Research Paper

ALSDOC: ADAPTIVE LEARNING STYLE FOR DOCUMENT RETRIEVAL

Nur Baiti Afini Normadhi¹
Department Information Systems, Faculty
Computer Science and Information Technology,
University of Malaya
nurafininormadhi@gmail.com

Liyana Shuib²
Department Information Systems, Faculty
Computer Science and Information Technology,
University of Malaya
liyanashuib@um.edu.my

Mohd Hairul Nizam Md Nasir³
Department Software Engineering, Faculty
Computer Science and Information Technology,
University of Malaya
hairulnizam@um.edu.my

Abstract

Learning can be enhanced when its learning process aligned with learner learning styles. Individual has different learning preferences. The consideration of learner preferences in finding document can enable a learner to obtain knowledge easily and fast where it constantly changes and shift according to learning situation and environment. Thus, the incorporation of Learning Style (LS) with adaptive learning environment is one of a method to assist novice learner in finding a suitable document and enhance the e-learning system; while it can overcome the one-size-fits-for-all problem. The LS identification is an important component to identify the learner learning style. There are two conventional techniques to identify learners learning style, which are questionnaires and computer-based detection technique. The questionnaire involves the learner to fill up a survey explicitly. However, existing of LS identification techniques facing some major drawbacks can lead the LS tool to become static nature. The questionnaire technique facing issues such as questionnaire too long and took long time that can make learner lack of motivation to answer the question. Moreover, the result from the questionnaire technique is fixed because it only prompts a learner to do it only one at the time. Therefore, a few researchers employed computer-based detection techniques, which use a numerous computer algorithm to determined LS. However, these techniques suffer on cold start problem, required a large amount of training data and the existing computer-based detection were not focused document as learning material. Hence, there is a need to develop an adaptive learning style identification that uses document as a learning material. This paper presents the architecture for ALSDoc, an adaptive LS identification for document retrieval. In particular, this study explained how LS is adapt to the learner that allows the retrieval the suitable document that match their LS.

Key Terms: Adaptive Learning Environment, Collaborative Learning, Learning Style, Information Retrieval, Document.
1. Introduction

E-learning is a platform which let learner learn and grasp knowledge through the network, whenever and wherever they want. However, most of the e-learning have ignored the individual difference and retrieved a unified documents (Chen & Zhang, 2008). Furthermore, a one-size-fits-for-all is one of the major limitations in e-learning. This is because of the same documents are provided to all students (Halawa, Hamed, & Shehab, 2016). Therefore, a few researcher has employed an adaptive learning systems which take into account learner preferences. This is because finding a suitable document based on learner preferences can help enhanced their learning process (Hidayat & Utomo, 2017). It can be verify according to the facts and data where some of the learner prefer learning based on experiences, some other prefer learn through visual representation and some prefer to the verbal and audio (Kusumawardani, Prakoso, & Santosa, 2014).

Learning Style (LS) can be defined as an individual characteristic and preferences in the way of receive and perceived information (Fleming, 2012). By alleviating and incorporation of LS in the adaptive learning systems, it will have some benefit. First, the learner can obtain knowledge easily and fast (Pourhosein Gilakjani, 2011). This is because of learner preferences constantly shift and changes according their preferences. Secondly, since learner know how to learn according to their learning preferences. Learner can improved their understanding and increase the confidence (Pourhosein Gilakjani, 2011). Lastly, by integrating LS in adaptive learning environment, student can experienced a personalized experience whereby the recommended document are tailored to their learning style.

However, major limitation in integrating LS in the adaptive learning system is the need of identification technique to identify learner learning style. There are two types of LS identification technique which are by using questionnaire and computer-based detection. Initially, LS is identified by using questionnaire technique which learner was asked to complete a survey or questionnaire (Pham & Florea, 2013). However, this technique faced limitations such as learner has lack motivation to answer a tons of question in questionnaires, take extensive time to complete the questionnaire, random guess, fixed learner learning style result and learner reluctant to answer (Truong, 2015; Mwamikazi, Fournier-Viger, Moghrabi, Barhoumi, & Baudouin, 2014). Hence, some of researcher employed a computer-based detection technique to overcome aforementioned limitation in the questionnaire technique. A computer-based detection technique use numerous program or algorithm to automatically identify learning style (Pham & Florea, 2013). However, this technique also faced several limitations such as cold start problem (Baldiris, Graf, & Fabregat, 2011), required a huge training data to process which takes extensive time (Lukasenko & Grundspenkis, 2010) and the existing technique were not focused document as learning material to recommend and adapting in the adaptive learning system.

