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

第20号

The Nineteenth Issue

平成24年9月

September, 2012

The University of Aizu

はしがき

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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Number of the diploma of the Doctoral Degree 学位記番号	甲 CI 博第 28 号
The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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	Voice-based Emotion Excitation of Collaborative Virtual Environments 仮想環境での音声に基づいた感情表現
Thesis Review Committee Members 論文審査委員	University of Aizu, Prof. Michael Cohen (Chief Referee) University of Aizu, Senior Associate Prof. Konstantin Markov University of Aizu, Senior Associate Prof. Incheon Paik University of Aizu, Senior Associate Prof. Satoshi Nishimura 会津大学教授 マイケル コーエン(主査) 会津大学上級准教授 コンスタンティン マルコフ 会津大学上級准教授 白 寅天 会津大学上級准教授 西村 憲

Abstract

Collaborative Virtual Environments (CVEs) are important components in the Human-Computer Interaction (HCI) domain. 3D CVEs enable computer networks into computer-simulated 3D spaces that support interpersonal interactions and social events. Such CVEs encourage people to establish or maintain social relationships, to get real world-like exciting experiences, to exchange ideas, and to feel real-world emotions.

Second Life is a popular CVE among online communities and Open Wonderland is another widely used CVE among research communities. Second Life provides an scripting interface to modulate avatar movements, but the source is not provided as Open Wonderland developers do. For our research, we have used both environments as emotion expression platforms.

In order to communicate emotionally in Second Life, a user must trigger the appropriate emotional gesture and facial expression of the respective avatar via a click events of GUI. In this research, we introduce a new framework to trigger emotional gestures and facial expressions based on voice of the speaker. Though Open Wonderland is not rich in emotion expressions, we used it for prototyping purposes.

Speech is a salient conveyor of emotional cues, and can be used as an important source for emotional studies. Speech is modulated for different emotions by varying frequency- and energy-related acoustic parameters such as pitch, energy, and formants. In this study, we explore analyzing inter-subband energy, the energy variation between high vs. low frequency bands and intra-subband energy, the energy variation within frequency bands intra-subband energy to differentiate six emotions. The emotions considered are anger, disgust, fear, happiness, neutral, and sadness. Two-Layered Cascaded Subband Cepstral Coefficients (TLCS-CC) analysis was introduced to study energy variations within low and high arousal emotions as a novel approach for emotion classification. The new approach was compared with Mel frequency cepstral coefficients (MFCC) and log frequency power coefficients (LFPC). Experiments were conducted on the Berlin Emotional Data Corpus (BECD).

Second Life allows residents to upload Biovision Hierarchy (BHV) files to make new postures and gestures available to one’s own avatar. We have created poses for each of the six Ekman emotions using QAvimator software according to the published literature. QAvimator is a BHV animation editor, created to make animations for Second Life.

For offline emotion classifications, with TLCS-CC features, we could achieve average accuracy of 62.7% and 82.3% for speaker-independent and -dependent emotion classification respectively. The output of the proposed emotion classification system was conveyed to modulate postures, gestures, and facial expressions of Second Life avatars.

Keywords: emotion classification, hidden Markov models, emotion expression, sentiment analysis, subband energy

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The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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 of Longterm Pulse Rate Variability and Its Application in Personal Health Care 長期脈拍変動の解析と個人別健康管理への応用
Thesis Review Committee Members 論文審査委員	University of Aizu, Prof. Wenxi Chen (Chief Referee) University of Aizu, Prof. Michael Cohen University of Aizu, Associate Prof. Xin Zhu University of Aizu Associate Prof Yasuhiro Hisada Fukushima Medical University, Prof. Ryuki Kassai 会津大学教授　陳　文西(主査) 会津大学教授　マイケル　コーエン 会津大学准教授　朱　欣 会津大学准教授　久田　泰広 福島県立医科大学教授　葛西　龍樹

Abstract

The clinical importance of heart rate variability (HRV) has been apparent over the past three decades. In certain circumstances, the evaluation of HRV has been shown to provide an indication of cardiovascular health. Pulse rate variability (PRV) may serve as a supplement and potentially a replacement of HRV when application. However, unlike HRV has been studied extensively in clinical practice, the application of PRV in health care domain still remains unclear in many aspects. This thesis aims to explore approaches for PRV analysis and exploit the potential application of PRV in the field of personal health care.

The scope of this research covers several aspects in personal health including health condition tracking, biorhythm detection, and sleep quality evaluation, etc.. All studies are based on real data from subjects differed in age, gender, and health conditions. Pulse signals are recorded nightly over long term. Both linear and nonlinear methods are selectively conducted for PRV analysis according to different requirements and purposes.

