

Overview of the Symbio-Information Processing Project of TUAT

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Abstract—Ubiquitous computing is one of the promising technologies for the future information technology which brings convenient and efficient environment to people who hold their own mobile devices. In this paper, we introduce the project of symbio-information processing in Tokyo University of Agriculture and Technology. We have got together eleven teams with twelve laboratories to innovate information technologies on ubiquitous computing.

Keywords—Ubiquitous Computing, Ubiquitous Network, Wireless Network, Human Interface, Artificial Intelligence

I. INTRODUCTION

Ubiquitous computing, which is introduced under concept of anytime and anywhere and have been evaluated, is currently going to be in mature era. For the sake of the technology, we can get many kinds of profitable information in our living days and economical activities. On the other hand, since everyone can dispatch information, all of them cannot be believed nor confirmed in details. For example, accident of a nuclear power plant in Fukushima by a huge earthquake and Tsunami in east of Japan has brought unclear information and people in Japan has been in confused situation.

In the era of vast information, in order to realize symbio-information society with a harmony among human beings, information technology which supports people's intellectual activities is indispensable. For the sake of efforts of staffs in Tokyo University of Agriculture and Technology, continuous researches have been conducted with supports of many kinds of research budgets, research corporation and entrusted research with companies.

On the other hand, by Asian Human Resource Program by METI and MEXI in Japan titled "Advanced IT Engineer Promotion Program." excellent foreign students from east Asia especially Thailand, Vietnam or China has visited and studied with sufficient budget.

Under such backgrounds, we have been carrying out the research on supporting human intellectual activities such as processor architecture, system architecture, embedded technology, user interface and intelligent applications for five years since our proposal to MEXI "Promotion of symbio-information technology to realize information environment

in harmony with human beings." During the project, we have adopted some young excellent researchers and the results has been restored to the world as papers or presentation.

In this paper, the research results of our projects are shown during these five years and future development to explore another new technologies.

II. OVERVIEW OF THE PROJECT

Over ten years have passed since Mark Weiser proposed concept of ubiquitous computing. Thereafter, information devices such as cellular phones and home appliance have been advanced, thus ubiquitous information environment for human beings to live symbiotically with information devices has been realized. However, though convenience or efficiency for information accessing with RFID is currently closed up, it does not really bring appearance of intellectual productivity of human in spite of the convenience. Somehow, people are confused by vast information and impeded with their essential intellectual activities. Besides, true ubiquitous information environment should built not only merely anytime nor anywhere but contribute information adaptively on demand and bring exhibition of people's capability without any disturbance of users' activities.

On the other hand, concept of universal design has been accepted widely with a guide for design of concept between human and information devices such as displaying design or operation devices. However, to support human intellectual activities truly, an essential function of information processing to contribute needed information as the needed formats and media has been shown.

Therefore, environment which supports our intellectual activities with contributing information which users need according to their situation in easy way to understand is the true ubiquitous information environment. To implement it, consistent design and development from the viewpoint from hardware to interface at the standpoint of supporting intellectual activity as well as system evaluation at the standpoint of engineering based on psychology or physiology. However, there has been few overlooked trials in all over the world, thus we had to urgently tackle on the trials in consideration of the critical situation in which

only convenience in accessing information under ubiquitous environment is focused on.

In this research, we have been realizing symbio-information environment among human and IT devices. In the environment, the system contributes required information according to the situation without disturbing users' thinking with supporting intellectual activity and drawing our ability as much as possible. Our project conduct consistently from hardware to application at an overlooked standpoint.

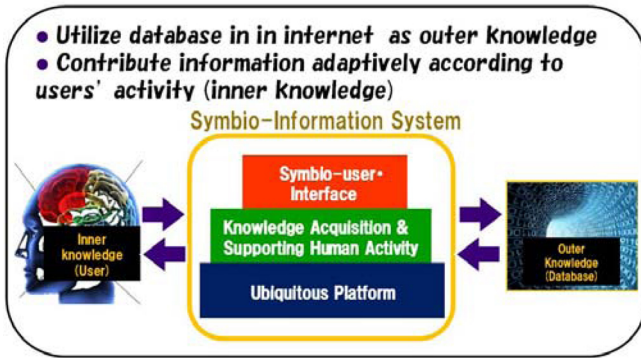


Figure 1. Overview of symbio-information processing project

Figure1 shows overview of the symbio-information processing project to realize above purpose. Since human intellectual activity is based on their knowledge, to support it, it is required to adequately contribute not only inner knowledge in their brain but also outer knowledge which exists outside of them. However, though existing information devices can record and play information, human interface part which supply operation and display is not sufficient from the view point of fluent intellectual supports.

