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学位(専攻分野)	博士(情報学)
学 位 記 番 号	総研大甲第 1635 号
学位授与の日付	平成25年9月27日
学位授与の要件	複合科学研究科　情報学専攻 学位規則第6条第1項該当
学 位 論 文 題 目	An Advanced Cloud-Based e-Learning Platform for Higher Education for Low Speed Internet
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論文内容の要旨
Summary of thesis contents

The social demand for internationalized educational program is continuously increasing. The role of universities is therefore to change the learning environment to e-Communication approach because the traditional classroom-based education cannot respond to this kind of on-demand distant learning and social demands. Moreover, video-based content format is increasing since it has more attractive visualization than former formats. In fact, streaming video can offer very exciting opportunities for online teaching and learning. Not only the video-based content is required to support the new learning environment, but also e-Meeting technology for real time online lecture and meeting. Currently, several e-Learning systems have been established to support academic institutions in rural areas. Likewise, many collaborative projects have the target to increase the number of e-Learning contents based on video materials, and to be shared within the collaborative developing countries. However, it is hard to use video materials for the e-Learning contents, and provide the video meeting system among members, since the Internet infrastructure in these countries is not good enough for applications requiring high-speed network. This dissertation provides two main contributions based on the WebELS system to solve the limitations of existing authoring tools for video-based learning content, and to support the social demand for internationalized educational program and suitable online meeting management requirements in the business sector.

This dissertation consists of seven chapters briefly described as follows:

Chapter 1 presents the background and current technologies of e-Learning platforms. The recent progress of information and communications technology (ICT) and information of society has made Internet-based communication become a popular approach and widely used methodology on delivering various educational programs and organizational business situations. Graduate students and company employees are continuously in need to learn more advanced knowledge, but oftentimes have limited opportunities due to time, location, and cost limitations. To support self-learning on higher education, a Virtual Learning Environment (VLE) is considered. Moreover, the trend of video-based learning content is increasing since it can increase the students' intention to learn with the attractive content. Furthermore, cloud computing system, being a popular technology, is considered to serve the server side services because it can be implemented in a wide variety of architectures and technologies. It can also minimize IT investment costs for the education and business sectors. The implementation of a cloud computing to e-Learning system has its peculiarities and therefore needs a specific approach for the developing countries where the Internet condition is not good enough.

Chapter 2 presents the review of related studies and technologies. The background

information, recent progression, and approaches of e-Learning and e-Meeting technologies are summarized. E-Learning system can be integrated with a physical learning environment which may be referred to as blended learning. It can take place synchronously or asynchronously. The author summarizes the important components common to e-Learning systems in the point of view of its functionalities. The system consists of five main components such as course management for managing the course programs, content management for managing the learning content, user management for managing users and assigning user permission, communication management to managing communication resources and administrator tool for the administrator to manage the e-Learning system.

Chapter 3 describes the overview of the WebELS system. The proposed concept, overall architecture design, system structure, and system functionality are described. WebELS is an Internet-based content management system for distance self-learning designed to support higher education in engineering and science. It usefully supports online learning, via the Internet, using the slide-based content. It can also support off-line mode learning by downloading the content and play at a stand-alone computer. The system provides an easy authoring tool for creating their learning materials. In addition, the WebELS system is adapted to implement on cloud computing technology as software as a service (SaaS) concept to increase efficiency and performance of the system. The system is also optimized to support cross-platform to break the limitation of various usages.

Chapter 4 introduces the design concept of the proposed video-based authoring tool for the e-Learning system. The proposed architecture, techniques, and data structure are explained. The author proposes an aggregated video by key marking method for synchronizing raw video stream and presentation slides. Virtual video clips that relate to each slide are produced from key markings, and are encapsulated into aggregated video stream. The virtual video clips in an aggregated video stream are used to synchronize to the slide presentation for creating learning content. The aggregated video also becomes the baseline for the viewing function. A metadata file is proposed and applied to retain the content definitions, such as content title, description, references, etc. The benefit of using metadata file is that it is a simple text file. It is small and fast to transfer between client and server. A template is utilized to keep the temporary synchronization data. Several data are contained in the content template, such as video index, key mark values, slide index, and pointer actions. Thus, the learning content package can be a container of learning content. It includes metadata, presentation slides, video stream, and synchronization data. Furthermore, video and pointer synchronization are also proposed for enhancing the students' learning efficiency.

Chapter 5 shows the implementation of the proposed video-based authoring and viewing tools. The system framework, system design and system architecture are

described. Functionalities of the system are also presented. The authoring function is used for creating video-based content by the instructor, and the viewing function is for self-learning by students. In the authoring function, the tool can help an instructor to create a new content by automatically generating key markings onto the raw video stream to produce virtual video clips related to each slide. Based on aggregated video stream methodology, it is convenient to create a new content. Some parts of the raw video stream can be easily skipped. It is also easy to edit a created content since content editing requires only the changing of key markings without editing the raw video file. The synchronized content can be previewed immediately at the client computer prior to saving at the server. In viewing function, video quality control and an adaptive video buffering method are implemented to support usage in various network environments.

Chapter 6 focuses on the online video meeting improvement. The author presents a new simple group-based concept for managing users of the system with easier management. The author proposes a meeting management system for controlling member groups and contents in the WebELS Meeting system to meet suitable meeting controls at a reasonable cost in business situations. The system is divided into two parts - the system management and the conference streaming management. The main concept of the system is group-based management of members and contents. Each group holds two password types - manager password and guest password. The group manager can manage the contents on their group. The system can limit the number of content and concurrent access in each group. Moreover, the system can control the behavior of logging-in members. In addition, the author also presents a quality improvement for video meeting while operating the meeting in the unstable network environment. The author proposes the video meeting auto-reconnection for boosting up the performance of web-based online conference system to be used in the unreliable network environment.