Chapter 1 introduces the characteristics of PRV including its mechanisms, physiology significance, clinical implications and measurements. Chapter 2 explores the application of PRV in health tracking over seven successive seasons. A combined linear (time and frequency domain) and nonlinear (noise limit, detection rate, sample entropy, and Poincar´e plots) method is proved to effectively reveal long term features in PRV. Early changes in health condition and its temporal transition are able to be detected. Monthly and seasonal orbits of pulse rate (PR) nonlinearity of the patient are also observed to follow different trajectory compared with a healthy subject. Chapter 3 observes PR dynamics of a normal pregnant woman during her late pregnancy and 1 year post partum. Histogram and a two-Gaussian mixture model are used to analyze weekly PR changes. Time required for full restoration of normal cardiac dynamics after parturition is investigated. Chapter 4 detects cardiac biorhythms in both health and disease. The first study unveils circaseptan features in PR and PRV by using ensemble empirical mode decomposition and cosinor analysis method. The second study detects seasonal characteristics in PR chaos by using noise titration, sample entropy and spectral analysis. Chapter 5 studies the nightly behaviors of PR from an elder resident of a local nursing home and proves the capability of PRV as a supplementary tool for pre-evaluation of sleep quality. Chapter 6 gives the conclusions and the future works.

In sum, results indicate the feasibility of applying PRV as a potential prognostic index for health evaluation. Methods proposed may contribute to better understand the cardiac function in a more convenient and effective way which makes PRV analysis capable to serve as a supplementary tool in health care practice.

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The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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	Noninvasive Estimation of Two-Dimensional Distribution of Deep Body Temperature Based on Finite Element Analysis of a Human Abdominal Model 人体腹部モデルの有限要素解析による深部体温の2次元分布の無侵襲的推定方法に関する研究
Thesis Review Committee Members 論文審査委員	University of Aizu, Prof. Wenxi Chen (Chief Referee) University of Aizu, Prof. Gennadiy Nikishkov University of Aizu, Prof. Ihor Lubashevsky University of Aizu, Associate Prof. Xin Zhu Osaka Electronic Communication University, Prof. Tamura Toshiyo 会津大学教授　陳　文西(主査) 会津大学教授　ジェナディ　ニキシコフ 会津大学教授　イゴール　ルバシェフスキー 会津大学准教授　朱　欣 大阪電機通信大学　田村　俊世

Abstract

Focusing on the noninvasive deep body temperature (DBT) estimate, the works of this study consists of two aspects. One is the close investigation of the promising noninvasive DBT measuring method: dual-heat-ux (DHF) method. In this study, its measuring performance was systematically evaluated; suggestions for performance improvement were put forward. What is more, this method was applied to the clinical trial. Regarding the performance of the DHF method, the results showed that the estimated temperature with this method was affected by the ambient temperature as well as the blood perfusion rate. However, the measuring depth of the probe was about 6 mm beneath the probe in the skin and tissue layer even the blood perfusion rate was varying. Based on the simulation procedure, an optimized structure was proposed, whose height was half of the prototype and the radius wasn't changed. The conjunct improvements with these two modifications extended the estimated depth to 7.6 mm in the skin and subcutaneous tissue. According to the results with clinical application with DHF method, some special rhythmic DBT fluctuations were observed to be encompassed by the normal circadian rhythm for the patients with cerebral infraction sequela.

The other aspect of this study is: by integrating biophysics, physiology and computer science principles, a brand-new noninvasive DBT estimation method was proposed and validated with finite element model. The results showed that inverse method was promising in providing a two-dimensional DBT map based on some assumptions. It may provide accurate estimation for the target zones, whose temperature variation can be reflected by the cutaneous sensors. The standard deviation of the absolute error for these zones was at ten to the negative 4^{th} power. This method provides accurate estimation even of the heat effects of blood perfusion and metabolism in the muscle and skin are included.

According to the results, the measuring depth of the DHF method would be less than 10 mm, which is the approximate thickness of the forehead, temporal region or the preauricular region of human adult. Thus, the head is a preferable measuring location for the DHF method to attain accurate measurement of DBT.

