

行政院國家科學委員會專題研究計畫 期中進度報告

子計畫一：自適應式及滲透式的居家照護環境(1/3)

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執行單位：國立臺灣大學資訊工程學系暨研究所

計畫主持人：朱浩華

計畫參與人員：張耿豪 吳忠穎 游創文 王科植 吳瑞傑 陳奕超

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行政院國家科學委員會專題研究計畫期中報告

總計畫: iCare: 社群化智慧型居家照護

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摘要

"自適應式及滲透式的居家照護環境"是主計畫 "iCare: 社群化智慧型居家照護"的子計畫之一。在這子計畫的第一年裡, 我們已經設計和做出支援主計畫的系統元件雛型, 計有室內定位系統, 穿戴式系統, 適應性中介軟體, 以及飲食追蹤系統。

Abstract

This project "自適應式及滲透式的居家照護環境" is a subproject of the main project "iCare: 社群化智慧型居家照護". In the first year of this subproject, we have designed and prototyped the following system components to support the main project: indoor localization system, wearable system, adaptive middleware, and dietary tracking system.

Keywords: Indoor location system, adaptive middleware, wearable, smart objects.

I. Background

This subproject "adaptive pervasive environment for home care" is a subproject of the main project "iCare: Community-supported Intelligent Care for Successful Aging in Place". The overall goal of the main project is to create an elders' care framework that can demonstrate the concepts of *pervasive computing* and *proactive control*. Pervasive computing means that elders' care is available anywhere the elders may be, e.g., at (nursing) home, hospital, play, etc. Proactive control means that the computing system can anticipate elders' needs and take actions before being asked explicitly.

During the 1st year of this subproject, we have focused our efforts on building the following key technical components:

Indoor localization system: tracking the elders' location is one of the key information used in the elder's well-being. We have designed and implemented two localization systems that can track the physical locations of the elders in the indoor environments (e.g., home, hospital, etc.). The first localization system is called the *Geta sandals* based on our unique footprint-based method. The 2nd localization system is an *adaptive* WiFi-based localization system that can significantly reduce the adverse effect of environmental dynamics on location accuracy.

Wearable sensors: we have put together a wearable

sensor module that can monitor the elders' vital signs, such as blood oxygen level, temperature, etc. The vital sign sensors are connected to a wearable sensor board.

Adaptive middleware: we have designed and implemented an adaptive middleware that can dynamically reconfigure the applications based whether the elder is mobile (away from home) or in the home environment. In the mobile environment, the application is reconfigured to run on a personal device. In the home environment, the application is reconfigured to run on the home gateway

Dietary tracking system: based on our discussion with medical experts on this project team, they have identified that tracking of dietary habits of crucial importance for the well-being of elders – given that many of the chronic diseases can be controlled with proper dietary habits. We have built a dietary tracking system into a dining table that can track the elder's food consumption and dietary behavior on this table.

II. Objectives

The objectives of this subproject are to provide system and wearable components for the upper i-care layers. These components covered are (1) indoor location system, (2) wearable vital sign sensors, (3) middleware, and (4) dietary tracking system.

III. Related Work

We provide a brief description of the related work as follows. For more thorough related work survey, please see the papers listed in the results section.

Indoor localization system: many indoor location systems have been proposed in the past decade, such as Active Badge [1], Active Bat [2], Cricket [3], RADAR [4], and Ekahau [5]. However, we have seen very limited market success of these indoor location systems outside of academic and industrial research labs. The main obstacle that prevents their widespread adoption is that they require certain level of system infrastructural support (including hardware, installation, calibration, maintenance, etc.) inside the deployed environments. To reduce this high infrastructure deployment barrier, our GETA sandals are designed specifically to require minimum or no infrastructure support.

Wearable sensors: there are many wearable systems that monitor vital signs, such as the wrist-worn alarm system [10] by VTT, gesture pendant [11] from

Georgia Tech, BodyMedia [12] from SenseWear, MIThrill [13] from MIT, etc. In this project, we have adapted the MIThrill solution from MIT.

Adaptive middleware: there are several research projects working on adaptive middleware, such as JEcho [6], Mutable service project [7], Abacus [8], etc. These projects use either compile-time analysis or runtime technique to reconfigure the application partition between the client and server.

Dietary tracking system: The closest system to our dietary-aware dining table is the load sensing table [9] from Lancaster University. They have utilized four load cells installed at four corners of a rectangular table to acquire positional information of tabletop objects, and infer interaction events. However, our table is targeting different application of dietary tracking. This requires tracking multiple simultaneous person-object interactions, in which the Lancaster table is not designed for.

IV. Method

We provide a very brief description of our methods for each of the system components as follows. For more information, please see the papers listed in the results section.

Indoor localization system: we have designed and implemented the *Geta sandals*. This footprint-based indoor location system is built on a pair of traditional Japanese Geta sandals. It can track the indoor position of a user wearing the sandals. It works by measuring and tracking the displacement vectors along a trail of footprints (each displacement vector is formed by drawing a line between each pair of footprints). The position of a user can be calculated by summing up the current and all previous displacement vectors. In comparison to existing indoor location systems, our footprint location system has a unique advantage that it is infrastructure-free. A user simply has to wear the Geta sandals to track his/her locations without any setup or calibration efforts. This makes our footprint method easy for everywhere deployment.

Wearable sensors: we are currently using a wearable sensor board called MIThrill. It has several analog and digital ports that can connect to a variety of vital sign sensors. Using this board, we are able to hook up several vital sign sensors: blood oxygen level and temperature.

