Chapter

Smart Learning Environment: Paradigm Shift for Online Learning

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Abstract

Online learning has always been influenced by advanced technology. The role of online learning is expected not only for delivering contents to massive learners anywhere and anytime but also for promoting successful learning for the learners. Consequently, this emerged role has introduced the concept of smart learning environment. More specifically, smart learning environment is developed to promote personalized learning for learners. Personalized learning focuses on individual learner and provides appropriate feedback individually. Currently, the advances of modern technologies and intelligence data analytics have brought the idea of smart learning environment into realization. Machine learning techniques are generally applied to analyze real-time dynamic learner behavior and provide the appropriate response to the right learner. In this chapter, the evolution of online learning environment from different points of technological overviews is first introduced. Next, the concepts of personalized learning and smart learning environment are explained. Then, the essential components of smart learning environment are presented including learner classification and intervention feedback. Learner classification is to understand different learners. Intervention feedback is to provide an individual response appropriately. Additionally, some machine learning techniques widely used in smart learning environment in order to perform smart classification and response are briefly explained.

Keywords: technology enhancing learning, smart learning environment, online learning, personalized learning, machine learning

1. Introduction

Generally, a face-to-face classroom environment is a traditional way of learning. For this learning, the teacher or the instructor can explicitly observe real-time interaction and participation of the learners. The advantage is that the instructor can provide the appropriate intervention immediately. However, face-to-face learning frequently faces some difficulties in challenging successful learning. For example, the instructor may find it difficult to gain attention from a large class. The adaptation of the teaching method can be challenging to fit in the large class size, such as flipped classroom, problem-based learning, active learning, etc. Generally speaking, time and space always affect learning management.

With the limitation of time and space, teaching and learning process has been transformed into many different forms for promoting effective and convenient

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learning. Pieces of evidence show that innovations of a system supporting learning usually employ the technologies emerging at different points of time [1]. Computer aided instruction (CAI) and instruction tutoring system (ITS) demonstrate the excellent examples of the system supporting learning with the advance of computer technology. They can provide convenient learning without the instructor as traditional learning through a stand-alone computer program. Both CAI and ITS are generally used for supplementing traditional face-to-face learning [2, 3].

Online learning has become the solution of time and space constraint explicitly. After the introduction of computer communication, electronic learning (e-learning) has been developed based on the basic requirement of delivering content in the digital form to the massive learners conveniently anywhere and anytime [4, 5]. Without time and space constraint, e-learning can be used not only for supplementing the face-to-face class but also the main class as an online course nowadays [6]. E-learning even becomes more popular after the high-speed Internet becomes commonly available and low cost. It is also customarily called web-based learning (WEB) [7, 8]. As shown by its name, web technology has influenced the presentation of e-learning. For WEB, interactive learning is also one of the main purposes besides convenient learning [9]. Web 2.0 has demonstrated how effectively web technology can promote interactive learning [10]. Interactive environment helps the online classroom to be more interactive overcoming the limitation of space as in the traditional classroom environment.

With mobile technology, mobile learning (m-learning) has been widely offered. The mobile phone becomes the smartphone having high-performance computing ability within portable size devices. It is evitable that mobile phone or portable devices have become necessary for the learner's daily life. M-learning explicitly promotes convenient learning which the learning process can happen anywhere and anytime, although the learning process on a small screen of the mobile phone might be easily distracted for some learners [11]. For m-learning, interactive learning is very challenging because of the small screen and the compatible ability of smartphone. However, it is easily integrated into the learner's daily life.

Currently, there has been the introduction of ubiquitous learning (u-learning) [12–15]. It employs the concept of ubiquitous computing [16] in which the computing can happen anywhere and anytime through the seamlessly connected small computing units. The users do not even realize about computations. For u-learning, learning can happen anywhere and anytime. Notably, the learning process of each learner happens unconsciously. The learners do not even realize those learning process. U-learning can be implemented as the physical learning environment [17]. For this environment, the contribution from different types of advanced technology such as sensors, sensor networks, embedded system, wireless communication, etc. is required. U-learning is commonly used for providing situation simulation for the learners. At the same time, u-learning is generally developed to guide the learners to achieve their learning goals or outcome individually with different learning paths and contents. It can be considered that u-learning has confirmed the concept of personalized learning, which the learning depends on individual context [18] such as needs, performances, goals, etc.