The inverse method, comparing with the DHF probe, is expected to provide more information about the DBT distribution, that is, a two-dimensional map of DBT distribution inside human abdomen. Basing on the aforementioned advantage, this method, except for the general DBT monitoring, is promising in, for example offering diagnostic assistance on tumor control and prevention, organ

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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 31 号
The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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	A method for classification of images using features based on pixel correspondence between images 画像間の画素対応にもとづく特徴を用いた画像分類の手法
Thesis Review Committee Members 論文審査委員	University of Aizu, Special Honarary Prof. Ryuichi Oka (Chief Referee) University of Aizu, Prof. Qiangfu Zhao University of Aizu, Prof. Michael Cohen University of Aizu, Associate Prof. Jung-pil Shin University of Aizu, Senior Associate Prof. Keitaro Naruse 会津大学特別栄誉教授　岡　嶐一　（主査） 会津大学教授　趙　強福 会津大学教授　マイケル　コーエン 会津大学准教授　愼　重弼 会津大学上級准教授　成瀬　継太郎

Abstract

Categorical classification for real-world images is a typical problem in the field of computer vision. This task is extremely easy for a human due to our visual cortex systems. However, developing a similarity recognition model for computer is still a difficult issue. Although numerous approaches have been proposed for solving the tough issue, little attention is given to the pixel-wise techniques for recognition and classification. Typical problems such as “What is it?”, “Where is it?” are central to computer vision and have received much attention in recent years. Moreover, the performance of current state-of-the-art computer vision algorithms for image classification is significantly insufficient compared to human abilities.

To reduce this gap, it is important to evaluate if machines have “mastered” certain aspects of the problem, and not just focus on the side of “human-like.” Towards this goal, we focus our investigation on the pixels, the atomic elements of an image, and identify the performance bottleneck. In this paper, we adopt dynamic programming into our pixel-wise method to determine the similar parts between two images. The goal of our paper is to determine a solution which is able to optimally capture the corresponding pixels within nonlinearly matched areas in an input image and a reference image representing an object without segmentation pre-process in advance. Moreover, categorical classification can be realized simultaneously.

In this paper, we consider an innovative method for recognizing real-world images based on pixel matching between images. A method called two-dimensional continuous dynamic programming (2DCDP) is adopted to optimally determine the corresponding pixels within nonlinearly matched areas in an input image and a reference image representing an object without advance segmentation procedure. Direction pattern (a set of scalar patterns based on quantization of vector angles) is made using a vector field constructed from the matching pixels between a reference image and an input image. Two classification algorithms, Cross Reference based Algorithm (CRA) and Intermediate Reference based Algorithm (IRA) have been proposed for categorical classification. The category of the test image is then deemed to be that which has the strongest correlation with the orientation patterns of the input image and its reference image. Experimental results show that the proposed IRA method achieves a competitive and robust performance on the Caltech 101 image dataset, especially on 15 training level, IRA achieves (67:4%), which outperforms most state-of-the-art conventional methods. Furthermore, for those “difficult tasks,” IRA also achieves a better performance (65:9%) than previous works.

Keywords: categorical classification, image processing, segmentation, pattern recognition and machine learning.

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Number of the diploma of the Doctoral Degree 学位記番号	甲 CI 博第 32 号
The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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	Architecture-based Performance and Energy Optimization for Multi-core and Many-core Systems マルチ・メニーコアシステムのアーキテクチャ・ベースのパフォーマンスとエネルギーの最適化
Thesis Review Committee Members 論文審査委員	University of Aizu, Senior Associate Prof. Song Guo (Chief Referee) University of Aizu, Prof. Stanislav G. Sedukhin University of Aizu, Prof. Qiangfu Zhao University of Aizu, Senior Associate Prof. Abderazek Ben Abdallah 会津大学上級准教授　ソン　グオ　（主査） 会津大学教授　スタニスラフ　セドゥーキン 会津大学教授　趙　強福 会津大学上級准教授　ベン　アブデラ　アブデラゼック

Abstract

Nowadays, multi-core and many-core systems have been the mainstream of computer systems, shifting Instruction Level Parallelism (ILP) to Thread Level Parallelism (TLP). The evolution of computer architectures and parallelism mechanisms bring much performance benefits, however also make system researchers face new challenges - Explicit Parallelism and Energy/Thermal Crisis. This Thesis try to answer to two challenges. With focus on tag reduction technology, energy awareness of multi-core systems are deeply researched; besides, with the Genetic Algorithms (GAs) as the case study, architecture-based analysis and optimization are explored for multi-core and many-core systems, so that the work in the thesis can help GA researchers and engineers to beat the challenge of Explicit Parallelism on multi-core and many-core systems. Tag reduction technique can save energy of the single-core system, also called Chip

Multiprocessor (CMP). Firstly, we propose the Tag Reduction on CMP (TRoCMP) that is a novel approach to energy saving for multi-core system to answer the challenge of energy crisis. With features of multi-core architecture, we find the new opportunity of tag reduction to save more energy. Then we extend tag reduction from single-core to multi-core processor, including proposing three heuristic algorithms to implement TRoCMP. Also, the performance overhead is considered, so that Core Degree mechanism and a refined heuristic algorithm are further introduced and designed to find out the trade-off of energy saving and performance overhead of TRoCMP. With consideration of energy saving and performance overhead, the TRoCMP is an enery-aware system for multi-core architectures.

