CHAPTER 1

INTRODUCTION

E-learning is becoming popular nowadays, and many learners learn by using online educational technologies. E-Learning provides an educational environment, where, learners are able to access educational materials, anytime, and at any place. With the growth and popularity of computer networks through the World Wide Web (WWW) and the Internet, e-learning technology has gained significance. The major limitations of the existing e-learning systems are that they provide learners with the identical educational materials, without considering the learners’ diverse knowledge levels, learner states, and learner preferences. In e-learning, learners’ profile information plays a major role in providing effective educational materials to the learners (Esichaikul et al 2011). This profile can be used for developing individual and adaptive learning courses and also take learners through the learning process so that the learner’s learning potentials and progress can be optimized. In this thesis, we discuss the challenges in adaptive e-learning, processes involved in providing learning objects for content design, instructional design strategies and machine learning approaches for achieving the above goals of e-learning.

1.1 ADAPTIVE E-LEARNING

Adaptive e-learning is a new approach that can make a e-learning system more effective by adapting the presentation of the learning content to suit individual learners, in accordance with their knowledge and behavior, and
based on a complete profile structure (Das et al 2010). Adaptive e-learning is expressed as a unique, integrated educational model that is customized to the individual learner’s needs and goals. Adaptive learning systems should not be restricted by time, place and learner’s other requirements, but mostly focus on learner’s preferences and current state of the learner to provide suitable learning content based on the learner’s situation and has driven the development of teaching and learning towards a dynamic learning environment. Adaptive e-learning system that considers the intellectual/cognitive characteristics of the learners is a comparatively new trend of research based on the combination of the pedagogical and technical aspects. Accordingly, e-learning systems should be able to integrate various learning content (theory, flow diagram, definition, block diagram, etc.), and navigation facilities in order to satisfy the needs of various learners.

Research in adaptive e-learning systems has addressed issues such as facilitation of the learning process of learners by providing recommendations, classifying learners based on various learning styles, or highlighting recommended learning paths. Research in e-learning, such as, personalized learning content suggestions (Chang et al 2012), dynamic learning path generation (Dharani & Geetha 2013), student model for adaptive learning (Graf 2013) and Student behavior prediction (Anari & Anari 2012) have been carried out. While the learning content can be offered in a flexible way, adapted to the individual learner’s behaviors through the e-learning system, the system can also deliver the learning content, so that it exploits the learner’s behaviors in order to optimize the learning results (Bhaskar et al 2010; Chu et al 2011; Hammami et al 2012). The challenges in the creation of adaptive e-learning systems, such as, tracking learner characteristics, deciding system design models and assessing the performance of the users have been illustrated in existing work (Mahajan et al 2012; Goyal et al 2012; El Bachari et al 2011).
Furthermore, obtaining adaptive learning content is an important issue and two major problems arise here: the “one size fit all” approach gives the same learning materials to each learner (Brusilovsky 2001; Stewart et al 2005), while the immense amount of information available leads to information overload (Berghel 1997). Thus, adaptive e-learning has gained attention in the last decade (Graf et al 2012; Dasgupta et al 2011; Dall 2009) basically in designing learning content according to the learners’ characteristics, goals, and capabilities.

1.2 LEARNING OBJECTS

Most educational materials located in the web environment or learning portals are in the form of digital objects. These digital objects are known as, Learning Objects (LOs) as they are used specifically for learning purposes in the educational environment (Noor et al 2011). The concept of learning object came about from the need to create highly structured e-learning content with pedagogical aspects in a way that it can be reused in different learning scenarios. LOs are small, self-contained and reusable units which represent learning materials. The IEEE Learning Technology Standards Committee (LTSC) describes learning objects as “any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning”. Learning object has also been defined as “any digital resource that can be reused to support learning” (Wiley 2000). Learning objects play a vital role during resources structuring of the learning content and sustaining flexible adaptive tactics for navigation through this content (Boytcheva & Kovatcheva 2005). To describe these learning objects, many metadata standards are available. The purpose of the Learning Object Metadata (LOM) (Hodgins & Duval 2002) is, to support the reusability of learning objects, to aid discoverability, and to facilitate their interoperability, usually in the context of online Learning Management Systems (LMS). One of the
objectives of this thesis is to recognize various essential processes of learning content design that can deal with the diversified learning objects with various information granularities, representation formats, learning objects processes based on the learning object metadata, so that each learner can utilize the learning object based on the learning scenario, which is adapted to the individual learners’ necessities. In the next section, we discuss about process that learning objects undergo during content design.

