Improving Learning Efficiency for Engineering Courses in Mobile Learning Environments

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Abstract: - In conducting mobile learning activities, there are several problems to be coped with, including the slow data transmission speed, the high communication cost and the low screen resolution of mobile devices, which might significantly affect the learning efficiency of the learners. To cope with this problem, in this paper, a course content restructuring approach is proposed. By applying the novel approach, the contents in a course are restructured into a content hierarchy based on the degrees of relevance to the concepts to be learned, such that the more relevant and meaningful contents are located closer to the root of the content hierarchy while the potentially irrelevant or meaningless contents are located farer from the root. That is, the students only need to read more detailed contents whenever necessary. Numerical results gained through various experiments have evinced that the novel approach can significantly improve the learning speed in a mobile learning environment.

Key-Words: - mobile learning, distance education, content restructuring, wireless communication

1 Introduction

The advent and popularity of mobile equipment has facilitated the development of new tutoring strategies and learning activities. For example, Luchini et al. indicated that handheld computers could make an impact on collaborative work [17]; Stanton et al. found that the mobility of Handhelds is helpful for the group members in a Computer-Supported Cooperative Learning (CSCL) environment to coordinate collaboration between them while exchanging information via wireless networks [18]. Zurita and Nussbaum attempted to conduct CSCL activities using wirelessly interconnected handheld computers [19]. They demonstrated how weaknesses in coordination, communication, negotiation, interactivity and mobility can be solved with a mobile CSCL environment with handhelds interconnected by a wireless network.

Although mobile equipment seems to be helpful to the learning activities, Jipping et al. argued that collaboration learning only works when the technology is designed to meet the context of intended usage [16]. With an inappropriate design, a mobile interface may become a barrier to learning. Some other researchers, such as Stanton et al. [18], also indicated the importance of well-structured information in a mobile learning environment.

To cope with these problems, this paper proposes a course content restructuring approach. The courseware designer only need to indicate the concepts to be learned in the course, and a content hierarchy consisting of course contents with different degrees of relevance to the concepts will be generated. The more relevant and meaningful contents are located closer to the root of the content hierarchy while the potentially irrelevant or meaningless contents are located farer from the root; therefore, the students only need to read more detailed contents whenever necessary. An experiment on three science and engineering courses has shown that the novel approach is able to improve the learning efficiency of students.

2 Relevant Research

Wireless communication is capable of providing instant information and services, such as e-mail

service, real-time stock information and service, banking service, instant news, e-commerce information and service, etc, without considerations about spatial and temporal constraints. For enterprises, wireless communication offers an instant and safer environment for their business and internal communications [6][12]. However, the limitation of communication bandwidth, memory size and screen size to date, has hindered the accessing and displaying of Internet contents via a WAP mobile phone, or other wireless equipment. For most Internet content providers, it is highly time-consuming to rephrase or reorganize their Web content for wireless applications. The maintenance of an additional WAP site is also a burden to Internet content providers.

In recent years, several HTML-to-WML systems have been proposed and implemented [13]. Although the existing HTML-to-WML systems can work properly on HTML file translations, the limitation of communication bandwidth, memory size and screen size has proved impracticable when accessing and displaying HTML contents on a mobile phone or any other wireless equipment. In 2002, an intelligent WAP site management system, I-WAP, was developed to cope with these problems [8]. With the help of I-WAP, the original contents of HTML web sites can be automatically translated to proper WAP contents. As a consequence, the costs associated with maintaining WAP sites could be significantly reduced. The management system also allows the system manager to define the relevance of numerals and keywords for removing unimportant or meaningless contents. The original contents will be reduced and reorganized to fit the size of mobile phone screens, thus reducing the communication cost and enhancing readability.

Although the performance of I-WAP seems to be promising, there exist some problems in applying it in the practical applications, including the difficulty of understanding and defining the values of so many parameters and the high probability of eliminating some important sentences. Moreover, as the users with different backgrounds or reading abilities may have different degree of understandings of the same sentences, it is almost impossible to reduce document contents to fit all of the on-line users. Such drawbacks make it difficult to apply I-WAP to the development of mobile education systems, which do not allow any possible misleading description being presented to their users. To cope with these problems, in the following sections, a content restructuring approach is proposed to generate subject content hierarchy for the mobile learning courseware.