Thus, in the project, we have divided our research groups into three groups : (1) Ubiquitous platform, (2) Symbio-user interface and (3) Knowledge acquisition and supporting intellectual activity. Under consistent concept of symbiosis among human and IT devices, by development of intuitive user interface which does not disturb thinking and dedicated hardware which adapts to users, we have set a purpose to realize true ubiquitous information processing environment. In the each group, we have been tried to show our research results of overall project as shown in the following sub-themes.

III. UBIQUITOUS PLATFORM

In this sub-group, constructing ubiquitous platform is targeted to contribute interface functions to be developed newly. For the purpose, reconfigurable processing mechanisms and their development environment are indispensable to switch functions according to situations as well as speed up of a processor itself and research on processor microarchitecture for high performance.

Besides, to contribute adequate outer knowledge to users, development of mechanism to describe combination of basic behavior of parts of a body is needed as well as mechanisms to increase reliability of data in recognizing the basic behavior by confirming existence of sensors or places to be equipped. In this sub-theme, we have developed the original hardware devices and experiment system including fundamental parts such as network.

A. Massively parallel computing environment with embedded devices

To implement massively parallel computing environment, we have been researching processor microarchitecture and a parallel signal processing method for highly accurate signal processing technologies. For ubiquitous environment we have been investigating a high performance mobile terminal, accelerating mechanism for higher performance based on an Android device. For the future embedded processing technologies, we have been developing a reconfigurable Android terminal device with utilizing Field Programmable Gate Array (FPGA). For the next generation massively parallel processing, dividing a large size of digital circuits and communication among divided circuits are required. Figure2 shows our implementation of an accelerator of Dalvik VM which is a virtual machine for Java byte code on Android.

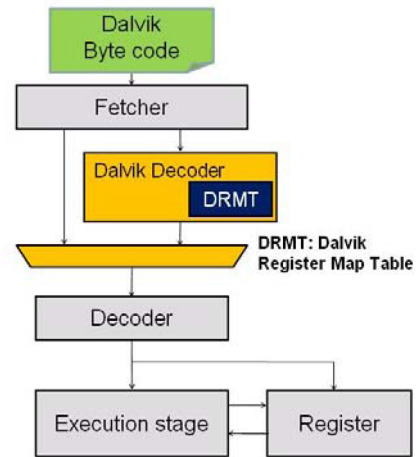


Figure 2. Microarchitecture of Dalvik VM accelerator

B. On-demand typed ubiquitous network and its application

In this research, we have proposed and modeled on-demand typed ubiquitous network. As the model, we have introduced Base/Use typed network model with focusing on difference of characteristics between mobile cellular phone network and Wi-Fi network. In order to show effects of the proposed model, we have developed automatic selecting

wireless network system with considering application behavior and have shown its evaluation results. Figure3 shows the proposed network architecture.

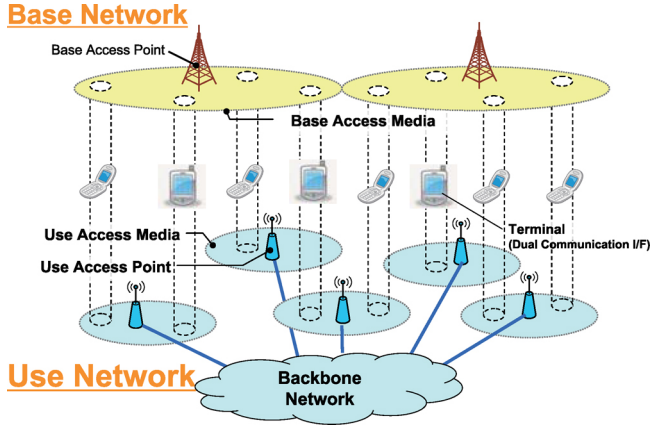


Figure 3. Network architecture of Base/Use typed network model

C. Adaptive cross-layer communication control method under wireless internet environment and evaluation of QoE

Under wireless LAN environment, contributing fine communication quality for video streaming is difficult with current network architecture. In order to overcome this problem, we have to grasp usability of wireless network and contribute an adequate control mechanism. Namely, a system has to estimate and control channel usage which means congestion in wireless LAN from the control information of a MAC layer acceptable at an own terminal. We have proposed and implemented cross layer control which performs traffic control adequately according to congestion of wireless channels and have tried to increase quality of communication of wireless LAN. Figure4 shows the proposed concept of this research.