1.3 LEARNING OBJECTS FOR CONTENT DESIGN

The ultimate aim of the field of learning content design is to develop a common understanding of the learning material structures, make it interoperable so as to make the learning environment effective, and compose the educational content made available in any format according to the learners’ needs. Hence, the concept of ‘LO’ has been used in the field of learning content design for several years. In Chapter 2, we describe the processes involved in providing effective learning objects, such as, LO_design, LO_sequencing, LO_composition, LO_presentation and LO_evolution and their role at various adaptation levels of e-learning. The process of transformation of traditional learning materials into learning objects involves the selection, adaptation and transformation of learning materials so that they incorporate various design models, to meet different learning styles, needs and abilities. In other words, the developed e-learning content which incorporates learning objects should comply with the following main principles: Granularity, Interoperability, Accessibility and Adaptability (Wiley 2000) (will be discussed in chapter 2). Hence, we relate these LO processes and have carried out a survey with a new classification based on adaptation levels, learner context parameters and models/components of adaptive e-learning. In this research, we focus on e-learning content discovery, retrieval and re-ranking, learning object optimization and
sequencing. For adaptive e-learning, we carry out learner profiling, learner classification and dynamic course composition. These tasks basically focus on the learners’ behaviors and needs. Moreover, the learning objects can be adapted while designing the e-learning content, based on the individuals’ characteristics and goals. We focus on instructional design strategies and pedagogical principles while composing the learning content for adaptive e-learning system.

1.4 INSTRUCTIONAL DESIGN FOR E-LEARNING

Research on e-learning systems has found that the software design of e-learning systems do not completely cater to instructional and pedagogical strategies. Minimal guidelines are available for analyzing, designing, developing, supplying, and managing e-learning materials pedagogically. Instructional Design (ID) has evolved through a combination of three basic learning theories, namely, behaviorism, cognitivism, and constructivism (Alonso et al 2005). The goal of instructional design is to help the teaching and learning process by ensuring that education experiences are optimized for particular learning goals (Nichols 2010). Learning objectives and learning outcomes are the two terms that play an important role in instructional design strategies, which is applied at each level of education. Learning objectives are statements, usually of a behavioral nature, that specify what a student will be able to do after the lesson is completed. Learning outcomes are statements, which describes important and essential learning that learners have achieved, and can reliably demonstrate at the end of a course. This research focuses on learning objectives while designing and providing learning materials and ensures better learning outcomes.

ID is the art and science of creating instructional environment and materials that will bring the learner from the state of not being able to accomplish certain tasks to the state of being able to accomplish those tasks
The importance of instructional strategies is the creation of best practices guidelines for all aspects of the instructional process. The aspects are planning and management of online instruction, teaching techniques, student assessment and evaluation techniques. There are a number of different instructional design models. ADDIE is the famous model. In e-learning, instructional design is usually associated with the ADDIE model, which describes the process for entire courses (Nichols 2007). The author also stated that e-learning is sometimes seen as a sub-set of instructional design and e-learning is a partnership between pedagogy and digital technology. In this thesis, we follow the systems oriented Dick and Carey ID model, while designing the dynamic learning courses (Chapter 7). This model generally follows the ADDIE concept; but it provides the task-specific process steps at each stage. Another major focus of this thesis is the design and use of appropriate machine learning techniques for achieving the goals of the e-learning system.

1.5 MACHINE LEARNING APPROACHES

In web, a huge amount of documents are stored in unstructured format that is difficult for machine processing. Therefore, processing techniques are required in order to discover, retrieve and re-arrange the learning materials from an e-learning perspective. Machine Learning (ML) is a branch of Artificial Intelligence (AI) with powerful techniques, which are useful in the development of adaptive e-learning systems. In this work, we use a machine learning technique, called, Latent Dirichlet Allocation (LDA) for ranking mechanism, where we re-arrange the learning materials to suit e-learning scenario.

