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.)

目　次

Contents

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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)
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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	Development of a Layout-driven Behavioral Synthesis System for Asynchronous Circuits with Bundled-data Implementation 束データ方式による非同期式回路を対象としたレイアウトを考慮した動作合成システムの開発
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Abstract

This thesis presents a layout-driven behavioral synthesis system for asynchronous circuits with bundled-data implementation. The objective of the proposed system is to synthesize a near-optimal circuit in terms of the latency. The proposed system accepts a behavioral description written in the C language, a resource library, and a set of design constraints as inputs. It then applies bit-width analysis, initial allocation, operation scheduling, resource binding, control synthesis, and floorplanning. The proposed system iteratively performs behavioral   synthesis and floorplanning to consider the effect of wire delays. In addition, we apply three optimization methods during the behavioral synthesis and floorplanning. During behavioral synthesis, the insertion of additional delay elements is prevented by removing hold constraints in register allocation and satisfying branch constraints in operation scheduling. Additionally, in the floorplanning stage, the proposed system optimizes the latency of the synthesized circuit while minimizing the delay of the control circuit in consideration of timing constraints.

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Thesis Title 論文題目	Application-driven Algorithms in Mobile Sensor Networks モバイルセンサネットワークにおけるアプリケーション指向のアルゴリズムに関する研究
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Abstract

With progress of ubiquitous technologies, several devices around us (e.g., laptop, mobile phone, TV, music player) can be interconnected through wireless technologies such as WiFi, Bluetooth, and RFID. This trend is accelerating in recent years and everything will be connected to the Internet in the future, so-called Internet of Things (IoT). Wireless sensor networks (WSNs) will also play an important role in IoT where sensor nodes collect required data and collaborate to accomplish tasks. One of the most popular applications in WSNs is observing target environments which are too dangerous or inaccessible to humans or large robots. However, there are many challenges for deploying and maintaining WSNs in such unfriendly environments. A mobile sensor network system solves this problem from several points of view (1) to enhance and complement existing sensor network applications; (2) to provision more event-driven applications; and (3) to provide more user-centric service in the next-generation network.

From the first point of view, sensor network systems may take longer time to gather data if the number of sensors is greatly increased. Services for users should be provided in a timely manner, so that time-effective data gathering is important. In addition, data gathering mechanisms for WSNs should be energy-efficient because a sensor node's energy resource is limited. Most existing WSNs use a traditional server/client model, which poorly performs data gathering when many sensor nodes are deployed. One solution for the problem is to introduce mobile agents (MAs) to WSNs, which is a kind of software autonomously migrating from node to node over WSNs while it performs computation independently. Most of a conventional MA-based model uses a fixed server in the network, which leads hot spot problems in the networks and to shorten the network lifetime. To solve those problems, we first develop MAs called TinyBee which works collaboratively with a mobile server. TinyBee can collect data from randomly deployed nodes and autonomously returns to the mobile server with gathered data. The TinyBee system can successfully save energy as well as distribute energy consumption of each node. However, MA's itinerary should be determined unlike the routing in WSNs such as focusing on energy efficiency to prolong the lifetime of a WSN and time efficiency not to take much time to deliver data from node to node. These metrics are also important to decide an MA' route but are insufficient since MA is intended to gather specific information from many sensor nodes by utilizing one of MA's features which is capable of local computation in a network. Research on MAs still remains unfledged in development of application-oriented data fusion, which is highly desired in WSNs deployed in recent days for environmental and disaster monitoring. We propose a dynamic itinerary planning for MAs (DIPMA) to collect data from sensor networks with an application-oriented approach. In particular, the DIPMA algorithm is applied to the data collection for frost prediction which is a real-world application in agriculture using next-generation sensor networks. The performance of the DIPMA is evaluated by simulations and the experimental results show that the total execution time of MA can be reduced significantly with our approach while frost prediction accuracy is maintained.

From the second point of view, although MA-based WSNs can significant improve the performance of gathering data from environments as well as providing context-aware services to

users in more flexible ways, MA cannot perform actions according to situations directly since MA is program code/software. A mobile actor is a promising tool for wireless sensor and actor networks (WSANs) provisioning energy and time efficient data collection. In WSANs, sensors are low-cost and low-power and deployed throughout a field to sense environments, while actors are powerful and resourceful and are deployed much less than the number of the sensors. The actors collect and process data reported by the sensors and perform actions according to situations when the sensors detect events in the monitored field. We study actors' mobility control in WSANs for efficient events detecting in terms of time and energy consumption. We introduce an innovative approach, ORACLE, to make actors predict events before sensors detection and migrate to the areas where the event may occur. In specific, we propose an event prediction scheme to predict an event from collected sensory data by utilizing the maximum likelihood estimation. Based on the perception, we design a control policy of actor's mobility pattern with Markov decision process. ORACLE not only enables minimal motion of actors which conserves time and energy to reach the event areas but also is energy-efficiency for sensors to reduce the forwarding range for event detection message. We evaluate the effectiveness of our proposed scheme through extensive experimental analysis.

