博　士　学　位　論　文

Doctoral Thesis

内容の要旨

及び

審査結果の要旨

Thesis Abstracts

and

Summaries of the Thesis Review Results

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博士の学位を授与したので、学位規則（昭和28年4月1日文部省令第9号）第8条の規定に基づき、その論文の内容の要旨及び論文審査の結果の要旨をここに公表する。

学位記番号に付した「甲」は学位規則第4条第1項（いわゆる課程博士）によるものであることを示す。

Preface

On granting the Doctoral Degree to the individuals mentioned below, abstracts of their theses and the theses review results are herewith publicly announced, in according to the provisions provided for in Article 8 of the Ruling of Degrees (Ministry Of Education Ordinance No.9, enacted on April 1, 1953)

The Chinese character, “甲”, at the beginning of the diploma number represents that an individual has been granted the degree in accordance with the provisions provided for in Paragraph 4-1 of the Ruling Of Degrees (what in called “Katei Hakase,” or the Doctoral Degree granted by the University at which the grantee was enrolled.)

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Name 氏名	Mizuo Kansen 甘泉　瑞応
The relevant degree 学位の種類	Doctoral degree (in Computer Science and Engineering) 博士(コンピュータ理工学)
Number of the diploma of the Doctoral Degree 学位記番号	甲 CI 博第 8 号
The Date of Conferment 学位授与日	March 23, 2010 平成 22 年 3 月 23 日
Requirements for Degree Conferment 学位授与の要件	Please refer to the article five of “University Regulation on University Degrees” 会津大学学位規程　第5条該当
Thesis Title 論文題目	Analysis Methods for Grasping Learner's Status from Multiple Viewpoints and Their Applications to e-Learning Systems 学習者状況の多角的分析法及びその e-Learning システムへの応用
Thesis Review Committee Members 論文審査委員	University of Aizu, Prof. S. Tei (Chief Referee) University of Aizu, Prof. M. Osano University of Aizu, Prof. S. Bhalla University of Aizu, Associate Prof. H. Kurokawa 会津大学教授　程　子学 会津大学教授　小佐野　峰忠 会津大学教授　S. Bhalla 会津大学上級准教授　黒川　弘国

Analysis Methods for Grasping Learner's Status from Multiple Viewpoints and Their Applications to e-Learning Systems

Thesis Abstract

With rapid development of networked society, various activities have been performed on Internet. Furthermore, the technologies about "Web2.0" and "Cloud computing" have brought about the innovation of the services in various fields. One of the services is e-Learning. Also in the educational field, the advance of these technologies has built the foundation of e-Learning. Multiple-choice Test is one of the most popular testing formats as a way to measure the understanding status of a learner in e-Learning. That is because the evaluation steps of grading is easy and statistics can also be processed easily on a computer. In e-Learning a learner can learn anytime and anyplace and at own his/her pace, efficiency of learning can be increased. However, in Multiple-choice Test, it is hard to catch the information about a learner's understanding statuses beside the scores. Furthermore, in e-Learning, a learner has a little communication and the limited feedback, and needs to know his/her status timely for keeping motivation.

In this thesis, our purpose is to study how to grasp the information which reflect the every learner's status by not only the score but also other information, such as response time and learning understanding level.

In order to achieve the goal, we have to solve the following problems.

1) How to represent the real/deep status of each learner for each item (question).
2) How to analyze the status of each learner, for each question from his/her answer.
3) How to provide a learner the e-learning support in an e-Learning environment.

The first contribution of this study is to propose a LT/R・W model, which can be represented by a LT/R・W-Chart, to build a model for representing learner's status in order to solve the first problem. A LT/R・W Chart is composed of two LT Charts (i.e. a LT/R Chart and a LT/W Chart) by "right answer (=R)" and "wrong answer (=W)". Each LT chart is a two-dimensional graph which takes the "difficulty level" along the horizontal axis and the "answer time required" along the vertical axis. A L-T plane is divided into four areas (A, B, C, D) by the "difficulty level" of a horizontal axis, and the "answer time required" of a vertical axis. Each answer of each learner is evaluated by the "difficulty level" L (=Level) and the "response time" T (=Time), and it plots on a L-T plane using the evaluated values.