Online learning can also be considered with learning style points of view. Generally, online learning can promote both collaborative and individual learning. Collaborative learning believes that the learning process happens when the learners collaborate [19]. The learning outcome can be evaluated from the group product or even the consensus built within the group. Collaborative learning is important because this kind of skill is one of the marketable skills required in real-life situation. More specifically, collaborative learning aims to practice collaborative skills for the learners besides knowledge. It is essential for learners to learn how to encourage and engage team members to accomplish a common goal together.

On the other hand, individual learning aims to promote each learner individually. The assumption is made that all learners are unique and they require their learning path to achieve their individual learning goals. Personalized learning is one of the famous individual learning approaches. It can be implemented in many different forms and types of learners. It is popularly implemented as the curriculum for child learning [20] because of the expectation to enable the unique development of the child. Although, there are many different ways for the personalized learning pedagogy in child learning curriculum, the most critical processes are to assess an individual carefully and to provide the intervention appropriately. At the same time, personalized learning is widely found in online learning. Also, those two processes are essential for this environment. It has been claimed that personalized learning promotes flexibility and freedom for the learners as they are necessary not only for the twenty-first-century learning but also for lifelong learning.

2. Online learning environment

Generally, online learning is also called a virtual learning environment (VLE) [21–24]. After the emergence of the Internet in early 1990, VLE has been playing the leading role to support learning and teaching activities through Internet connection. Generally, VLE is used for distance learning as a complement to the traditional classroom. It provides convenient access to contents, tests, and virtual workspaces. It also provides communication tools and assessment for the instructor. Additionally, it is defined to cover the existing online learning environment including e-learning, m-learning, and u-learning.

In the recent past, VLE or online learning environment has successfully achieved a considerable interest from the learners worldwide. For example, massive open online course (MOOC) [6, 25], which is the largest online learning platform nowadays, provides massive online courses from all over the world for all learners. Although there are many provided online courses available, the learners are expected to be the active participants who know their own learning goal and can find their ways for achieving their goal. On the contrary, the concept of smart learning environment is that the learning system is smart enough to understand the learners individually both capability and personality so that it can provide the appropriate response or intervention appropriately. The learner may not even realize the happening learning process [14, 15].

2.1 Personalized online learning

As mentioned before, personalized learning is a significant characteristic of the smart learning environment, which expands the opportunities for lifelong learning and explores additional resources for individual according to personal interests [26]. Recently, personalized learning has become the most popular learning paradigm because it focuses on learners' interests. It is also tailored to promote online learning as personalized online learning [27]. Generally, personalized online learning can be described as the teaching and learning paradigm applying intelligent technology for matching the learners with the content or learning activities accordingly to their proficiency level, learning styles, and interests through different types of learning environments. Currently, personalized learning is extensively popular because it results in the awareness of learners' actual proficiency and needs. The instructors can design the course or give proper suggestions for the best results of learning.

In the early stage, the English instructional systems have been playing the primary role for personalized support for learners [28]. It makes the learners to be engaged with the learning system. The recommendation is given through the selection of lessons that can be matched with the learners' skills and abilities [29, 30]. Nowadays, personalized learning can easily simulate the situation for engaging the learners in a lesson, discussion, and any learning activities [31–33]. It can also provide online learning experience that professionals will need for professional learning. At the same time, web-based learning becomes a flexible way to promote personalized learning recently [10]. Currently, there is an increasing demand for personalized online learning to serve huge demands of learners with all ages [34, 35]. It is thus challenging to provide personalized online learning that can satisfy all current and future demands.