From the third point of view, with recent advances in low-power wireless communications and micro-electronics, the next-generation networks emerge on several kinds of fields such as a health-care system and a transportation system. An Intelligent Transportation System (ITS) requires the context information to provide various services to drivers/passengers such as cooperative traffic information management and parking guidance systems. Vehicular Ad hoc Networks (VANETs) are one of the next generation networks where moving vehicles as nodes construct networks and have been envisioned to use in road safety and comfort for passengers by collaborating with ITSs. Recently, the ShanghaiGrid (SG) project presents an innovative cost-efficient way to collect traffic conditions using VANETs where traffic sensors are deployed on several thousands of mobile taxies. Traffic condition information perception from these sensory data is very challenging because individual taxi reports are error-prone and sparse in terms of temporal and spatial distribution. In this thesis, we use a data aggregation approach to overcome the "error-prone" problem and "sparse" problem. We first extensively study the characteristics of the measurement data from over 3000 operational taxies in Shanghai City. Utilizing the spatial correlation of traffic conditions, we propose a correlation based traffic estimation algorithm to successfully expand the coverage of taxi sensors. Our experimental result demonstrates the significance of the proposed algorithm by providing the traffic information at any time and any location in Shanghai City.

Moreover, we design an application model using our traffic estimation method, which supports a vision of VANETs. The traffic estimation method can be applied not only to traffic congestion control and driving path planning, but also to a new paradigm of information sharing among vehicles and road-side stores. To provide drivers/passengers of vehicles real-time local information (e.g., slot occupancy at parking area and daily flyers of supermarket), we propose information provisioning policy using real-time traffic conditions of each road segments and selectively provide local information as much as possible to match each user's range of interest

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Thesis Title 論文題目	A smart reminder system for coupling-paired activities 両腕対動作のためのスマートリマンダシステム
Thesis Review Committee Members 論文審査委員	University of Aizu, Associate Prof. Vitaly Klyuev (Chief Referee) University of Aizu, Associate Prof. Keitaro Naruse University of Aizu, Prof. Shigaku Tei Former University of Aizu Prof. Minetada Osano 会津大学上級准教授 ヴィタリー クリュエフ(主査) 会津大学上級准教授 成瀬 継太郎 会津大学教授 程 子学 前会津大学教授 小佐野 峯忠

Abstract

A significant number of elders live with memory impairment issues, as a result of the normal aging process. Therefore various kinds of supporting systems have been developed to help the elders, who have mild memory problems. But most of those systems are not designed to provide reminders for crucial complex human activities in daily life. Therefore,in our doctoral dissertation research we have proposed a Smart Reminder System for reminding forgotten complex activities, in home environment. Subjected complex activities are the activities, which should be completed as originally intended, after they are initiated. Some common examples for those activities are closing hot water flask after filling the water, buttoning up a suit after wearing, closing a medicine container after taking medicine, etc. Two clear phases could be identified in those kinds of activities, such as initiation phase and conclusion phase. For example, when a bottle is used, initiation phase is opening the bottle and conclusion phase is closing that bottle. A significant feature of subjected processes is the ―strong dependency of conclusion phase to the initiation phase‖. Therefore those kinds of activities are called Coupling Activities in this research. Concentrated Coupling Activities (CAs) in this work are, the activities which are done by using particular object and involving the both hands of the user. While performing those activities, both hands are paired simultaneously to perform the activity in each initiation and conclusion phase. As both hands are pairing simultaneously while performing particular phase, they are called Paired Activities (PAs) in this research. When always the conclusion PA is depended on the initiation PA, they are called Coupling-Paired Activities (CPAs) in this dissertation. Some common CPAs in daily life are: opening and closing a bottle, opening and closing a bag, opening and closing a door, etc. Due to busy life style or memory issues, those kinds of CPAs can be forgotten to be completed easily after they were initiated. Therefore many issues can be occurred with those kinds of CPAs in daily life. For example, forgetting to close a hot water flask after filling hot water may cause changes in water temperature, forgetting to close a hand bag after opening may cause loss of valuables. Therefore it is important to keep attention on those kinds of CPAs and remind them when they are likely to be forgotten. But research is yet to addresses above mentioned issues in any great detail. Currently available activity reminder systems are not much focused on identifying Paired Activities (PAs) and limited to identify the abstract nature of simple activities like eating, sleeping, walking, toileting or other past experience that happen with regular frequency. Therefore in this work an attempt is taken to provide reminders for the Coupling-Paired Activities (CPAs), which are easy to forget. In order to provide reminders for the CPAs, which are likely to be forgotten, the initiation and conclusion phases of those activities should be recognized. For example, to detect whether the opened bottle has been closed within the intended time period, it is necessary to recognize, bottle opening and closing phases separately. Paying attention to that fact, major contribution is done to recognize initiation and conclusion phases of those kinds of Coupling-Paired Activities. When we consider the behavior of those phases independently, each phase can be considered as a Paired Activity. Subjected PAs in this work take very short time period to be performed comparing to other daily activities. The objective of our study is to recognize CPAs requiring a short period of time for processing and