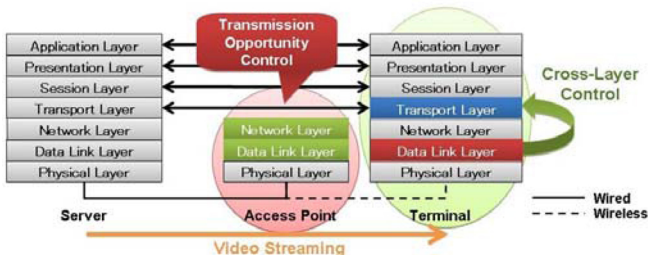


Figure 4. Proposed concept of wireless network architecture

D. Framework for guarantee function with intelligent sensors

In order to recognize behavior with using a cellular phone and to increase accuracy of environment measurements as

well as to support recognition of information by receiving a phone call or a mobile e-mail, it is important to grasp the place where a cellular phone are held in a user's body. In this research, we have proposed and developed grasping methods for it. We have implemented the functions on a Android mobile terminal as a basic system and minimized the developed part as small as possible for each application. Though our proposed concept of placement-aware computing is needed for ubiquitous computing environment to penetrate into our real lives truly, these kind of researches are not conducted in all over the world. Figure5 is the developed experiment system with an Android mobile terminal which warns user.

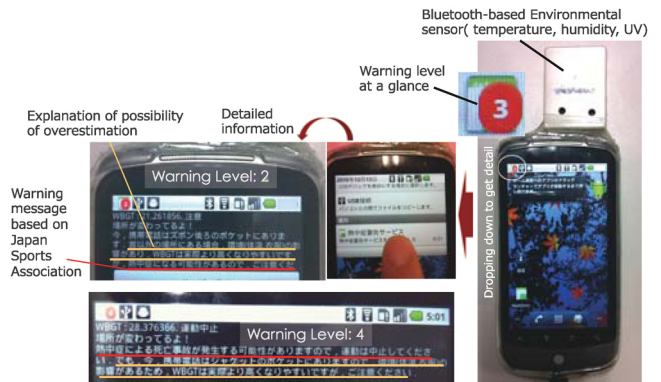


Figure 5. Developed Android experiment system

IV. SYMBIO-USER INTERFACE

Adequate evaluation and improvement are indispensable for the developed system to implement a fine system. In this section we introduce sub-themes which synthesize bio-signals of human bodies and visualize psychological status or hidden information of human beings.

Hazardous signal of stress appears as bio-signals in many ways such as electroencephalogram, electrocardiogram or electromyogram. Therefore, we have developed visualizing methods to grasp these bio-signals totally and expanded monitoring to whole intellectual activities, which would lead to truly intellectual ubiquitous information environment with monitoring processes totally from thinking to generating new knowledge in details.

Besides, we have been analyzing many kinds of behavior of people with utilizing a high performance digital camera which is equipped in a cellular phone or PDA. Moreover, for creative user interface, we have developed a new technology in which hand-written characters can be recognized even if they are mixed with figures in a document.

A. 3D space recognition to implement ubiquitous environment

To realize ubiquitous environment where anyone can retrieve required current information from a vast information

explosion, natural interface is indispensable. For the purpose, technologies to recognize users' behaviors or expressions with a camera equipped in the environment are indispensable for implementing interface without complex operation.

In this research, we have developed a basic technology of image recognition to realize ubiquitous environment and utilize outer knowledge. Concretely, we have developed algorithms to learn and recognize a large amount of image database as well as to retrieve and recognize basic geometric elements included in image data. We are going to develop a faster and more robust method for these algorithms.

Figure6 shows the proposed schemes for 3D image recognition.

