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Simple Applications of Smart-Classroom

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Abstract: This paper first presents four essential characteristics of futuristic classroom in the upcoming era of ubiquitous computing: natural user interface, automatic capture of class events and experience, context awareness and proactive service, collaborative work support. Then it elaborates the details in the design and implementation of the ongoing Smart Classroom project. Finally, it concludes by some self-evaluation of the project's present accomplishment and description of its future research directions.

Keywords: Ubiquitous, Computing, Intelligent Environment, Multimodal Human-Computer Interaction, Smart Classroom

Introduction:

From UBICOMP to Smart Classroom Desktop and laptop has been the center of human-computer interaction since the last century. As it is a typical situation of human's dialogue with computer that a single user sits in front of a screen with keyboard and pointing device, interacting with a collection of applications. In this model, people often feel that the cumbersome lifeless box is only approachable through complex jargon that has nothing to do with the tasks for which they actually use computers. Too much of their attention is distracted from the real job to the box. Deeper contemplation on valuable matured technologies tells us: The most profound technologies are those that disappear, which means they weave themselves into the fabric of everyday life until they are indistinguishable from it.

We use them every day, everywhere even without notice of them. Based on this point of view, computer is far from becoming part of our life. We developed special interest in exploring the impact of ubiquitous computing to education. This leads to the project of Smart Classroom. The Smart Classroom is a physical experimental environment, which integrates multimodal human computer interface with CSCW modules collaborating through inter-agent communication language to provide a smart space for lecturer's natural use of computer to give class to distance learning students.

In the rest of this paper, we're going to first present our views of futuristic classroom in UBICOMP. And then toward the ideal model of classroom, which sounds a little utopian, we'll explain the idea and focus of our exploration. Later some details in the design and implementation of our present work will be illustrated. We'll conclude by a short description of our future goals.

Should Classroom in The Era of UBICOMP Be Like?

In our point of view, the following features are essential to a smart classroom in the era of UBICOMP, and will serve as the

guidelines in our ongoing Smart Classroom project.

We have generalized four characteristics of futuristic classroom, which are: natural user interface, automatic capture of class events and experience, context-awareness and proactive service, collaborative work support.

Natural user interface

In accordance with this essence of UBICOMP, it is necessary for a smart classroom occupant's attention to computer. To rescue people's energy from irrelevant interaction with computer to the intentioned goal, allowing user's interaction with computer as naturally as possible is vital. In such a new paradigm of human-computer interaction, people input information into computer in their most familiar and accustomed ways like voice, gesture, eye-gaze, expressions etc. Auxiliary input devices like keyboard, mouse, are not necessary.

In the reverse side, computer tends to serve people like an intelligent assistant. It utilizes technologies like projector display, voice synthesis, avatar, etc. This is what we call natural user interface. To get a clearer image, suppose a lecturer in the Smart Classroom conducting the class by voice. "Let's go to chapter two".

Computer recognizes phonetic command and projects the wanted courseware of chapter two on display. Lecturer also uses hand gesture as a virtual mouse to annotate on the projected electronic board. Through combination of eye gaze (or finger pointing) and voice command, lecturer can zoomed in the image of an area in the projector to give emphasized explanation on a specific topic.

Automatic capture of class events and experience

This is what class project of Gatech called "automated capture, integration and access" problem. We use computer in classroom not only to improve the quality of teaching activity, but also to augment its capability, which was impracticable traditionally. The automatic capture of class event and experience belongs to such capabilities. It's not just record of video and audio in the environment, which is common in traditional distance learning-television broadcasting program. For example, suppose a lecturer giving a class on Artificial Intelligence in a Smart Classroom. All the audio, video information, lecturer's annotation events, student's question events, Smart Classroom's controlling of lights, slides, etc, are recorded into a multimedia compound document.

Context-awareness and proactive service
What is context-awareness?

"Context is any information that can be used to characterize the situation of an entity, where an entity can be a person, place, physical or computational object", "context-awareness is to perceive the context by system so as to provide task-relevant information and/or services to a user, wherever they may be". Which means the Intelligent Environment can understand user's intention not only based on audio-visual inputs, but also based on its situational information. Proactive service means to serve the user without his request. Proactive service is based on the Intelligent Environment's capability of Context-awareness.

For example, the lecturer is explaining a formula displayed on the electronic board. When the lecturer points at it and starts to

talk about it, the computer understands that the lecturer is going to attract students' attention to the specific area of display. Then it zooms in the area containing that formula on the display without the need of lecturer's commanding "Zoom in this region".

Collaborative work support

Class is essentially a collaborative procedure evolving multiple participants. In the environment of ubiquitous computing, the introduction of many interconnected computing devices and wide area network support enables us to extend beyond the space boundaries imposed by traditional classrooms. With this technological advance, collaborations of multi-user and multi-device can be possible. And the support for collaboration is becoming a requisite of a smart classroom. The collaborative work support of a Smart Classroom can be categorized into two classes.