Therefore, it is important to develop an adaptive learning environment according to the learner’s learning style using VARK learning style (Fleming, 2012). Fleming (2012) introduced VARK learning styles, which represented Visual, Aural, Read/Write and Kinesthetic. VARK learning style is suitable for document representation since is a sensory perception where learner is learn through of the sense (Hamtini, 2015).

The rest of the paper is organized as follows. Section 2 present the literature review. Section 3 present the methodology of this research. Section 4 present the architecture. Conclusion and future works are covered in Section 5.
2. Literature Review

In recent years, the development of an adaptive learning system with LS has drawn interest in the area of computer-based learning. The adaptive learning system is referred to the computerized system which tries to adapt the individual characteristic by presenting the learning materials according to learner preferences (i.e. LS) (Surjono, 2011). The adaptive learning system was developed by overcoming the conventional of e-learning that presents the same material to all learners (Surjono, 2011). Moreover, the information in the learning material can be presented in various forms such as text, pictures, flow charts, maps, drawing, figures and mathematical expression (Shuib & Abdullah, 2013). Therefore, a suitable learning material presentation according to the learner preferences can assist the learner in improving his or her understanding, confidence and learning process.

According to Kay (2006), the adaptation has two types of way where it depends on who takes the initiatives either the system or learner. The adaptivity is referred to when the system is initiated, which the system has the capability to adjust its presentation based on learner characteristic automatically. Furthermore, the adaptability is referred when the learner is initiated which the capability of the system to support learner modification.

LS drawn a research interest which considered as an adaptivity dimension (Hazra, Patnaik, & Suar, 2012). There are several of LS models introduced by researchers such as Kolb (Kolb, 1984), Felder and Silverman (Felder & Silverman, 1988), Fleming VARK (Fleming, 2012) and others. Previous researches have employed these models to develop an adaptive system based on LSs. For instances, Shuib et al. (2013) developed an information seeking tool by taking learner learning style into account to assist a learner finding a suitable reading material. Fasihuddin, Skinner, and Athauda (2014) proposed an adaptive learning by monitoring the certain learners’ behavior (i.e. LS) while learner interact with learning materials; then use a recommender agent to recommend learning material according learner LS. Graf et al. (2010), proposed an adaptive learning system by using a navigational behavior of learner during learning process to investigate the state of learner with different learning style that’s learner prefer to use and learn during learning process.

2.2 Learning style

Learning style can be defined as the individual characteristic in the way of their perceived and received information (Noraziah et al., 2011). Therefore, different learner has a different learning style (Fasihuddin et al., 2014). There have many of learning style models has been proposed by the researcher. Most of learning style model divides a learner into a few dimensions. This is due to the learner learning style is constantly shift and changes based on learning situation and environment (Wan & Chengling, 2012).

In this study, the learning style that has a sensory perception which learner learn through of the sense that divided into visual, aural, read/write and kinesthetic (Hamtini, 2015). Fleming and Mill (2012) proposed the learning style model that uses a sensory perception; namely, VARK which are acronym of Visual, Aural, Read/Write and Kinesthetic. The four preferences of VARK learning style as shown below:
Table 1: Preferences in VARK learning style (Fleming, 2012).

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Preferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual (V)</td>
<td>Learner is those prefer pictures, diagrams, charts and other diagrammatic representation for study.</td>
</tr>
<tr>
<td>Aural (A)</td>
<td>Learner prefer video presentation.</td>
</tr>
<tr>
<td>Read/Write (R)</td>
<td>Learner is prefer to read textbooks, papers, reports, essay and assignment.</td>
</tr>
<tr>
<td>Kinaesthetic (K)</td>
<td>Learners learn by experience and real-life examples.</td>
</tr>
</tbody>
</table>

The VARK learning style was suitable for learning material such as document presentation where it provides a medium of self-learning and exploring opportunity during the learning process. Moreover, this LS can be adopted into multimodal learning style (Fleming, 2012). Moreover, the VARK learning style is a sensory perception where it is combining the perception and memory of an individual in the way of their receive and stores information (Shuib et al., 2013). However, the indicator to identify learning style in the adaptive learning environment is an important parameter to make sure it can identify learner preferences in the adaptive learning system. Section 2.3 discussed the learning style identification used in the adaptive learning environment.