Adaptive middleware: we have designed and prototyped a smart client middleware. This smart client middleware can detect the amount of computing & networking resources the target device has. Based on the amount of computing and networking, it can reconfigure and repartition the application, i.e., placing more or less application components on the target client device or remote computing servers.

Dietary tracking system: we have designed and prototyped building a dietary-aware dining table that can track what and how much we eat. To enable automated food tracking, the dining table is augmented

with two layers of weighting and RFID sensor surfaces to detect and recognize multiple, concurrent person-object interactions occurring on the table.

V. Results

During the first year of this project, we have designed, prototyped, and demonstrated some of these systems in academic conferences (Ubicomp, iCare workshop) and technical talks (NCCU, III, Intel, etc.). We have received very good feedbacks on our systems. In addition, we have produced the following publications.

Indoor Localization System:

- Shun-yuan Yeh, Chon-in Wu, Keng-hao Chang, Hao-hua Chu, Jane Yung-jen Hsu, The GETA Sandals: A Footprint Location Tracking System, submitted to ACM Personal and Ubiquitous Computing (ACM PUC), 2005.
- Shun-yuan Yeh, Keng-hao Chang, Chon-in Wu, Okuda Kenji, Hao-hua Chu, GETA Sandals: Walk Away with Localization, to appear in the Demo Session of the Seventh International Conference on Ubiquitous Computing (ACM UbiComp 2005), Tokyo, Japan, September 11, 2005.
- Kenji Okuda, Shun-yuan Yeh, Chon-in Wu, Keng-hao Chang, Hao-hua Chu, The GETA Sandals: A Footprint Location Tracking System, Workshop on Location- and Context-Awareness (LoCa 2005), in Cooperation with Pervasive 2005, (also published as Lecture Notes in Computer Science 3479, Location- and Context-Awareness), Munich, Germany, May 2005, pages 120-131.
- Yi-chao Chen, Ji-rung Chiang, Hao-hua Chu, Polly Huang, Arvin Wen Tsui, Sensor-Assisted Wi-Fi Indoor Location System for Adapting to Environmental Dynamics, to appear in ACM/IEEE International Symposium on Modeling, Analysis and Simulation of Wireless and Mobile Systems (ACM MSWIM 2005), Montreal, Quebec, October 2005.

Dietary tracking system:

- Keng-hao Chang, Shih-yen Liu, Jr-ben Tian, Hao-hua Chu, Cheryl Chen, Dietary-Aware Dining Table - Tracking What and How Much You Eat, to appear in Workshop on Smart Object Systems, in conjunction with the Seventh International Conference on Ubiquitous Computing (ACM UbiComp 2005), Tokyo, Japan, September 11, 2005.

Adaptive middleware

- Chuang-wen You, Hao-hua Chu, Replicated Client-Server Execution to Overcome Unpredictability in Mobile Environment, IEEE 4th Workshop on Applications and Services in Wireless Networks (ASWN), Boston, MA, August, 2004.

References

- [1] R. Want, A. Hopper, V. Falcao, and J. Gibbons. The Active Badge Location System. *ACM Transaction on Information Systems*, 10:1, pp. 91-102, 1992.
A. Harter, A. Hopper, P. Steggles, A. Ward, and P. Webster. The anatomy of a context-aware application. In *Proc. of 5th MOBICOM*, pages 59-68, 1999.
N. B. Priyantha, A. Chakraborty, and H. Balakrishnan. The Cricket Location-Support System. In *Proc. of the 6th MOBICOM*, Boston, MA, USA, August 2000.
- [2] P. Bahl and V. Padmanabhan. RADAR: An In-Building RF-based User Location and Tracking System. In *Proc. of the IEEE INFOCOM 2000*, pages 775-784, March 2000.
Ekahau, <http://www.ekahau.com/>
- [3] D. Zhou, S. Pande, K. Schwan, "Method Partitioning – Runtime Customization of Pervasive Programs without Design-Time Application Knowledge", 23rd International Conference on Distributed Computing Systems, June, 2003.
- [4] D. Lambiri, A. Totok, V. Karamcheti, "Efficiently Distributing Component-Based Applications Across Wide-Area Environments", *ICDCS 2003*, MAY, 2003.
- [5] Amiri, K., Petrou, D., Ganger, G., and Gibson, G. Dynamic function placement for data-intensive cluster computing. *Proceedings of the USENIX 2000 Annual Technical Conference*, San Diego, CA, June 2000.
- [6] A. Schmidt, M. Strohbach, K. Van Laerhoven, A. Friday and H.-W. Gellersen. "Context Acquisition based on Load Sensing". In *Proceedings of Ubicomp 2002*, G. Boriello and L.E. Holmquist (Eds). *Lecture Notes in Computer Science*, Vol 2498, ISBN 3-540- 44267-7; Springer Verlag, Gothenburg, Sweden, September 2002
- [7] I. Korhonen, et al. "Application of ubiquitous computing technologies for support of independent living of the elderly in real life settings", the 2nd International Workshop on Ubiquitous Computing for Pervasive Healthcare Applications, 2003.
E. D. Mynatt, et al. "Aware Technologies for Aging in Place: Understanding User Needs and Attitudes", *IEEE pervasive computing* , p36~p41, April-June, 2004.
- [8] Bodymedia, <http://www.bodymedia.com>
R. Vaul, M. Sung, "MIThrill 2003: Applications and Architecture", *Seventh IEEE International Symposium on Wearable Computers*, October, 2003.