The Focus of Smart Classroom

Smart Classroom is a big project; every above-mentioned aspect of it is challenging and a long-term effort. Our institute has been committing itself to the research on multimodal human computer interfaces, CSCW in wide area network, and also multimedia integration. Based on our existing research results we have been investigating Smart Classroom's following features: natural user interface, automatic capture of classroom events and experience, and collaborative work support. So in initial phase of our project, we focus on applying our previous research achievements to realize an experimental environment. We have set up the physical experimental environment to demonstrate our idea and focus.

The layout of Smart Classroom

Our Smart Classroom is physically built in a separate room of our lab. Several video cameras, microphones are installed in it to sense human's gesture, motion and utterance. According to UBICOMP's characteristic of invisibility, we deliberately removed all the computers out of sight. Two wall-sized projector displays are mounted on two vertically crossed walls. According to their purposes, they are called "Media Board" and "Student Board" separately. The Media Board is used for lecturer's use as a blackboard, on which prepared electronic courseware and lecturers' annotation are displayed.

The Student Board is used for displaying the status and information of remote students, who are part of the class via Internet. The classroom is divided into two areas, complying with the real world classroom's model.. Augmented means we'll try to extend beyond the limitation imposed by the incapability of traditional technology, which is the reason for remote student.

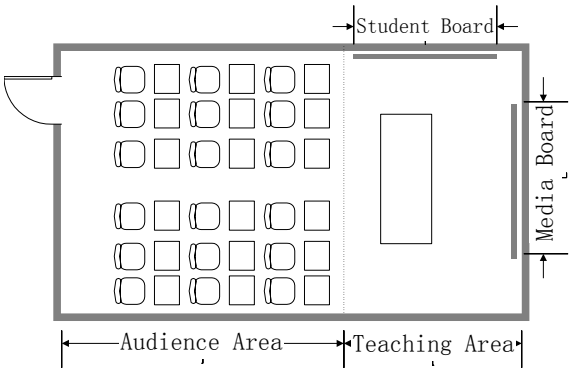

Fig1. Layout of Smart Classroom

In Smart Classroom, users' rights to use the room are mapped to their identification. There is an audio-visual identification module for identifying the users in this room and authorizing control right to lecturer. With the help of visual motion-tracking module, Smart Classroom can be aware of its occupants' places in the room. Once a

user identified as lecturer entering the teaching area, he is authorized to control the Smart Classroom by voice and gesture command. Lecturer can use hand-gesture as a virtual mouse on the Media Board to annotate, or add/move objects on the electronic board. He can also command linking in courseware; perform operations like scrolling pages, removing objects, granting speech right, etc by voice.

A typical user experience scenario

The following is a typical user-experience scenario happened within the Smart Classroom. Multiple persons enter the room through the door. At the door, there is an audio-visual identification module identifying the entering person's identity through facial and voice identification. If the person is identified as lecturer, he is granted the control right of the Smart Classroom. When the lecturer is in the teaching area, he can start the class by just saying, "Now let's start our class." The Smart Classroom then launches necessary modules such as Virtual Mouse agent, Same View agent (which will be talked about later).

Lecturer loads prepared electronic courseware by utterance like, "Go to Chapter 1 of Multimedia course". Lecturer can use hand-motion to stimulate the Virtual Mouse agent to annotate on the electronic board. Several type of hand gestures are assigned corresponding semantic meanings, which cause several operations like highlighting, annotating, adding pictures, remove object, executing links, scrolling pages etc, on the electronic board.

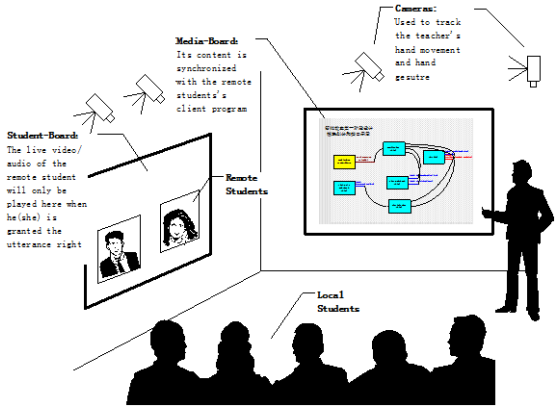

Fig2.Typical scenario in Smart Classroom

Details of Smart Classroom's Design and Implementation

The Smart Classroom is essentially a distributed parallel computing environment, in which many distributed software/hardware modules collaborate to accomplish specific jobs. Software infrastructure is the enabling technology to provide facilities for software components' collaboration. There are some alternative solutions to software infrastructure, such as Distributed Component-Oriented Model, like EJB, CORBA, DCOM, etc, and Multi-Agent Systems (MAS).