The second contribution of this study is to present two analysis methods called, LT-Distance method and Value-Sheets method based on the LT/R・W model.

The LT-Distance method classifies the characteristics of factors into eight types. This method evaluates relationships between each right answer or wrong answer, the level's gap between difficulty of each question and each learner's degree of comprehension, and the relative time which each learner takes to response a question. Moreover the method expresses them on a LT/R・W Chart. This model carries out the grouping of the factors which resulted in the correct or incorrect answer

for every question, and analyzes them. Furthermore, it measures the strengths of the factors using the Euclid distance, and reasons a learner's degree-of-comprehension status. Thereby, the tutorial-process can be enriched further. Thus, it becomes possible to improve a learner's self-learning ability.

The Value-Sheets method is the improved version of the LT-Distance method. Adding some improvements to the first method, we propose the new learning support using Value-Sheets. This method can grasp a learner's understanding status from various view points using two or more Value-Sheets adapting to the LT/R・W method. Values which show the strengths of the properties are given on the coordinates of these sheets. Furthermore, in order to acquire precise diagnosis and to enable an exact grasp of a learner's understanding status, a framework of making an actual subject's status customized by the information which can be acquired from "status confirm questionnaire" is proposed. Thereby, characteristics for every item are made to reflect in value sheets more clearly.

The third contribution of this study is to develop two e-learning systems based on LT/R・W methods. One is a web-based system and another is a mobile-phone based system. We have designed and implemented the system composed of some modules including a control-module, Connector-module with DB, and some Databases. Moreover, we conduct the evidence experiment using the systems implemented the proposal two methods. And we check that the analysis result by the proposal method exactly reflects the factor resulted in the right or wrong answer, and serves effective learning diagnostic information for the learners.

The web-based system is built by using the LT-Distance method and it is realized by the client/server architecture by JSP using Java in the Computer language. By the learner's operating in a learner client side, the data of necessary time when a learner answers every question is collected.

The mobile-phone based system is built using the Value-Sheets method. Furthermore, the system is designed and implemented based on the ARCS theory which is for increasing a learner's motivation. A mobile phone can be used anytime, anywhere, so it can be used in one's spare time. One question-one answer type test is suitable for learning application of the mobile phone. We show that the system increases the users' satisfaction and important to improve learner's motivation.

The features of our proposals are as follow.

1) Our approach can merge advantages of approaches of "S-P Chart Theory", "Research on Response Time", "the Item Response Theory", and "the Probability Testing".
2) A learner's learning status can be measured from various educational view points comprehensively.
3) The systems using our proposed method can be personalized to an individual and have the wide extent of grasping status

Summaries of the Thesis Review Results

The applicant has made a good progress on this research.

The applicant has proposed a novel method called LT/R・W. A LT/R・W model represented by a

LT/R・W Chart to represent learner's status. Two kinds of analysis methods are proposed to improve learner's self-learning ability, which are called LT-Distance method and Value-Sheets method. After that, two e-learning systems based on LT/R・W methods are developed to implement and evaluate the proposed method. The first one is a web-based system and the second one is a mobile-phone based system. Finally, the experiment result shows the proposed method is effective for learner and can improve learner's learning motivation.

All comments and requests discussed in the preliminary thesis review are properly addressed in the doctoral thesis.

The committee members think the applicant has responded well to the questions and comments given by the committee members in preliminary review meeting and greatly improved his work. The committee unanimously agreed that the applicant pass the final doctoral thesis review.