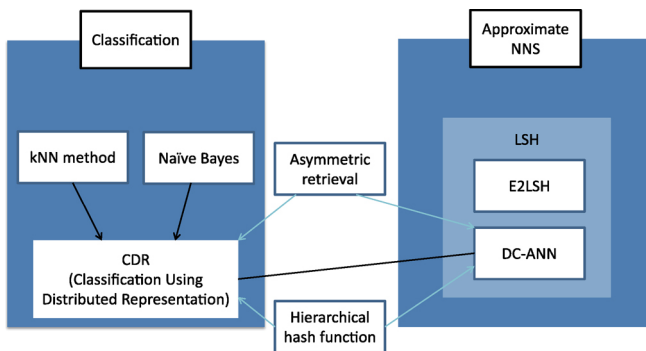


Figure 6. Proposed scheme for 3D image recognition

B. Inconspicuous access system to ubiquitous outer knowledge

In this sub-theme, we have developed an interrupt reject presuming method focusing on switching application during work with a PC in order to display information which minimize disturbing his/her work with presuming status of intellectual activity inconspicuously. Currently, we have been developing tele-working environment to get awareness as if they felt in their own office and a system which adequately let office devices to be operating from the future forecasting with the presumed situation as well as enhancing generality and presuming accuracy of target action in order to realize less carbon world based on technology of presuming a user's intellectual activity. Figure7 shows configuration of the system to gather work history.

C. Quantification of a mental state by measurement of living body information and ubiquitous display for the information

In order to notify effective information from vast information efficiently to users, we have been researching a method of information with considering human recognition features and mental states. As a basic technology for that, it is indispensable to measure and analyze human information of a living body and to obtain knowledge on relationship between the mental state and hidden information. Thus,

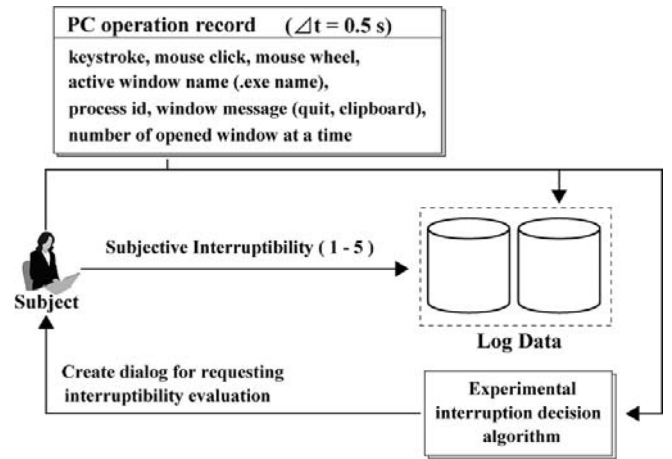


Figure 7. Configuration of the system to gather work history

we have been trying to visualize a mental state or hidden information within human's body with analyzing human information of a living body. Though there exist many kinds of information in a human living body, we focus on brain waves, an electromyogram and an electrocardiogram those are signals of a living body to obtain easily with considering practical use. Signals of a living body involve information which causes many kinds of disease such as stress. A visualization technology of information to promote total grasp of these information is important. Though there have been many methods of visualization, it still has been some hurdles in visualization as information to be investigated increases. Therefore, we have proposed a method to display a large amount of information compactly and comprehensively with a new visualization method. Figure8 shows a measurement system of brain waves.

D. Recognition technology of hand-written characters for thinking- friendly hand-writing interface

In this research, we have been researching to implement environment in which a human can interact a computer with hand-writing and a computer can support and expand natural activities with familiar hand-writing. Concretely, as a basis of the research, we have been conducting the researches on acceleration of pattern recognition of hand-writing, establishment a method of human interface for handwriting and development of applications with hand-writing. It is important to integrate three technologies in balance; a powerful recognizing engine, user friendly human interface and applications which should exist. Figure9 is one of examples of recognized results with our new system.

V. KNOWLEDGE AQUISITION AND SUPPORTING INTELLIGENT ACTIVITIES

In this research group, we have been trying to clear an implementation method of familiar artificial intelligence more



Figure 8. Measurement system of brain waves

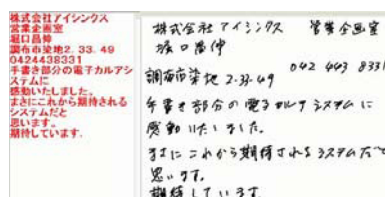


Figure 9. Recognition results with our new system

similar to a human beings and to confirm the effectiveness. Besides, we have been developing learning environment where a user can learn really anytime and anywhere. As a target of the learning, practical English conversation is focused with movie and audio materials. The developed system is implemented with functions of searching conversation scenes and words to contribute highly interesting materials to learners. Moreover, we have been trying to prove that sustainable inter-adaptive functions are indispensable to implement artificiality in harmony with human beings constructively with an actual robot.