2.2 Personalized online learning and challenges

As mentioned before, personalized learning aims to promote successful learning individually. Understanding different learners are challenging since the learners are different in many aspects such as age, goal, need, etc. Personalized online learning is widely adopted for all learners of different ages. Different ages of learners imply different characteristics and require different intervention or recommendation. For child learning, the learners are still immature. The child might not know exactly their performances and their goals. There is the necessity to have the professional to estimate the potential performance and predict the learners' needs. For the teenager, some of them have explicitly shown their interests, goals, and demands. However, their goals can be changed dynamically due to many circumstances such as friends, family, school, etc. For professional learning, the learners know precisely about their goals. However, their different knowledge and backgrounds usually affect the ability to learn the same content. The content representation needs to be adjusted to fit different learners. For senior learning, their goals usually are clearly defined. However, the health condition may distract their ability to learn. Nowadays, implementing personalized online learning for learners of all ages is very challenging, as the learning environment is expected to cope with any differences dynamically. The environment needs to be smart enough to deal with and interpret any types of data. Consequently, smart learning environment is indeed required.

3. Smart learning environment

The concept of smart learning environment has been widely introduced [15, 36, 37] to satisfy the high demand for freedom in learning. Smart learning environment means that the learning environment can promote successful learning to the learners automatically. The concept of being smart can be implemented with both physical and online learning environments. The critical requirement is to make the environment to be smart. There have been many smart learning environments developed with a different degree of smart services or responses. For this chapter, smart learning environment focuses on only the online learning environment. More specifically, smart services or responses in an online learning environment mainly focus on promoting individual learning. It can be seen that smart learning environment in this context requires the implementation of personalized learning.

Generally, smart learning environment consists of two main components including learner classification and intervention feedback as shown in **Figure 1**.

In **Figure 1**, the learner classification is also called as learner modeling or learner assessment. For this component, the primary objective is to understand the different learners. There are different types of information which can be called as the contexts involved, such as individual context and interaction context, to classify the learner. Individual context includes any information relating the learner individually such as profile, preference, performance, goal, need, clinical data, etc. On the other hand, the interaction context means the context is generated from the interaction of any entities such as interactions among learners, interactions between learner and learning object, interactions among learning objects, etc. The combination of different types of contexts is expected to provide a better understanding of the learners. The classification can be done in many different ways.

In this chapter, machine learning-based data classification is the main focus. Machine learning is widely used for data classification. For learner classification, all involved contexts are classified into different types of learners. The machine learning technique learns the data and makes a decision based on the data. It can employ both supervised and unsupervised learning to perform data classification. Supervised learning technique requires the given answer for the classification process. On the contrary, the unsupervised learning technique can perform data clustering without any given answer during the training process. Selecting the right technique is challenging; the comparison between different techniques is generally performed. The knowledge-based system is usually required for determining different types of learners. Human experts generally do this process. At the same time, the intervention feedback provides the appropriate intervention to each learner. This process is to map the types of learners with a set of appropriate intervention obtained from the experts. Sometimes, the predictive model may be involved. Predicting what the learner wants and what they want to be after learning may help to provide the intervention more appropriate. Additionally, the predictive model frequently employs machine learning-based technique for analyzing historical data and predicting the right output based on any relationship among data. Generally, the contribution from different areas may be involved in the learner classification component to increase higher classification accuracy such as behavioral science, physiology, cognitive science, etc.

Along with the evolution of technology, supporting learning mentioned before, the concept of context-aware computing [38] has already illustrated implicitly and explicitly into the modern online learning environment nowadays. Generally, context-aware applications can be found with different forms of online learning

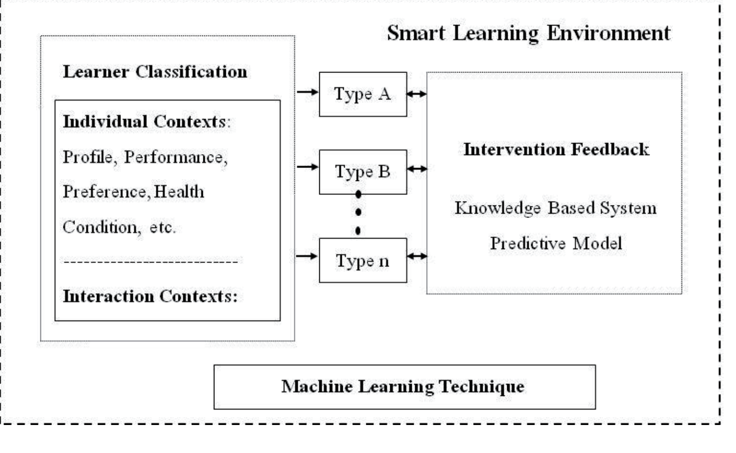

Figure 1.
Components of smart learning environment.