Chapter 7 presents the experimental results of the system. There are two issues that need to be evaluated based on the system framework of the proposed video-based authoring tool, i.e., the system performance on the server side and the client user acceptance of the total system. On the system performance evaluation, the author makes a comparison for the conversion times of the source files and video buffering during playback for each quality condition as this would influence the user acceptance. In the user acceptance evaluation, the author conducts a survey to determine the user acceptance of the system by sending out survey questionnaires to users of the system from four different countries. Most respondents agree with the usefulness, ease-of-use, and user satisfaction of the proposed system. Finally, the overall results show that the proposed authoring and viewing tools have higher user acceptance as a tool for e-Learning. The proposed method can provide easy authoring processes with clear user interface design for instructors, and help students utilize learning contents

effectively and efficiently. Regarding to video meeting enhancement, this improved system can help the administrator for managing and controlling the member groups and contents in the meeting system. Furthermore, the proposed solution helps the participants who use the unreliable network by preserving the quality of online conference operation for the best distant meeting.

Chapter 8 concludes the dissertation. This dissertation describes a combination of e-Learning and e-Meeting functions approaches of a new e-Communication to be a flexible instrument for higher education activities. A new online authoring tool for e-Learning system using Flash technology is implemented. The proposed system can be used to support advanced knowledge by self-learning. It is considered to support the classroom-based learning due to the increasing social demand in international scale, and to reduce the limitation of classroom-based traditional learning due to time, location, and cost limitations. Moreover, the author proposes the suitable meeting management tool for the WebELS Meeting module to meet the requirements of the business sector. The main function of the management tool is to be utilized for controlling user members and contents using simple group-based control concept. The author also implements network connection handler for the online meeting system when used in the unreliable network environment. The proposed system is achieved and optimized to work under the cloud computing technology since it is implemented in a wide variety of architectures, services, models, and other technologies.

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博士論文の審査結果の要旨

Summary of the results of the doctoral thesis screening

7 月 9 日に論文審査会を開催した。はじめに出願者が 45 分間の発表を行い、博士論文の目次にそって、研究の動機、先行研究の動向、出願者が提案するコンテンツ・オーサリング／ビューイング技術および多地点ビデオ会議機能を含むクラウド型プラットフォームの構成ならびに WebELS サーバへの実装とテスト運用の結果について説明した。出願者は、大学院教育の多様化と国際化という社会的ニーズに応えるため、低速インターネット環境対応の汎用 e ラーニングプラットフォーム WebELS の新機能開発と性能向上の研究に取り組み、2 つの重要な成果として、１）ビデオコンテンツのクラウド型簡易オーサリング／ビューア・システムと、２）低速不安定なインターネット環境での多地点ビデオ会議を安定的に行うための、回線切断に対応する自動再接続機能を開発した。

１）講師の動画ファイルと教材スライドを同期させて e ラーニングコンテンツ化するオーサリングシステムが普及しているが、コンテンツの編集には専用の機器が必要とされ、再編集が困難であるという制約がある。そこで出願者は、スライドと動画ファイルの対応づけを柔軟にするミドルレイヤーとしてポインターを使うキーマーキング手法を開発し柔軟性の高いデータ構造を導入した。また、クラウド環境で動画とスライドの位置関係を画面上で確認しながら、編集ボタンを選択してクリックするだけで自動的にコンテンツが生成されるユーザインタフェースを開発して WebELS に実装した。本機能により、対応する映像および音声の関連性を保ちながら編集することを実現した。出願者の提案するシステムでは、編集対象となるコンテンツをクラウドサーバに置いた状態で、編集者側の端末にコンテンツをダウンロードすることなく、オーサリングインタフェースによる編集指示を通信することによって、サーバ内にデータ構造が自動構築される。さらに、キーマーキング・データ構造を活用した柔軟性の高いオンデマンドビューア機能を WebELS に実装した。出願者が提案するこれらの機能により、発展途上国の低速インターネット環境においても高容量の映像コンテンツの編集作業を容易に行うことが可能となった。

２）出願者はさらに、低速かつ不安定なインターネット環境において、WebELS システムによる会議中に回線切断が発生しても自動的に再接続して連続性が保たれる機能を提案し、WebELS システムに実装した。出願者の提案したこれらの機能は、UNESCO のジャカルタ事務所が運用する WebELS サーバによる低速インターネット環境向けの e ラーニングコンテンツ配信において実際に利用された。配信テストに参加した各国の利用者からは、低速インターネット環境においてもこれら機能が正常に動作したことが報告された。出願者の開発した機能が実装された WebELS 改訂バージョンは、NII に置かれたオープンソースサービスサイトを通じて教育・研究団体向けに無償ダウンロード用に提供されている。国内外の 20 以上の大学等でダウンロードされており、出願者の開発した機能が利用者環境で正常に動作していることが確認された。

予備審査では、先行研究との差分について機能対照表を付して明確化すること、テスト配信に参加した利用者のインターネット環境を明記すること、および、提案する機能の長短所について記載することの各項が、改良することが好ましい点として示されていたが、出願者はいずれの課題にも対応したことが確認された。

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出願者は、ミドルレイヤーとしてのポインター機能に関する研究に関して、電子情報通信学会英語論文誌 D に査読付き論文が採択され、2013 年 E96-D 巻 8 号に掲載されている。出願者は、遠隔教育をテーマとする ETT 2010 をはじめ 3 件の国際会議に採択され、電子情報通信学会ソサエティ大会をはじめ 2 件の国内学会における英語発表を行っている。これらの成果が、学位論文提出の要件を充たすことを確認した。