2.3 Learning style identification technique

In literature, there has two type of learning style identification techniques, which are questionnaire and computer-based detection. The questionnaire required a learner to fill up the several questions explicitly (Khenissi & Essalmi, 2015). The researcher has employed a questionnaire according to the learning style models such as Kolb's learning style model and experiential theory used 80 questions to identified learner learning style (Kolb, 1984), Myer-Briggs Type Indicator (MBTI) used 90 questions (Briggs & Jung., 1944), Felder-Silverman Index of Learning Style (ILS) use 44 questions (Felder & Silverman, 1988) and Fleming VARK use 16 questions (Fleming, 2012).

There has several previous researchers has employed this technique in the adaptive learning environment. For example, Soflano, Connolly, and Hainey (2015) use an ILS to identify Felder-Silverman learning style which is integrated into the adaptive learning environment and Shuib et al. (2013) asked a learner to answer 16 questions of Fleming VARK learning style before beginning the searching process. However, there is some a limitation in this technique such as learner lack of motivation to answer the tons collection of the question in the questionnaire which take extensive of time to complete (Mwamikazi et al., 2014). There are also some the individual factors such as reluctant to answer, random guess and inaccurate judgement which can lead to the identification of LS towards learner are not accurate (Mwamikazi et al., 2014). Beside that, the learner were asked to frequently update their LS manually since the result of LS is fixed and asked to do it at only one time can lead to unreliable learner model (Latham, Crockett, & Mclean, 2013).

Hence, a few researcher employ a computer-based detection technique which use a numerous computer program or algorithm to automatically identify learner LS (Khenissi & Essalmi, 2015). The computer-based detection technique uses a machine learning and non-machine learning technique. Machine learning technique is a technique that uses algorithms which need computer programming efforts (Ethem & Alpaydin, 2004). Non-machine learning is a traditional programming technique which is explicitly understand the feature activity (Sommer & Paxson, 2010). Table 2 shows the existing computer-based detection technique used in the adaptive learning system.
Table 2: Existing computer-based detection techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Learning Material</th>
<th>Learning Style Model</th>
<th>Limitation</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuzzy logic</td>
<td>Video Games</td>
<td>Felder Silverman</td>
<td>Lack of Transparency Problem</td>
<td>(Khenissi and Essalmi, 2015)</td>
</tr>
<tr>
<td></td>
<td>Audio and Video Tutorial</td>
<td></td>
<td>Take extensive of time</td>
<td>(Crockett et al., 2013)</td>
</tr>
<tr>
<td>Bayesian Network</td>
<td>Dialogue</td>
<td>Fleming VAK</td>
<td>Insufficient information for new learner.</td>
<td>(Rajper et al., 2016)</td>
</tr>
<tr>
<td></td>
<td>Video, Audio, picture, dialogue</td>
<td>Kolb’s LS</td>
<td>Not focusing on document presentation.</td>
<td>(Permanasari et al., 2014)</td>
</tr>
<tr>
<td>Association Rule based</td>
<td>Dialogue and course link</td>
<td>Myers Briggs</td>
<td>Insufficient information for new learner.</td>
<td>(Halawa et al., 2016)</td>
</tr>
<tr>
<td></td>
<td>Dialogue</td>
<td>Felder Silverman</td>
<td></td>
<td>(Santos et al., 2014)</td>
</tr>
<tr>
<td>Decision Tree</td>
<td>Video Games</td>
<td>Felder Silverman</td>
<td>Required large amount of training data to process.</td>
<td>(Lin et al., 2013)</td>
</tr>
</tbody>
</table>

As shown in Table 2, different techniques used to identify LS automatically for adaptive learning systems. For example, Rule-based technique which are applied a rules to map a pattern of learner behaviours that associated with particular learning styles (Felder & Silverman, 1988). Bayesian Network which uses a probabilistic model that has been used to take into account of LS based on the history of learner behavior interaction in the adaptive learning system (Garcia et al., 2008). Decision tree uses to predict the value of LS from the value that has been inputted based on learner behaviour (Cha et al., 2006). However, this computer-based technique faced limitations such as cold start problem during obtaining information for the new learner (Baldiris et al., 2011) and it required huge training data to process the algorithms (Lukasenko & Grundspenkis, 2010). Furthermore, the existing computer detection technique does not cover the document as learning material as shown in Table 2. Hence, the new learning style identification technique is needed.