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The relevant degree 学位の種類	Doctoral degree (in Computer Science and Engineering) 博士(コンピュータ理工学)
Number of the diploma of the Doctoral Degree 学位記番号	甲 CI 博第 9 号
The Date of Conferment 学位授与日	March 23, 2010 平成 22 年 3 月 23 日
Requirements for Degree Conferment 学位授与の要件	Please refer to the article five of “University Regulation on University Degrees” 会津大学学位規程　第5条該当
Thesis Title 論文題目	Psychoacoustic Roughness Applications in Music: On Automatic Retuning and Binaural Perception 音響心理学ラフネスにおける音楽アプリケーション
Thesis Review Committee Members 論文審査委員	University of Aizu, Prof. M. Cohen (Chief Referee) University of Aizu, Associate Prof. J. Huang University of Aizu, Associate Prof. S. Nishimura University of Aizu, Associate Prof. I. Wilson University of Sydney, Associate Prof. W. Martens 会津大学教授　M. Cohen 会津大学上級准教授　黄　捷 会津大学上級准教授　西村　憲 会津大学上級准教授　I. Wilson シドニー大学准教授　W. Martens

Psychoacoustic Roughness Applications in Music: On Automatic Retuning and Binaural Perception

Thesis Abstract

The goal of this study is to help to understand the influence of psychoacoustic roughness in music. Roughness is an auditory attribute produced by rapid temporal envelope fluctuations (normally resulting from wave interferences), and it has been related to musical dissonance. After reviewing the main theories that explain the origin of roughness, a software program created for the purpose of this research is presented. This software application, based on a spectral model to predict roughness (a physical predictor of the auditory attribute), is able to control (usually, to reduce) the predicted roughness of a sound ensemble in realtime. Experimental results were analyzed with a standard measurement software tool to corroborate the predicted roughness reduction. The audio output of this software application was compared by human subjects with renditions of the same musical content using some well known tuning systems (twelve tones equal tempered and just tuning). The results of these subjective experiments are presented and analyzed. Preliminary results on binaural roughness perception are presented at the end of the dissertation as a new direction of research. Contributions of the present work include the creation of an adaptive tuning program capable of retuning audio streams in realtime to minimize the measured roughness due to the interaction between sounds (extrinsic roughness). To the best of our knowledge, this procedure had been applied only to MIDI sequences for which realtime constraints implied oversimplifications that are not assumed in our program. We were able to determine that roughness by itself can explain musical preference among musically naïve participants. In the analysis of that experiment, we found that, contrary to popular belief, predicted roughness of 12-TET intervals is not always greater than pure intervals. This discovery correlates with preference choices reported by participants. We also show that current roughness models need to be revised to include the effect of binaural cues. Other minor contributions include several entries in Wikipedia (e.g., Vicentino's keyboard layout) and to Mutopia (e.g., Bach choral BWV 264).

Summaries of the Thesis Review Results

The dissertation could be summarized as:

Chapter 1: Presents a theoretical framework for the research derived principally from the Popperian cosmological concept of worlds, and applied directly to musical domain.

Chapter 2: Introduces roughness as a sound attribute produced by rapid temporal envelope fluctuations, and reviews the main theories that explain the origin of roughness and the historical link between roughness and musical dissonance.

Chapter 3: an adaptive turning software program created for the purpose of this research is presented. This application, based on a spectral model of roughness, is able

to reduce a sound ensemble's roughness in realtime. Experimental results were measured with a standard measurement software tool.
Chapter 4: In this chapter, the output of this software filter was compared by human subjects with renditions of the same musical content using some well known turning systems (twelve tones equal tempered and just tuning). The results of these subjective experiments are presented and analyzed.
Chapter 5: Preliminary results on binaural roughness perception are presented at the end of the dissertation as a new direction of research.

Contributions of the present work include the creation of an adaptive tuning program capable of retuning audio streams in realtime to minimize extrinsic roughness. To the best of our knowledge, this procedure had been applied only to MIDI sequences for which realtime constraints implied oversimplifications that are not assumed in our program; we were able to determine that roughness by itself can explain musical preference among musically naïve participants. In the analysis of that experiment, we found that, contrary to popular belief, twelve tones equal tempered intervals are not always rougher than pure intervals. This discovery correlates with preference choices reported by participants; we also show that current roughness models need to be revised to include the effect of binaural cues.