provide reminders for them, when they are going to be forgotten. The specific case study of opening and closing various types of bottles in a home environment is addressed to represent short time consuming CPAs. This type of activities have not been addressed in past human activity recognition research studies.

In order to provide user adaptable smart reminders, we utilize user's current behavior, current location as well as past activity patterns in the system development. Unlike previous reminder systems, this system employs better simulation models, to recognize complex

human behavior. In order to define subjected PAs, a new model called Paired Activity Model (PAM) is introduced. That model simulates the paired behavior of both hands. To recognize paired activities using PAM, Paired Activity Recognition Algorithm (PARA) is implemented. In order to express the CPAs clearly, a new model called Coupling Paired Activity Model (CPAM) is proposed. That model also simulates the probable human behavior while performing CPAs, in a real world scenario. A Smart Reminder System (SRS) is developed, based on the CPAM. It provides reminders for the CPAs. SRS consists of PA Recognition Layer (PARL), Location Recognition Layer (LRL) and Reminder Prediction Layer (RPL). To provide most accurate reminders, PARA is used in PARL, to recognize performed PAs. User's paired motion patterns are collected by wrist worn three axis accelerometers. Frame base activity modeling method is used to model the activities using raw accelerometer data. Then time domain and frequency domain features are extracted from the segmented frames. Features, which represent the individual and correlative behaviors of both hands are extracted under those time domain and frequency domain features. A new threshold value called Sub Frame Confusion value of a Sub Frame is proposed to reduce the confusions which can be occurred in frame base activity modeling. An Artificial Neural Network (ANN) algorithm is used for data categorization in Paired Activity Recognition Algorithm. In the LRL, user's current location is captured by a body worn web camera. RGB (Red, Green, Blue) values of each pixel are extracted from the captured images for image categorization. The ANN algorithm is used for image recognition as well. Fuzzy logic is used in Reminder Prediction Layer (RPL) for predicting reminders. User's past activity patterns are utilized in the decision making process in RPL, in order to provide user adaptable smart reminders. Paired Activity recognition performance of ANN is compared with a Support Vector Machine (SVM) algorithm also. Proposed Smart Reminder System and the aforementioned approaches were evaluated using different test scenarios. Those test scenarios were designed according to the typical real world scenarios. In addition to bottle opening and closing experiment, performance of PARA was tested with some other general Paired Activities in home environment also. Ten subjects who were aged between 20-60 were participated to the experiments. The results of the experiments were evaluated using standard statistical methods. Performance of PARA was depended on the performed activities and the nature of working environment. According to the received results we could analyze that, the performance of PARA was depended on the simultaneous behavior of both hands while performing the activity. It could achieve better recognition rate for fully Paired Activities rather than less Paired Activities. Activity recognition performance was reduced when the Unrelated Activities were performed with Target Activities. However it could achieve 93% average recognition rate for performed activities.

Comparatively high false positive rate could be identified among similar type of activities. ANN significantly outperformed the SVM algorithm in real time evaluations. Average recognition accuracy of Location Recognition Algorithm was in higher level (90%). But always recognition performance was depended on the quality of captured images. Image quality was changed with external environmental factores such as background lighting, moving objects, etc. Proposed Smart Reminder System performed well in the experiments and could achieve 80% average accuracy rate in reminder prediction for Coupling-Paired Activities. It reacted accurately with minimum supervision by the user and could predict reminders adapting to the user's dynamic behaviour. But always reminder prediction performance was depended on the performances of activity recognition and location recognition. The dissertation consists of 87 pages (with publications of 100 pages). It includes 6 chapters and conclusion. A list of references consists of 102 items.