environment covering from stand-alone program and web-based, mobile, and ubiquitous learning environments. With the context-aware computing perspective, existing smart learning environments can be considered as a context-aware computing system. Any recommendation systems [39–41] frequently assess the learning's ability and employ it as the main factor for providing the appropriate response. The learner's ability can be considered as the primary context executing the smart intervention. The contexts used for smart learning environment can be any single context or the combination of many types of contexts [42]. It can be concluded that the vital element of context-aware computing is context awareness which is explicitly appropriate for smart learning environment so that all dynamic changes are observed, interpreted, and responded appropriately. It can be seen that developing a smart learning environment which can provide personalized learning for the learners requires the solution from multidisciplinary such as behavioral science, physiology, cognitive science, etc.

In conclusion, smart learning environment in this chapter mainly means the online learning environment with personalized learning implementation. This learning environment is expected to automatically respond to the learners appropriately for achieving their learning goal individually. For this instance, it is evitable to have advanced technology in many areas for satisfying smart ability of this learning environment. Machine learning-based techniques are the main aims of this chapter. Some techniques commonly used in the learning area are also briefly introduced in this chapter.

3.1 Machine learning for smart learning environment

Machine learning is a method of data analysis for building analytical model autonomously. It is a subset of artificial intelligence. As humans learn from experience, machine learning learns from data. It is widely used for identifying and classifying the pattern as well as making a decision on behalf of the human. Machine learning is popularly used in classifying problems in many different areas, such as manufacturing, finance and banking, and medical diagnosis [43]. For the learning environment, machine learning is generally used for supporting the learning and teaching process on behalf of a human instructor. As mentioned before, smart learning environment requires not only an automatic response but also an individual response. Machine learning technique applied in smart learning environment requires specific knowledge from different points of view to understand each learner correctly such as pedagogy, behavioral science, psychology, etc. For example, from the pedagogical point of view, different teaching approaches can engage different learners. From the behavioral science point of view, the individual learner acts differently when they are in the learning process. From the psychology point of view, the learner can be classified into different learning styles representing individual ways of gathering information and absorbing the knowledge. Machine learning needs to be trained with this different knowledge so that the classification of learner and intervention will be performed and given correctly.

Many machine learning techniques have been widely applying K-nearest neighbor (KNN) for different purposes such as learning analytics supporting instructor decision [44], predicting successful learning for the learners [45, 46], classifying learning patterns [27, 47], predicting the learning outcomes from historical learning behavior of each learner [45], etc. Another popular method for pattern classification problem is an artificial neural network (ANN). It usually is one of the comparative alternative techniques for learner classification [48]. Lastly, decision tree has also gained much attention for grouping or matching different types of learners to particular recommendation or feedback [27, 49].

In this chapter, a brief introduction of these machine learning techniques is introduced. The examples are shown in the next section to demonstrate the principle concept of applying K-nearest neighbor, artificial neural network, and decision tree for simple learner classification.

3.1.1 K-nearest neighbor

K-nearest neighbor algorithm is a type of lazy learning in pattern recognition. It is used to classify and perform a regression of the dataset. It can define whether target data matches with the specific classes by investigating the number of K in the nearest condition. It will assign the weight for any contributing data along with the distance of neighbor to classify the target. **Figure 2** shows the principle concept of KNN applied for classifying types of learners.

In **Figure 2**, KNN is applied for classifying two types of learners including learner requires assistant (learner with assistant) and learner does not require assistant (learner without assistant). The learning expert sets types of learners for the training process. The input of KNN can be any context relating to performance assessment of learners such as testing score, testing time duration, etc. It can be seen in **Figure 2** that the classification result changes accordingly to different K values. For K = 3, the new learner is classified as the learner does not require the assistant. For this case, two nearest neighbors of the new learner are learners without an assistant, and only one nearest neighbor is the learner with the assistant. However, when the nearest neighbor number has increased to 5 (K = 5), the classification of the new learner is the learner requires assistant because three out of five nearest neighbors are learners who require an assistant. Therefore, different K may cause a different decision. Generally, there are many considerations, such as K value, size of input data, etc., for obtaining the highest classification accuracy.