Software platform--OAA

In current stage, instead of developing our own Multi-Agent System, we choose to use SRI's famous open source MAS product, Open Agent Architecture (OAA) [OAA]. There're already many successful multimodal human-computer interaction projects built on OAA. Its delegating computing model also fits well in our need of software infrastructure. The Facilitator agent will make decisions about which agents are available and capable of handling sub-parts of the request, and will manage all agent interactions required to handle the complex query. Such distributed agent architecture allows the construction of

systems that are more flexible and adaptable than distributed object frameworks. Individual agents can be dynamically added to the community, extending the functionality that the agent community can provide as a whole. The agent system is also able to adapt to available resources in a way that hard-coded distributed objects systems can't.

Five dedicated agents in Smart Classroom

In the schematic figure of our Smart Classroom there're five dedicated agents (except for the Facilitator agent of OAA).

The Facial-voice identification agent is in charge of the Smart Classroom's login identification and authentication. The vision-part of the agent identifies the person by searching in a pre-trained user library, and the voice-part authenticates the identified person by voice-based speaker recognition.

The motion-tracking agent is a computer vision-based agent. There's a pan-tilt video camera mounted on the upper side of the front wall, monitoring the whole range of the room. Motion-tracking agent will signal the corresponding events to the agent society.

The voice command support of Smart Classroom is realized by a speech recognition agent, which can perform speaker independent and continuous voice recognition. We use IBM's simplified Chinese version of Via Voice SDK to wrap the voice recognition agent. The agent receives digitized signals from a wireless microphone, which is carried by the lecturer.

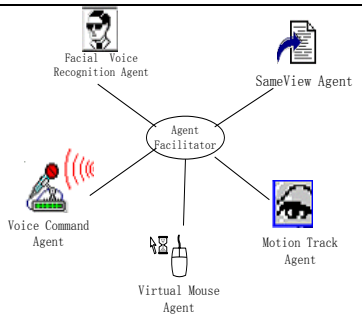

Fig3.Five dedicated agents in OAA model

The Virtual Mouse agent is used for handling hand-gesture, which stimulates the mouse events and shortcut command to activate operations on the playing courseware. It's also a vision-based agent. There are two video cameras specialized for virtual mouse event recognition. Through detecting and analyzing 3D movements of hand, gestures can be recognized. The virtual mouse agent then dispatches the recognized mouse event or shortcut command to the agent society.

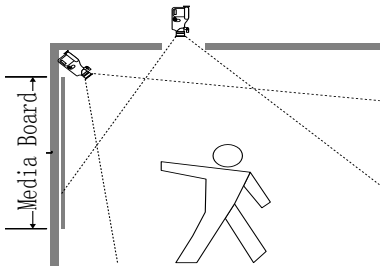

Fig4. How virtual mouse agent works

Same View agent plays a core role in our Smart Classroom's pedagogical scenario. It is based on a legacy desktop application, namely Same View [Pei 1999, Liao 2000, Tan 2000], which is developed by media group of our institute. The purpose of Same View is a software for supporting multimedia based group discussion whose members are spaciously distributed and connected by heterogeneous networks.

In our Smart Classroom, we recur to the Same View's desktop version code as much as possible. We only revised some of its input/output user interface. The most crucial reformation to Same View is the wrapping of it as an autonomous agent in Smart Classroom's agent community, which enables it to receive user's natural input from other dedicated agents like voice command recognition agent and virtual mouse agent, and then behave interactively.

Conclusion: Future Goals for Smart Classroom

Our current stage Smart Classroom is a primitive prototype of futuristic classrooms, which attempts to embody some of its distinguishing features like natural user interface, capture of class events and collaborative support. It is still far from a real Smart Classroom. Its resolutions to some key problems in Intelligent Environment are simple, intuitive and somewhat application- specific.

Add more modalities and applications. We'll try to equip some more modalities of human inputs like vision-based tracker, embedded microphone array and various distributed sensors to sense human's context. And progress in the sensing technologies needs to be matched by progress in applications that use sensed information. Add a brain.

The current design implementation of the Smart Classroom focus on the human's natural input to the computing environment, the next step is to move to a higher level and to give it the ability to understand. It is not just to utilize multimodal interface, but also to add-on context-aware intelligence. The classroom should be able to reason human's intention through analysis of all the gathered inputs and proactively serve its occupants. Add multi-user interaction. In the current stage Smart Classroom, there is only one user (lecturer) naturally interacting with the Intelligent Environment Other attendants are just observers or listeners and are not able to exploit the fascinating features of natural interaction.

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