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Abstract

Different clinics and hospitals have their own information systems to maintain patient data. This hinders the exchange of data among systems (and organizations). There is a need to provide standards for data exchange. In digitized form the individual patient's medical record can be stored, retrieved and shared over a network through enhancement in information technology. Thus, Electronic Health Records (EHRs) should be standardized, incorporating semantic interoperability. A subsequent step requires that healthcare professionals and patients get involved in using the EHRs, with the help of technological developments. This study aims to provide different approaches in understanding some current and challenging concepts in health informatics. Successful handling of these challenges will lead to improved quality in healthcare by reducing medical errors, decreasing costs, and enhancing patient care. The study is focused on the goals of understanding the role of EHRs, understanding the need for Standardization to improve quality, establishing Interoperability in maintaining EHRs, examining a framework for Standardization and Interoperability - The openEHR Architecture, identifying the role of Archetypes for Knowledge Based Systems, and understanding the difficulties in querying EHR Data.

Information sharing across medical institutions is restricted to sharing patient records between restricted groups of specific partners due to lack of standards. Medical practice also requires sharing of data by many agencies over long periods of time. Thus, the structure and content of the life-long electronic health records requires standardization efforts. The existing standards aim to achieve data independence along with semantic interoperability. Recent studies explore existing standards in healthcare from various perspectives. These include various efforts to study relationships and reduce mismatch and overlapping. Most studies focus their attention on the main standards HL7 CDA, openEHR and CEN TC251 EN 13606. At present, there is a lack of a common standard. It poses problems in exchange of information. This study aims to evaluate the existing standards. A frame of reference for analysis of EHR standards is aimed to be evolved. The study explores the gaps between the international standards and addresses the problem of information storage and exchange using archival storages.

Standardized EHRs make use of archetypes for representation of data. In combination with terminologies, the archetypes enable powerful possibilities for semantic querying of repository data. Such querying enables longitudinal processing of health data, regardless of the originating system. Further, the research presents a comparison of the existing information and querying methods and studies their applicability to the archetype-based EHRs systems. It further discusses the best approach to build a user-friendly querying interface for these systems. It has identified the need of high-level query language interface for improving information quality gains in EHR domain. It is possible to find query languages that are similar to database query language. The archetypes can
xiv
transform to XML form. An experiment for use of XQuery-by-Example (XQBE) (graphical user interface) has been performed for a sample set of queries for various database operations. A comparative analysis of the existing and the proposed query languages has been obtained. However,

it requires schema knowledge. The semantics of data is better understood by viewing the data in the context of the user interface (UI). For enhancing the query capability of EHR workers, a prototype query interface AQBE (QBE style queries for archetyped data) has been implemented at the service layer for the EHRs that follow the openEHR standard. It introduces a general purpose database transformation channel. It will shorten the application development process and increase the quality of the software by automatically generating software artifacts that are often made manually (and are prone to errors). It is possible to know the locations of each leaf datum within information conforming to an archetype. The tool helps in the inspection of an archetype in advance, which can yield a set of path fragments. It can be used to query instances which conform to an archetype for intelligent querying.

Further, the thesis focuses on usability, which is defined as the measure of the ease with which a system can be learned and used, including its safety, effectiveness, and efficiency. In order to realize usability improvements on continuous basis, the user centric design (UCD) approach has been selected. UCD is used for developing applications that incorporate user-centered activities throughout the development process. The Total Data Quality Management (TDQM) framework can be adopted for improving quality of user interactions. The TDQM framework has been evolved for development processes, for data and information quality needs. The UCD approach allows end-users to influence the design to increase ultimate usability of the EHR system. It involves assessing the intended users, analyzing tasks and requirements, testing prototypes, evaluating design alternatives, resolving usability problems, and testing interfaces with users (in an iterative manner). In order to automate the monitoring of human-computer interactions in the health care domain, a methodology to interpret and discover unknown patterns and relationships between the end-users and functional requirements has been analysed to improve the usability of EHR systems. It requires various steps to implement recommendations of a TDQM framework. It aims to capture the health worker's needs in a scientific way, on continuous basis.

The security requirements of health data are critical, and more difficult to satisfy than for any other kind of data. This is partly because of conflicting needs of the two categories of health data stakeholders: clinicians (who need easy access to electronic health records) and patients (who prefer secure closed electronic health records with restricted access). A brief light is thrown on various security issues and techniques. It presents a case study for openEHR, with the existing security features in a hospital.

Keywords: Electronic Health Records, Data Quality in Healthcare, Archetype-based EHR, Quality-based EHR, Semantic Interoperability, Standardization in EHR, openEHR, Querying, High-level Query Interfaces, Database Query Languages.

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