3.1.2 Artificial neural network

Having the inspiration by biological neuron networks, artificial neural network is widely applied in many application domains. An ANN consists of many neurons linked together with specific network architecture and learning algorithm. Those neurons usually are highly interconnected among each other. It can have many layers between the input and output layer so-called hidden layer. For learning algorithms, ANN learns from the examples and presents some degree of generalization

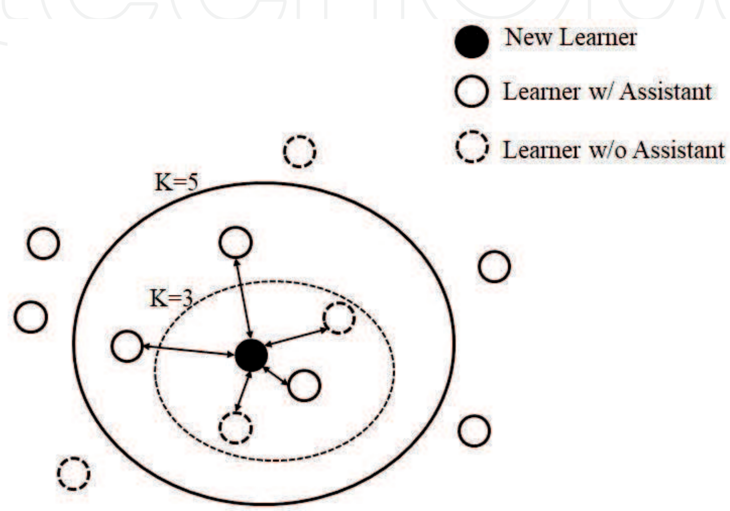

Figure 2.
Principle concept of KNN for learner classification.

from the training data later. Also, ANNs adapt itself by using some examples of similar problems with and without the desired solution during the training period. After sufficient training, the trained ANN can provide a solution relating to inputs and outputs. Moreover, it can offer an alternative solution to the new problem. The conceptual diagram of applying ANN for learner classification is shown in **Figure 3**.

Figure 3 shows that ANN is applied for classifying two types of learners including learner requires assistant (learner with assistant) and learner does not require assistant (learner without assistant). The learning expert sets types of learners. ANN learns from the examples or data during the process of the so-called training process. For the learning process, the corresponding type of learner together with its set of training data is required. The data can be any context, for example, the set of data representing the level of performance of the learners, time duration for content learning, etc. During the training process, the associated weights are adjusted so that the ANN can model two different types of learners correctly. The training process may require many times of iteration. Training parameters need to be set appropriately. Then, the trained ANN with updated weights is tested with testing data, which is the data from the new learner. ANN will finally classify the new learner into one of those two types. Selecting the type of ANN is challenging because different types of data fit with types of ANN differently. The comparison of classification accuracy among different types of ANN, different architecture, or even different configuration may need for achieving the highest classification accuracy.

3.1.3 Decision tree

The decision tree is another favorite machine learning technique for data classification. It is a predictive method having a tree structure which is built from a dataset for classifying data. More specifically, it has the leaf to represent a classification. The conjunction of features causing target classification is represented at each branch. The tree structure is constructed following the best attribute that can perform the best splitting set of data. The efficiency of this technique highly depends on the size of the training data. The conceptual diagram of the decision tree for learner classification is demonstrated in **Figure 4**.