3. Research Design and Methodology

The research methodology of this study consists of three stages:

Information gathering: This is the first stage of this study to collect the information that related to this study. The problem, research objective and significance of this study have identified in this stage. This stage was carried out the literature analysis and conducted a comparative study on the previous work which is related to this study.

Design and development: This phase involved design and development of technique and ALSDoc system. The Rapid Application Development (RAD) software methodology was used in this study to develop a ALSDoc system. The RAD was used since it is decreasing the time and cost in delivery the system. The RAD consist four phases which are requirement planning, user design, rapid construction and cutover (Butz, Sigaud, & Gerard, 2003) The module to develop the architecture were implemented and identified in this stage.
Evaluation: This is the final stage which involved in conducting the evaluation. The ALSDoc was evaluated using a Technology Acceptance Model to find the degree of acceptance of used by measuring the perceived usefulness and perceived ease of use. This evaluation as follow the guideline based on Davis (1989).

4. The architecture

This study developed a learning environment that retrieves a document according learner LS by identify learner LS in adaptive way. This study proposed the ALSDoc system. Identification LS is as part in the search process. This section present the architecture of ALSDoc. The modules of ALSDoc are:

- Input module: Received inputs information from learner and administrator.
- Process module: This is module contains three main model, which are learner model, domain model, and adaptation model. This module use information from input module to categorize and match the document with the learner learning style.
- Database module: The information about learner and document that provided by administrator was stored in this module.
- Output module: This module display the result from the process module.

The architecture is shown in Figure 1.

4.1 Input module

The input module receives information about learner which will be used to construct a learner model in the process module. The document information such as title, author, description and document LS is provided by administrator. The document LS is analysed using analysis technique in Shuib & Abdullah (2013).

4.2 Process module

The three basic models in the adaptive learning environment are used and it adopted in this module. The three models were interacting with each to assist a learner in finding and recommend the suitable document adaptively.

![Figure 1: ALSDoc Architecture](image)
4.2.1 Domain model

The domain model represent the structure of knowledge about the domain to be learnt. The domain in this study present the document's content information that were selected to be presented to the learner. The content information can be a various domain concepts such as theory, case study, example, glossary and tutorial (Siadaty & Taghiyareh, 2007). Hence, the document is chosen as learning material which it can represent various form of content information such as picture, mathematical expression, diagram, mind map, text and etcs (Shuib, Normadhi, & Shuib, 2015) which can be mapped with VARK LS. The feature extraction technique (Shuib et al., 2013) were adopted in this study to analyze the document LS based on VARK LS. Table 3 shows the consideration of element to analyze LS in the document.

Table 3: Consideration element according to learning style in the document.

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Visual</th>
<th>Read/Write</th>
<th>Kinesthetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primitive Element Category</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagram</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-Graphic</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case Studies</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Practice</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Text</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

4.2.2 Learner model

The learner model in this system architecture is divided into two learner profiles which known as static and dynamic learner profile. The static learner profile is the learner demographic information such as name, age, gender, institutions, educational level, username and password. The dynamic profile is the profile which consists of information about learner learning style, feedback and history where it can be modified and updated. The information in the dynamic profile will be process based on interaction of domain model, learner model and adaptation model.

4.2.3 Adaptation model

This model constitutes the core of this proposed system. The learner will insert the keyword in the ALSDoc search engine. The search engine of ALSDoc would be built by combining the Term Frequency Inverse Document (TF/IDF) index. Then, after the search engine would process the inputted keyword. The learning style is determined by using feedback that learner given on recommended document that relevant to their preferences.. In this study, feedback support will response all the learner preferences activities according to document content presentation. Hence, once the learning style of the learner is identified, the ALSDoc system will automatically implement the adaptation by recommending document that relevant to learner new detected learning style.
The process of matching the document into learner LS is executed after there is searching process. Then, the recommend document will be listed based on top-N which are organized from highest to the lowest according learner feedback on particular document.

4.3 Database module

This module consists of two databases which are learner and document databases. The information about learner which are gather on input module will be stored into learner database. Then, the information of document was stored into document database.

4.5 Output module

The recommended document based on identified learner LS would be identified in this module. Learner were asked to give feedback on each suitable document that they are preferred.