Generally, personalization plays an important role in all the areas. Specifically, in e-learning a main issue is learner modeling. Adaptive e-learning systems could accelerate the learning process by revealing the
strengths and weaknesses of each learner. They could dynamically plan lessons and personalize the communication and educational strategy. In adaptive e-learning, with the increasing complexity of adaptation tasks, the necessity for automated processing of usage data, information extraction and pattern detection grows. Therefore, machine learning techniques can be utilized for the collection, interpretation, and processing of learner activity and interaction data. A technique used for the interpretation of the data must be at least semi-intelligent as the information hidden in learner activities is too difficult to be detected by simple methods. Many intelligent approaches well-known in the field of machine learning can help to retrieve both fine-grained and multi-faceted information about individual learners and the associations and dependencies between them (Kock & Paramythis 2011). Hence, in this work we use Bayesian Belief Network (BBN) and Decision Tree (DT) techniques for learner classification, in order to identify the complexity level of learning content for all learners based on their characteristics.

In addition, there is a need to optimize the learning objects to provide enhanced learning content. We use Genetic Algorithms (GA) as the optimization technique for learning objects optimization and sequencing process in order to provide enriched and customized learning content to learners. Moreover, the problem of creating a user-friendly system that can learn from interactions with dynamic learning requirements is still unsolved. To tackle these dynamic interaction issues, we use, Spreading Activation Networks (SAN) and interaction based Reinforcement Learning (RL) technique in order to achieve the interactive based learning environment.

1.6 MOTIVATION

In e-learning content management system, search and discovery of appropriate learning content from open corpus sources is one of the major challenges. Though, the WWW provides access to a vast amount of web
content, efficient search process catering to requirements of e-learning remains as an issue. We need an effective searching mechanism for discovery and access to the required educational resources, which can then be used as e-learning content. This has resulted in the need to develop automatic methods for retrieving learning materials and ranking them corresponding to their significance to the specified query, yet again from the e-learning perspective.

The aim of adaptive e-learning is to provide students with the appropriate learning content. Since, the learning style of each learner is different; we must fit the e-learning to suit the different needs of learners. Hence, there is a need to classify learners based on their performance and knowledge level. Moreover, learner profiles play an important role in making the e-learning environment adaptive. However, using typical static learner profiles for adaptation, the users will not give the accurate results. Tracking the learners’ behaviors, preferences and performances dynamically are essential in adaptive e-learning. Furthermore, providing the learning content with redundant information and providing the same learning content to all learners leads to reduction in the learning progress. This factor motivated us to attempt the process of optimizing and sequencing the learning objects, in order to produce the enriched learning content and remove the redundant learning objects, without losing any important information conveyed by the learning content.

1.7 THESIS OUTLINE

This thesis is organized into eight chapters. Chapter 1 gives a general idea of the research problem of automatic content discovery from the web for e-learning, learner profiling, learner classification and learning objects optimization for adaptive e-learning, dynamic learning modules activation and composition and also discusses motivations of this research.
Chapter 2 presents the literature review on learning content design and learner adaptation for adaptive e-learning environment. This chapter generally focuses on learning object processes, at all adaptation levels and the relationships of these learning object processes with the learner parameters and e-learning components, since the learning objects play a key role in adaptive learning content design.

Chapter 3 provides the overview of our adaptive e-learning system and the corresponding modules carried out in this research work. Chapter 4 details the topic profiling, content discovery for e-learning using Information Retrieval (IR) techniques and ranking mechanism using LDA. Chapter 5 presents dynamic learner profiling and learner classification using BBN and DT techniques.

Chapter 6 discusses the learning objects optimization and sequencing process using GA, for providing the enriched and personalized learning content to learners. Chapter 7 presents dynamic learning content selection mechanism for learners to obtain their appropriate learning modules at each stage and compose the learning courses dynamically for e-learning, using, SAN and RL.

Chapter 8 concludes with the work done for the research towards adaptive e-learning environment, and discusses future directions of the work.