In **Figure 4**, the decision tree is applied for learner classification problem which has two different target classes including learner requires assistant (learner with assistant) and learner does not require assistant (learner without assistant). The learning expert sets types of learners for training. As mentioned before, the training

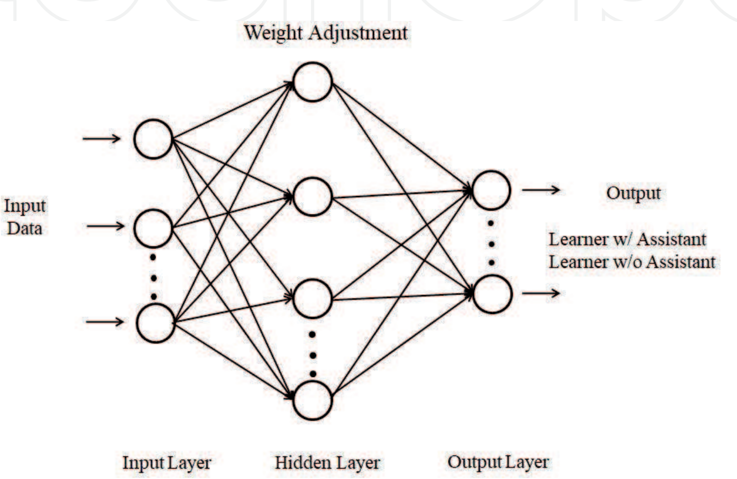

Figure 3.
Conceptual diagram of ANN for learner classification.

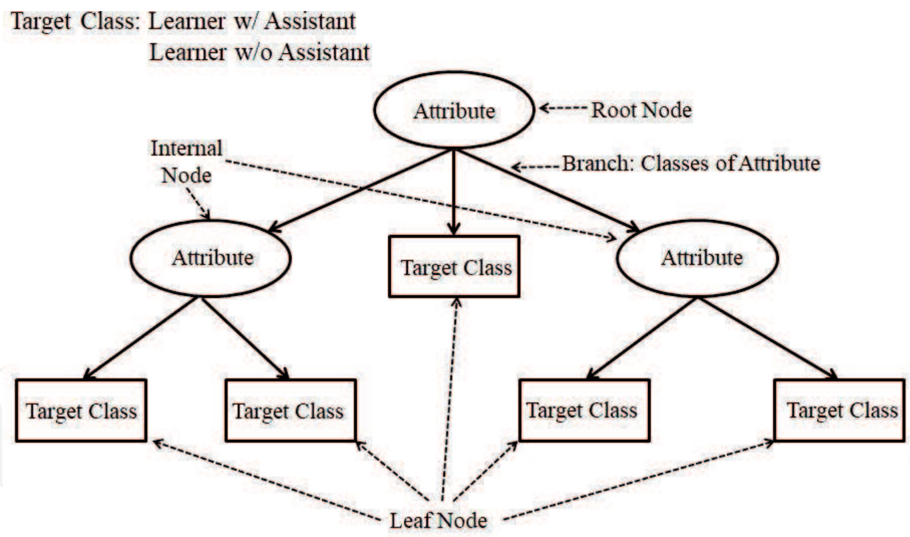

Figure 4.
Conceptual diagram of decision tree for learner classification.

data can be any context representing the performance level of each learner. After having the set of training data, the root node representing the best attribute can split the training data the most. Classes of the associated attribute are represented at each branch. For splitting data, all internal nodes represent all attributes involved in data separation. Target class is represented at the leaf node whether the learner requires or do not require the assistant. At the end of the process, all relevant rules are constructed based on all relevant attributes. The size of the training data always influences the separation of data. More specifically, different data sizes may obtain a different tree structure.

4. Conclusion

This chapter presents the concept of smart learning environment as the online learning that can promote personalized learning. For this instance, the smart learning environment consists of two main components including learner classification and intervention feedback. The objective of smart learning environment is to understand the different learners individually and provide each learner with the appropriate support or intervention for successful learning. Therefore, it is necessary to have smart data analytic method so-called machine learning technique involved particularly in dealing with a vast of dynamic change and real-time intervention. For this chapter, KNN, ANN, and decision tree are chosen to demonstrate for solving a simple learner classification problem. Although machine learning has been playing a critical role in a smart learning environment, supporting learning and teaching still require the knowledge from the multidisciplinary area such as pedagogy, behavioral science, psychology, etc. so that the leaner classification and intervention feedback in the smart learning environment can be performed correctly.

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