3. Course Content Restructuring Approach

The basic idea of the novel approach is to restructure the course contents into a content hierarchy. Each subject unit, U_i is divided into several pieces of contents, say U_{i1}, U_{i2} … U_{in}, which are located in the content hierarchy according their degrees of relevance to the concepts to be learned in the subject unit. That is, the more relevant and meaningful contents are located closer to the root of the content hierarchy while the potentially irrelevant or meaningless contents are located farer from the root. Fig. 1 shows an illustrative example of a content hierarchy consists of three subject units, i.e., “Description of Computer Hardware”, “Description of Computer Software” and “What are the Peripheral Devices”.

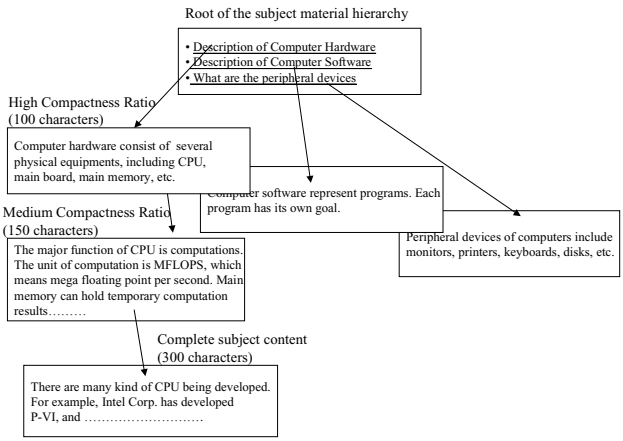

Fig. 1 Illustrative example of a subject content hierarchy

To abstract the contents with different degrees of relevance to the specified concepts from the original course contents, a Wave-based algorithm is employed [20]. During the process of restructuring course content, several parameters have to be taken into consideration. Table 1 shows a Wave (k, r) matrix defined to represent the degree of relevance of a sentence to the specified keywords, where k is the distance (number of sentences) between the current sentence and the sentence that contains specified keywords (concepts to be learned), and r is the number of sentences affected by a sentence that contains keywords.

Table 1. Wave(k , r) matrix

K＼r	1	2	3	4	5
0	1	1	1	1	1
1	0.5	0.6	0.7	0.8	0.9
2	0	0.3	0.4	0.6	0.7
3	0	0	0.1	0.4	0.5
4	0	0	0	0.2	0.3
5	0	0	0	0	0.1

In addition to Wave (k, r), some parameters are defined as follows:

1) *Kw*: Importance of keywords

In most documents, there are some specific words that can significantly represent the main theme, or what is deemed "keywords". For example, "tutoring schedule" or "assessment contents", and the relevant sentences, are considered to be more important and meaningful to an educational document than the irrelevant ones. A set of possible ratings for *Kw* is presented in Table 2.

Table 2. Possible ratings for *Kw*

Rating	*Kw*
Absolutely important	1.0
Very important	0.8
Important	0.6
More or less important	0.4
Unimportant	0.2

2) *Cp*: Degree of Compactness

Content compactness degree ranges from 0 to 1.0. If *Cp* is close to 1.0, the algorithm will abstract only the very relevant contents from the original course contents. If *Cp* is close to 0, only the sentences that are definitely meaningless will be eliminated. The course content restructuring algorithm is given as follows:

Wave-based Relevant Content Selecting Algorithm

Index[0] = 0 ;Index[*i*] represents the degree of relevance for *i*-th sentence to the keywords.
θ=*Cp*
;θ represents the threshold of the minimum acceptable relevance. If the degree of relevance for a sentence is less than θ, we conclude that the sentence is less relevant to the topic of the course.
FOR i =1 TO N DO ;*N* is the number of sentences in a document.
    If sentence *i* contains keywords
        Kw_flag[i] =1
; Mark the sentences that contains keywords
FOR i = 1 TO N DO
  IF Kw_flag[i] = 1 Then
    FOR k = -r to +r DO
      If (i + k ≥ 1) AND (i + k ≤ N) Then
        Index[i + k] = Index[i + k] + Wave[|k|, r]
    ; Add the effect degree of the sentences containing keywords to the neighborhood sentences
FOR i = 1 TO N DO
    IF Index[i] < θ THEN
        Flag[i]= 1
        ELSE Flag[i]=0
    END
FOR i=1 TO N DO
    IF Flag[i] = 0
    THEN Sentence[i] is more relevant to the topic of the course

End of Relevant Content Selecting Algorithm

For example, consider the following sentences:

Sentence-1: We are going to Sun-Moon Lake in 12:00.
Sentence-2: My mother has prepared delicious food for picnic.
Sentence-3: My father will drive us there.
Sentence-4: I hope that we will have a good time.

