Computers & Education 68 (2013) 233–243

Contents lists available at SciVerse ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

The effectiveness of automatic text summarization in mobile learning contexts

Guangbing Yang [a], Nian-Shing Chen [b,*], Kinshuk [c], Erkki Sutinen [a], Terry Anderson [d], Dunwei Wen [c]

[a] School of Computing, University of Eastern Finland, P.O. Box 111, 80101 Joensuu, Finland
[b] Department of Information Management, National Sun Yat-sen University, 70, Lienhai Rd., Kaohsiung, Taiwan
[c] Athabasca University, School of Computing and Information Systems, Alberta, Canada, 1 University Drive, Athabasca, Alberta, Canada
[d] Athabasca University, Centre for Distance Education, Alberta, Canada, 1 University Drive, Athabasca, Alberta, Canada

ARTICLE INFO

Article history:
Received 7 February 2013
Received in revised form
7 May 2013
Accepted 8 May 2013

Keywords:
Human-computer interface
Teaching/learning strategies
Architectures for educational technology system
Interactive learning environments

ABSTRACT

Mobile learning benefits from the unique merits of mobile devices and mobile technology to give learners capability to access information anywhere and anytime. However, mobile learning also has many challenges, especially in the processing and delivery of learning content. With the aim of making the learning content suitable for the mobile environment, this study investigates automatic text summarization to provide a tool set that reduces the quantity of textual content for mobile learning support. Text summarization is used to condense texts into the most important ideas. However, reducing the amount of content transmitted may negatively impact the meaning conveyed within. Although many solutions of text summarization have been applied by intelligent tutoring systems for learning support, few of them have been quantitatively investigated for learning achievements of learners, especially in mobile learning context. This study focuses on a methodology for investigating the effectiveness of automatic text summarization used in mobile learning context. The experimental results demonstrate that our proposed summarization approach is able to generate summaries effectively, and those generated summaries are perceived as helpful to support mobile learning. The findings of this work indicate that properly summarized learning content is not only able to satisfy learning achievements, but also able to align content size with the unique characteristics and affordances of mobile devices.

1. Introduction

Mobile devices are rapidly becoming mainstream in today's world because of their immediacy, adaptability and cost effectiveness. Mobile learning benefits from these unique merits providing learners access information anywhere and anytime. However, this rapid evolution also gives rise to new challenges. Some particular challenges focus on the processing and delivery of learning content. From a learner's perspective, learning content is always the key element in education delivery, not the mobile technology itself even though the technology has improved mobile learning significantly. Most of 'smart' mobile devices are now capable of handling multimedia easily and effectively, but mobile content adaptation and development for mobile devices is still a significant problem. Plain text is still the main content format used in mobile learning settings (Shen, Wang, Gao, Novak, & Tang, 2009). However, delivering a text of several thousand words or more on a mobile device is inappropriate largely due to the costs of data download with mobile devices. The costs of using mobile devices for learning was the primary concern of students (Shen et al., 2009), especially in developing world, because free Wi-Fi access points are not always available to mobile learners and keeping a balance between the costs and learning achievements makes them seek out just the right amount of learning content; even further, due to the problem of the oft-decried information overload, delivering large amounts of text contents makes mobile learners challenging, especially for learning purposes. Therefore, this study aims to investigate a technology for

* Corresponding author.
E-mail addresses: yguang@cs.joensuu.fi, guangbing@athabascau.ca (G. Yang), nschen@mis.nsysu.edu.tw, nianshing@gmail.com (N.-S. Chen), kinshuk@athabascau.ca (Kinshuk), erkki.sutinen@cs.joensuu.fi (E. Sutinen), terrya@athabascau.ca (T. Anderson), dunweiw@athabascau.ca (D. Wen).

0360-1315/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.compedu.2013.05.012

content processing that can be used to summarize text contents effectively to align content size to match various characteristics of mobile devices.

To process learning contents effectively, many rapid authoring tools have been developed for mobile learning. However, the purpose of developing rapid authoring tools is mainly assisting with the instructional design, not for facilitating mobile learners. In addition, due to the highly fragmented mobile technology landscape and rapidly evolving standards, there is no single solution to make content working for every possible mobile device. This situation is compounded when reusing existing learning materials available on the web, as manual re formatting and summation is both time consuming and expensive. As a result, educators are forced to design new learning content or reformat existing learning materials for delivery on different types of mobile devices. Researchers have developed semantic-aware learning objects retrieval (Lee, Tsai, & Wang, 2008) systems for automatically delivering learning contents to learners. Unfortunately, automatic placement of semantic tags into learning content is difficult, and hence, no significant application of semantic techniques is available to support automatic labeling of learning content. To make the learning content suitable for mobile context, this study investigates technologies for text summarization to provide a solution to content processing for mobile learning support.