A. Symbiotic artificial intelligence with human sensitivity

In ubiquitous environment, it is important for anyone to be able to handle knowledge anytime and anywhere. To construct environment where anyone can handle knowledge, establishing a mechanism for a human beings is important, namely to construct familiar ubiquitous environment. In this sub-theme, we have been trying to construct environment where anyone can touch information or knowledge which is generated day by day. Thus, we focus on the following

three concepts to construct true ubiquitous environment by artificial intelligence with adopting viewpoint which is near to a human and consider intention of a user.

- Acquisition of system configuration drawing interests
- Automatic analysis of distributed information increasing day by day
- Development of educational tools with fun

Figure10 is the results of touching rule with a computer.

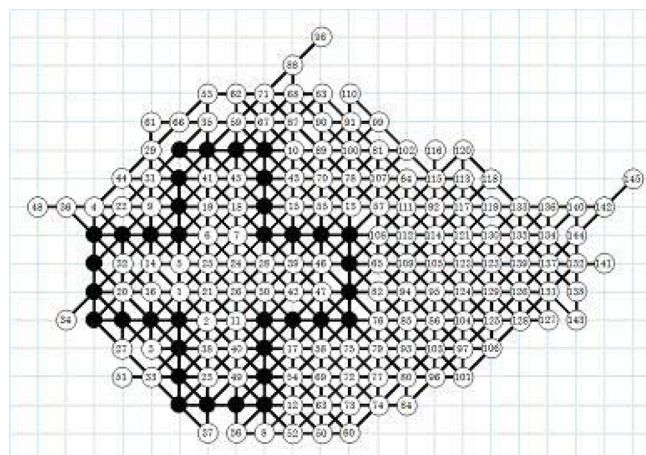


Figure 10. Touching rule with a computer: 145 steps of world record

B. Design and development of a ubiquitous learning system

We have developed a ubiquitous vocabulary learning system called PHI which works together with iPod or iPhone and have evaluated the effects. Moreover, we have developed the PSI system which supports to compose vocabulary learning materials used in PHI, then opened to learners. By letting learners to participate in the learning system, we have proposed a model which releases an instructor from burden to compose a large amount of learning materials. We have also developed a system called SIGMA which accumulates learning materials generated by learners to share the materials among learners. With using SIGMA, we have conducted three experiments in order to verify whether learners can learn autonomously or not. As the results, we have confirmed that learning materials generated by PSI offer sufficiently instructive effects and that learners can find instructively effective materials by themselves to some contents. Besides, we have proposed a method to easily measure abstraction levels of words as well as have proved that learners feel important to compose learning materials for more abstract words. Figure11 shows the ubiquitous vocabulary learning system called PHI (a personal handy instructor).

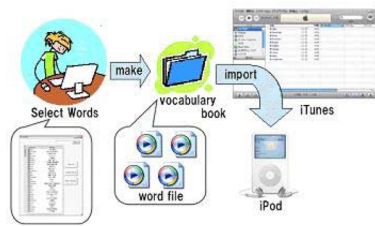


Figure 11. Ubiquitous vocabulary learning system PHI (Personal Handy Instructor)

C. Sustainable inter-adaptive functions to implement artificiality in harmony with human beings

One of indispensable functions for a symbio-information system is to implement an easy-using information system. We have been trying the following researches.

- Rhythm feedback typed walking navigation system
- Intelligent photo browser automatically classifying saved pictures
- Supporting system of building cloths database

We have been studying about the following subjects of information displaying system to promote a user's adaption.

- Supporting system to acquire a usage of novel tools
- Supporting system to acquire human motor nerve with visualization of muscle activity

Moreover, we have been conducting a research on an autonomously adaptive agent with inner motivation to objectively and quantitatively evaluate a user's recognition status in using a symbio-information system with fNIRS which is measurement device for a brain function.

Figure12 shows fNIRS FOIRE-3000 (Shimadu).



Figure 12. fNIRS FOIRE-3000 (Shimadu)

VI. CONCLUSIONS

We have introduced our research on symbio-information technology to realize information environment in harmony with human beings under supports of MEXI for five years. In this paper, the research results of sub-groups of our projects are shown. Now we have been preparing a new project to explore another new technologies for sustainable future society.

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