5. Evaluation

This section discussed the evaluation on ALSDoc system. The Technology Acceptance Model (TAM) has been used to conduct this evaluation. This TAM evaluation is widely used to performed user acceptance and satisfaction of the proposed system (Davis & Brandt, 2002). The perceived usefulness and perceived ease of use are used to measure user acceptance and satisfaction in this evaluation.

This evaluation was conducted on 80 participants from Faculty of Computer Science and Information Technology, University of Malaya. The participants were instructed to use the system before they start exploring and use the ALSDoc. After that, the survey was distributed which contained there section which is demographic, perceived usefulness and perceived ease of use question based on (Davis, 1989).

5.1 Result and Discussion

The results in Table 2 presented the 80 participants from Faculty of Computer Science and Information Technology and the Table 3 showed the result of perceived usefulness and perceived ease of use. From Table 2, the majority of participant involved in this evaluation is female (52.5%) whereas male (47.5%). This evaluation also collects the level of study of the participant. The majority of the participant is from undergraduate student who pursue a Bachelor Degree (61.25) followed by postgraduate which are from Master (23.75%) and PhD (15%).

<table>
<thead>
<tr>
<th>Demographic Profile</th>
<th>N = 80</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>38</td>
<td>47.5%</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>42</td>
<td>52.5%</td>
<td></td>
</tr>
<tr>
<td>Level of Study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor Degree</td>
<td>49</td>
<td>61.25%</td>
<td></td>
</tr>
<tr>
<td>Master</td>
<td>19</td>
<td>23.75%</td>
<td></td>
</tr>
<tr>
<td>PhD</td>
<td>12</td>
<td>15%</td>
<td></td>
</tr>
</tbody>
</table>
The value of perceived usefulness and perceived ease of use were computed by using statistical approach which are average mean to reveal each dimensions of questions. The summarization of the value were compute by using Cronbach Alpha for overall reliability of preferred of acceptance technology. Table 5 shows that the participant is optimistic to accept the technology of ALSDoc as medium in finding the document according their learning style. The overall reliability of has meet the general rule of thumb which are higher than 0.70 (Nunnaly & Bernstein, 1967).

Table 5: Prototype Evaluation Result based on TAM (Davis, 1989)

<table>
<thead>
<tr>
<th>N= 80</th>
<th>ALSDoc System</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perceived usefulness</td>
<td>Perceived ease of use</td>
</tr>
<tr>
<td>Q1</td>
<td>4.18</td>
<td>4.29</td>
</tr>
<tr>
<td>Q2</td>
<td>4.26</td>
<td>4.31</td>
</tr>
<tr>
<td>Q3</td>
<td>4.45</td>
<td>4.28</td>
</tr>
<tr>
<td>Q4</td>
<td>4.24</td>
<td>4.35</td>
</tr>
<tr>
<td>Q5</td>
<td>4.35</td>
<td>4.34</td>
</tr>
<tr>
<td>Q6</td>
<td>4.33</td>
<td>4.35</td>
</tr>
<tr>
<td>α</td>
<td>0.90</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Hence, this study found out that proposing the LS identification as adaptivity in the adaptive learning environment can assist a learner finding suitable document which are more useful and easier.

5. Conclusion

Learner faced on difficulty in finding a suitable documents, which are not suit with their preferences. The existing e-learning has a major limitation which are one-size-fits-for all. Therefore, the adaptive learning system developed by taking into account of individual characteristic such as LS. However, the identification of learning style has faced a several limitation such as in questionnaire technique learner tends to lack of motivation, the result of LS is fixed and inaccurate self-judgement. In computer-based detection technique it's required a huge of training data and its faced a cold start problem regarding to obtain a information from a new learner. Hence, based on the aforementioned limitation the ALSDoc have proposed to identify LS and architecture is presented. ALSDoc recommend the suitable document according to the identified learner’s LS. The user acceptance and satisfaction of the proposed system were evaluated by using TAM. ALSdoc able to assist a learner in finding the suitable document and also updated the learner LS automatically. The evaluation results showed that the ALSDoc has been accepted and satisfied on the overall performance of the system in recommending the suitable document to the learner. ALSdoc can assist a novice learner in finding the suitable document and enhance their learning process according their learning styles. In future, this study can be improved by combining the explicit and implicit feedback support to identify learner LS.

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