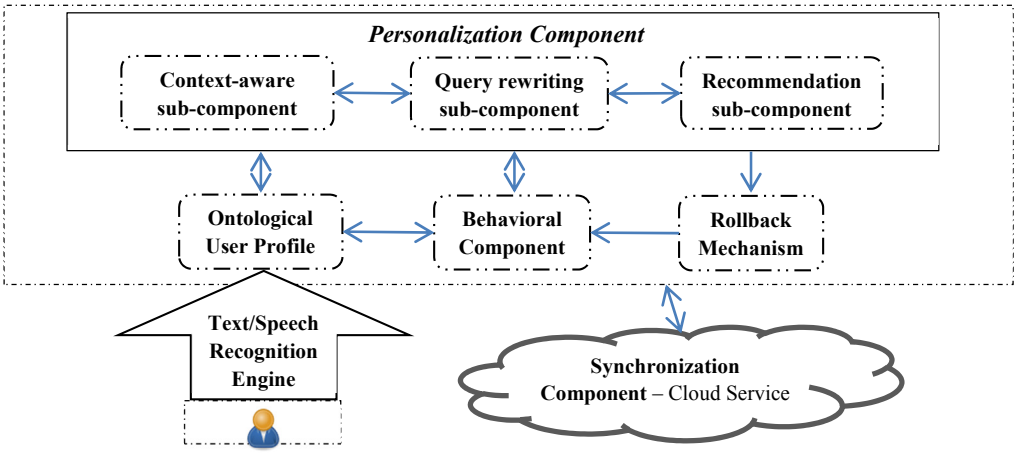

Figure 2: Proposed Architectural Design of LearneA.

integrated sub-components that interrelate and co-operate in order to provide personalized material, adapted for each user's requirements. These are the **context-aware sub-component**, the **query rewriting sub-component** and the **recommendation sub-component** respectively.

In the **Personalization component** a series of services are performed to provide an expressive personalization experience. The integration provided by this component has been implemented in other Personalized Learning Environments, but our ambition is to integrate all these mechanisms into a novel personalized engine.

Specifically, the **context-aware sub-component** encapsulates any necessary information surrounding the learner's environment (primarily place and time) as well as other device associated context (i.e. type of device used to access the Assistant, surrounding environment of the devices, frequency of usage the Assistant).

In a parallel manner, the **query rewriting sub-component** captures any query the learner poses and processes it accordingly. Specifically, a query processing mechanism analyses any given query, assigning weights to selected keywords, which are given as input to a modelling query rewriting algorithm. This algorithm essentially co-operates consecutively with the **recommendation sub-component.** The responsibility of this sub-component is the selection of appropriate learning resources to be recommended to the user.

Finally, a fundamental component to the whole learning model of LearneA's architecture that we envision to hold a key role is the **Rollback Mechanism**. This mechanism practically monitors the learner's activities in conjunction with the **Behavioural Component.** During the course of the whole learning path of the user and in a carefully automated selected time, the Rollback mechanism poses a selection of revising questions to the user, thus determining the overall progress upon the material. If necessary the mechanism suggests a revision upon the entire material already covered or selected parts of it.

5 CONCLUSIONS

In this paper, we presented LearneA, a novel Hybrid Personalized Learning Electronic Assistant that encompasses several personalization techniques. The basic architectural design of our proposed assistant has been illustrated and the basic functionalities have been outlined. The proposed system forms an innovative Personalized Assistant that resembles the usage and functionalities of other well-known assistants, like Siri and Cortana, focusing, though, on learning for particular courses. Furthermore, a number of other pioneering characteristics of the proposed system have been illustrated i.e. the integration of a text/speech recognition engine, the synchronization component and the behavioural component. We envision the harmonic cooperation of all these features within the Assistant, thus providing a diverse and personalized learning experience.

Our future plans include the elaboration of the design of LearneA, its stepwise implementation and, at the end the delivery of a product which will enhance in a significant way previous Personalized Learning Environments.

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