Automatic text summarization summarizes the contents, identifies the subject of information, and extracts important ideas from the discourse. Research and theory on summarizing has recognized that the critical information is helpful to gain a better comprehension to the learning materials (Marzano, Pickering, & Pollock, 2001, p. 30). Text summarization can simplify texts into their most important ideas in a particular context, but reducing the content may negatively impact the meaning conveyed within. Many solutions of automatic text summarization have been applied in literature with aim to provide learning support (He, Hui, & Quan, 2009; Yang, Kinshuk, Sutinen, & Wen, 2012; Yang, Wen, Kinshuk, Chen, & Sutinen, 2012b), but few of them have quantitatively investigated learning achievements of learners with the assistance of such solutions, especially in a mobile learning context. Thus, the problem that condensing content may negatively impact the meaning needs to be quantitatively evaluated within the context of mobile learning.

This study focuses on the methodology for investigating the effectiveness of an automatic text summarization approach, which was proposed in our previous work (Yang, Kinshuk, et al., 2012; Yang, Wen, et al., 2012), through the evaluation of learning outcomes of learners in mobile learning settings. The research presented here quantifies assessment results that come from a variety of experimental treatments where full text learning contents or various summaries are displayed to learners. Using the same test material, several assessments are compared to determine whether the summarized learning content satisfies learning achievements and expectations. Furthermore, this study tries to find out an optimal compression (ratio of summary length) for summaries. The goal of this study is to determine in use of summaries of the learning material, results in similar outcomes as achieved by using the full text of learning contents.

2. Background and related work

2.1. Automatic text summarization

Most of the previous work in automatic text summarization has focused on extractive summarization. These technologies use cue phrase, important sentences and sentence positions in rhetorical role identification (Munoz & Atkinson, 2013), key phrase extraction (Mangina & Kilbride, 2008), and lexical occurrence statistics and discourse structure (Louis, Joshi, & Nenkova, 2010). Others have used statistical-based approaches to produce summaries. These approaches determined the relevance of a sentence in a document by counting term frequency or inverse document frequency (TF-IDF) exclusive of stop words. The underlying assumption is that the most important words appear in a document more frequently. A well-known summarizer, the SumBasic (Nenkova & Vanderwende, 2005) exploited frequency exclusively to create summaries. Later, the system SumFocus (Vanderwende, Suzuki, Brockett, & Nenkova, 2007), based on similar algorithms, has shown the highest performance improvement in a standard ROUGE (Lin, 2004) evaluation at Document Understanding Conference (DUC) 2006. Some intelligent tutoring systems (Franzke, Kintsch, Caccamise, Johnson, & Dooley, 2005) have used latent semantic analysis (LSA) to produce summaries by determining the similarity of words using cosine correlation computed from a matrix. However, the achievement to date has not been significant due to the lack of semantic coherences in term frequency related approaches. To catch these coherences, several approaches have been proposed, such as the ensemble approach (He et al., 2009) that integrates LSA technique with n-gram co-occurrence and a modified BLEU algorithm (Noorbehbahani & Kardan, 2011) that is adapted for similarity measures from the n-gram co-occurrence scoring algorithm in machine translation. However, due to the ambivalence of words and the differences in word usage across authors (Manning & Schutze, 2001), these approaches have shown severe limitations when used on multi-document summarization.

Recent research in extractive based automatic text summarization has focused on using Bayesian statistic approaches in machine learning and language modeling to find semantic coherences between words and documents. Some Bayesian statistics based language models, such as the BayeSum model (Daumé III & Marcu, 2006), the DualSum model (Delort & Alfonseca, 2012), and Two-Tiered Topic model (TTM) (Celikyilmaz & Hakkani-Tur, 2011), have been developed in text summarization to address the shortcomings in term frequency approach. Experimental results from both Text Analysis Conference (TAC) 2011 and DUC 2007 have shown that this approach can significantly improve performance of document retrieval and text summarization. A similar approach, namely TopicSum (Haghighi & Vanderwende, 2009), imposed Latent Dirichlet Allocation (LDA)-based topic model (Blei, Ng, & Jordan, 2003) to estimate and allocate word distributions during the sentence selection. Experimental results in both ROUGE (Lin, 2004) measurement and manual evaluation in DUC have shown that TopicSum can achieve similar performance as the BayeSum model. Other approaches proposed recently in multi-document summarization adapt machine learning-based techniques, such as Support Vector Regression (SVR) based multi-document summarization (Ouyang, Li, Li, & Lu, 2011). However, a significant drawback in machine learning approaches is the need for a large training corpus consisting of a set of human-written summaries. Without large enough document collections, machine learning paradigms adapted in the summarization is insufficient to produce conclusive results (Nenkova & McKeown, 2011).

2.2. Content processing in mobile learning

Researchers in mobile learning have proposed various content processing techniques in recent years. Some of the techniques focus on the design of presentation of the content to fit the small screen of mobile devices (Churchill & Hedberg, 2008). Other content processing