Assume that the keywords are "picnic" and "traveling", and θ=0.5, the "Wave" value of each sentence is computed as follows:

Sentence-1: We are going to Sun-Moon Lake at 12:00. → Wave (1, 2) = 0.6 >θ
Sentence-2: My mother has prepared delicious food for picnic. → Wave (0, 2) = 1.0 >θ
Sentence-3: My father will drive us there. → Wave (1, 2) = 0.6 >θ
Sentence-4: I hope that the weather will be good. → Wave (2, 2) = 0.3 <θ

Therefore, only Sentence-4 is considered to be less relevant to the topic of the course.

The more relevant sentences will be used to construct the higher-level subject materials with a link to the lower-level ones. The algorithm is repeated applied to the current highest-level subject materials until no more "less relevant" sentence is found, and a hierarchy of subject materials is therefore constructed.

It can be seen that the performance of the content restructuring algorithm mainly depends on the keywords listed in the documents and the relevant parameters defined by the system manager. For those documents without a keyword list, a keyword-extraction algorithm, such as the ones proposed in [10], [14] and [15], may be helpful in determining the keywords efficiently.

4 Illustrative Example

Consider a course consists of the following chapters:

Barbarians at the Gate: An Introduction to Distributed Denial of Service Attacks

1. Introduction
2. What is a Denial of Service
3. A Distributed Denial of Service
4. Surviving DDoS Attacks
5. Preventing DDoS Attacks
6. Conclusion

Initially, the learner receives the Introduction section with CP=1, given as follows:

Recently, major news outlets reported that a coordinated attack designed to disable several of the Internet's root name servers had taken place, The attack, described as sophisticated and complex, is known as a distributed denial of service (DDoS), Similar attacks first made headlines in February 2000, Although discussed in security circles for some time before that, this was the first prolonged example of a DDoS, This article will explain the concept of DDoS attacks.

If the learner finds that the content is too brief, he/she can choose to extend the content to a more detailed version, e.g., CP=0.4, which is given as follows:

Recently, major news outlets reported that a coordinated attack designed to disable several of the Internet's root name servers had taken place, The attack, described as sophisticated and complex, is known as a distributed denial of service (DDoS), Although no serious outages occurred, it was a hot topic in the security world - again, Again, Similar attacks first made headlines in February 2000, Although discussed in security circles for some time before that, this was the first prolonged example of a DDoS, and prevented legitimate traffic from reaching major sites for several hours, Unfortunately the answer is yes, This article will explain the concept of DDoS attacks, how they work, how to react if you become a target, and how the security community can work together to prevent them.

The worst case happens while the learner asks to extend the content to the version with CP=0, as shown in the followings:

Recently, major news outlets reported that a coordinated attack designed to disable several of the Internet's root name servers had taken place. The attack, described as sophisticated and complex, is known as a distributed denial of service (DDoS). Although no serious outages occurred, it was a hot topic in the security world - again. Again? Similar attacks first made headlines in February 2000. Although discussed in security circles for some time before that, this was the first prolonged example of a DDoS, and prevented legitimate traffic from reaching major sites for several hours. Yahoo, eBay, Buy.com, and CNN were but a few mjor sites who were inaccessible to their customers for extended periods of time. Now, almost three years later, can it be that we're still vulnerable? Unfortunately the answer is yes. This article will explain the concept of DDoS attacks, how they work, how to react if you become a target, and how the security community can work together to prevent them.

Once the learned has finished reading the first section and has passed the unit test, he/she can start to read the next section, i.e., “What is a Denial of Service”, with CP=1, which is shown as follows:

In order to understand the incidents described above, it would be helpful to take a step back and look at a more basic form of the same attack, the denial of service attack, A denial of service, or DoS, is a very basic category of attack in the world of security engineering, one which can be used in several scenarios, The term can be applied to any situation where an attacker attempts to prevent the use or delivery of a valued resource to its intended audience or customer, an attacker can deny access to telephone systems by cutting the major telecom cable feeding a building, the attacker succeeds by denying the users access to the resource, an attacker who wishes to disrupt a specific service or device can do so by simply overwhelming the target with packets designed to consume all available resources, A DoS is not a traditional "crack", in which the goal of the attacker is to gain unauthorized privileged access, the attacks can be very serious in nature.