On the other hand, in order to answer to the challenge of Explicit Parallelism, we discuss GAs from an architectural perspective, offering a general analysis of performance of Gas on multi-core CPUs and on many-core GPUs. Based on the widely used Parallel GA (PGA) schemes, we propose the best one for each architecture. More specifically, the Asynchronous Island scheme, Island/Master-Slave Hierarchy PGA and Island/Cellular Hierarchy PGA are the best for multi-core, multi-socket multi-core and many-core architectures, respectively. Optimization approaches and rules based on a deep understanding of multi- and many-core architectures are also analyzed and proposed. Finally, the comparison of GA performance on multi-core and many-core architectures are discussed. Three real GA problems are used as benchmarks to evaluate our analysis and findings.

There are several extra contributions in the thesis compared to previous work. For the energy-aware TRoCMP, to our best knowledge, we are the first to extend tag reduction from single-core to multi-core processor. Besides, tag reduction is very sensitive to the usage of physical memory and the traditional multi-core simulator can not emulate the memory hierarchy when the multi-threaded applications are executed. We use a real system to evaluate the effect of TRoCMP, so that more convincing results of TRoCMP can be obtained. Thirdly, the performance is deeply considered, detailed model of energy saving and performance overhead is constructed, so that with the solid evaluation of TRoCMP, our work can make balance between energy saving and performance overhead. Regarding to the performance optimization of GAs on multi-core and many-core systems, our findings can be applied to all GA problems, even for other parallel

computing, not for a particular GA problem in the previous work. Secondly, the performance of GAs in our work not only concerns execution speed, also the solution quality that has not been considered seriously enough. Finally, the speedup of GAs on GPUs is compared to the well-optimized one on the multi-core CPU, so that the speedup presented in this work is more reasonable and is a better guide to practical decisions.

This thesis makes a deep exploration for multi-core and many-core architecture with focus on both performance and energy. Besides detailed theoretical analysis, solid experimental results validate the findings and conclusions in this thesis.

Keywords: CMP, GPU, performance evaluation, energy-aware, tag reduction, genetic algorithm.

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Number of the diploma of the Doctoral Degree 学位記番号	甲 CI 博第 32 号
The Date of Conferment 学位授与日	September 21, 2012 平成 24 年 9 月 21 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	Cross-Layer Optimization for Wireless Networks using Networks Coding and Cooperative Communication ネットワークコーディングと協調通信を利用した無線ネットワークのためのクロスレイヤ最適化
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Abstract

Network coding and cooperative communication are two of the most promising techniques to provide high capacity and reliability in wire- less networks. Network coding advocates intermediate nodes to process and combine packets instead of only forwarding them, while cooperative communication allows multiple single-antenna nodes to collaboratively form a virtual antenna array that increases the channel capacity and reliability. This dissertation focuses on exploring the benefits of network coding and cooperative communication in wire-less networks using cross-layer optimization method. The goal is to design and evaluate algorithms and protocols on the basis of these two techniques so as to provide high throughput and reliability for both unicast and multicast sessions. The contributions of this dissertation are as follows. First, we propose a reliable multicast protocol, called CodePipe, using network coding and opportunistic routing in lossy wireless networks. Compared with other multicast protocols, CodePipe can provide energy-efficiency, high throughput and fairness by using four key techniques, namely, LP-based opportunistic routing structure, opportunistic feeding, fast batch moving and inter-batch coding. Second, we study the throughput maximization problem via relay selection in cooperative communication. For unicast, it is a P problem and an optimal algorithm is developed. For broadcast, we show the challenge by proving it NP-hard and propose a greedy heuristic algorithm. Finally, we investigate the problem of maximizing the minimum transmission rate among multiple source-destination pairs using cooperative communication in cognitive radio networks. We perfectly combine the network coding and cooperative communication to provide a much improved max-min transmission rate under various network settings.

博 士 学 位 論 文
Doctoral Thesis

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審査結果の要旨
Thesis Abstracts
and
Summaries of the Thesis Review Results

第20号
The Twentieth Issue

平成24年9月
September, 2012

発行 会津大学

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