The new draft includes clarifications about the kind of roughness mentioned each time (perceived, measured, predicted, or reported), a more generous explanation about JT and tunings in general was included, as well as remarks on the differences between the proposed technique and previous techniques based on the MIDI protocol. Besides that, the analysis of a new experiment was included in the last chapter. This analysis helped to clarify the previous results on binaural effects on roughness perception. Redaction, correction to grammatical errors, and improvements in graphics and tables were also included. The candidate addressed all the suggestions resulting from the preliminary exam. These are the specific referees' concerns and the respective responses given by the candidate:

1. Michael Cohen: Explain how temporal reversal would affect roughness.
   Research conducted by Pressnitzer on the influence of the temporal envelope of a sound over roughness shows that for a given spectrum, sounds with rapid attack and slow decay were considered rougher than sounds with slow attack and rapid decay. Since most natural sounds are more similar to the former case, it can be said that in general, a reversal on time will elicit a less rough percept.
2. Jie Huang: Explain better your program that estimates (predicted) roughness.
   A more generous explanation about the inner mechanisms of the implemented prototype was included in Chapter 3.
3. William Martens: The candidate needs to clearly distinguish between estimated and reported roughness.

A close revision of the whole manuscript was conducted to identify and properly qualify each appearance of the term.

4. Satoshi Nishimura: The dissertation needs more explanation about JT (just tuning). Further, the relation of this research to other retuning applications based on MIDI streams should be clarified.

   An extended revision of tuning systems was included in the dissertation to address Prof. Nishimura's concerns.

5. Ian Wilson: Because the presentation seemed rushed, some topics were not adequately explained. For example, it wasn't clear how Vicentino's Archicembalo is related to this research.

   The presentation was revised to exclude some slides and give more room to explanations on topics such as that mentioned by Prof. Wilson. Vicentino's Archicembalo was historically important as one of the first consistent efforts to compromise pitch drift and perfect consonance

After the formal presentation, referees posed several questions:

Prof. Wilson asked questions about if anatomical differences in the basilar membrane across subjects might cause differences in perception of roughness. (The answer is "no.") He also asked if cultural differences would be a factor. (The answer is "yes.") He also asked if racial differences might be a factor. (The answer was "not likely.")

Prof. Nishimura asked about why MIDI wasn't used for representing the signals, since pitch shift is easy therewith. (The answer is that we wanted to handle real signals, not the idealized and unrealistically consistent timbres of MIDI patches.)

Prof. Martens asked about the potential contribution of the research to commercial products (Like Melodyne, which does source separation from polyphonic sound files). (The answer is that there might indeed be some commercial applications.)

Prof. Huang asked for a clarification of the details of the temporal vs. spectral approaches (duly offered). He and Prof. Martens also asked about the consideration of binaural cues to roughness perception. (The enthusiastic answer was that binaural considerations were the anticipated next phase of the research, and folding in binaural cues to the roughness model would inform various applications, including concert hall acoustics.) Prof. Huang inquired about the validity of the model of overall roughness being the accumulation of individual roughnesses, a simple sum of the cross product of frequency components. (This is a legitimate concern, and the model proposed by the research is admittedly a simplified first step, even before consideration of binaural effects.)

One of the non-referee guests asked about general applications and individualizability of roughness model parameters. (The answer was that such semicustomizability could enhance multimedia applications.)

Prof. Huang asked about non-linear effects, and if partials would cause higher roughness estimates. (The answer is "yes," with highlighted reminder of decoupling of roughness and preference.)

There was general consensus among the committee that the final exam's presentation was improved compared to the preliminary exam, as the candidate was more relaxed, and the explanations clearer and more confident. The questions were well fielded, and the candidate seemed authoritative on the topics.

It was the unanimous opinion of the committee that the candidate fulfilled all the requirements, both formal and implicit, for the doctoral degree.

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