Similarly, if the learned feels that the content is too brief to understand, he/she can choose to extend the content to the version with lower CP rate, e.g., CP=0.4, as shown in the followings:

In order to understand the incidents described above, it would be helpful to take a step back and look at a more basic form of the same attack, the denial of service attack, A denial of service, or DoS, is a very basic category of attack in the world of security engineering, one which can be used in several scenarios, The term can be applied to any situation where an attacker attempts to prevent the use or delivery of a valued resource to its intended audience or customer, It can be implemented via multiple methods, physically and digitally. For instance, an attacker can deny access to telephone systems by cutting the major telecom cable feeding a building, repeatedly calling every available phone line, or cracking the switch that handles the PBX. In all three instances, the attacker succeeds by denying the users access to the resource, as all incoming and outgoing calls would fail. So, an attacker who wishes to disrupt a specific service or device can do so by simply overwhelming the target with packets designed to consume all available resources, A DoS is not a traditional "crack", in which the goal of the attacker is to gain unauthorized privileged access, but it can be just as malicious, such as root DNS servers, the attacks can be very serious in nature, DoS threats are often among the first topics that come up when discussing the concept of information warfare, and very efficient.

It can be seen that the efficiency of learning the subjects can be significantly improved and the data transmission cost can be reduced if the contents have been well-abstracted. That is, the learners only need to download and read the useful part of the contents in the mobile learning environment.

5 Experiments and Evaluation

To evaluate the efficacy of the novel approach, an experiment has been performed on two on-line courses, including "Bioengineering", "Geography" and "Electronics Engineering". An evaluation group consisting of seven learners with different backgrounds is asked to review each reduced document for its readability. For each courses, ten documents have been abstracted by applying the Wave-based Relevant Content Selecting Algorithm with CP ranging from 0.2 to 1.0. Table 3 presents the experimental results on "Bioengineering" documents with the average Efficiency Improvement Rates (EIR) ranging from 31% to 52%. For each case, the colored grid with bold number in that row represents the version that is accepted by at least three of the seven learners. For example, in the first case, the accepted version is CP=0.8, which contains 544 words, while the original document contains 820 words; therefore, the Efficiency Improvement Rate (EIR) is 33.66%.

Table 3. Average Efficiency Improvement Rates for reading "Bioengineering" documents

Case#	Number of words to read with different CP values					Original size	EIR
	0.2	0.4	0.6	0.8	1.0		
1	778	689	544	**544**	486	820	33.66%
2	654	595	444	**444**	410	706	37.11%
3	979	850	741	**741**	692	1209	38.71%
4	638	638	519	**452**	447	775	41.68%
5	1035	933	751	**751**	639	1091	31.16%
6	1016	862	596	**596**	508	1262	52.77%
7	1064	957	745	**745**	664	1108	32.76%
8	478	412	361	**361**	324	586	38.40%
9	976	888	746	**746**	633	1110	32.79%
10	304	254	184	**184**	125	390	52.82%
Average Efficiency Improvement Rate							39.19%

Table 4 presents the experimental results on "Electronics Engineering" course. The average Efficiency Improvement Rates range from 33% to 58%.

Table 4. Average Efficiency Improvement Rates for reading "Electronics Engineering" documents

Case#	Number of words to read with different CP values					Original size	EIR
	0.2	0.4	0.6	0.8	1.0		
1	861	861	711	627	**602**	923	34.78%
2	1258	1139	1076	1076	**872**	1288	32.30%
3	943	888	754	754	**596**	960	37.92%
4	785	785	686	619	**588**	907	35.17%
5	1313	1313	1135	**927**	871	1527	39.29%
6	1357	1357	1213	**1013**	930	1487	37.46%
7	1071	811	721	**721**	645	1757	58.96%
8	1009	724	633	**633**	518	1058	40.17%
9	946	865	724	**724**	592	997	40.62%
10	1033	1033	873	**724**	674	1095	33.88%
Average Efficiency Improvement Rate							39.06%

6 Conclusions

In this paper, we have proposed a novel approach to improving student learning efficiency in mobile learning environments. From the experimental results on three science and engineering courses, it can be seen that our approach not only can improve the time needed to read the subject contents, but also can reduce the data transmission cost. Currently, we are trying to apply the novel approach to more engineering training cost in a mobile learning environment.

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