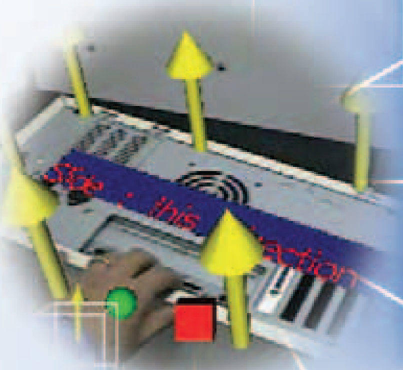
Ubiquitous



Ubiquitous Computing at AIST

Technology to Assist Humans

Ubiquitous Computing at AIST

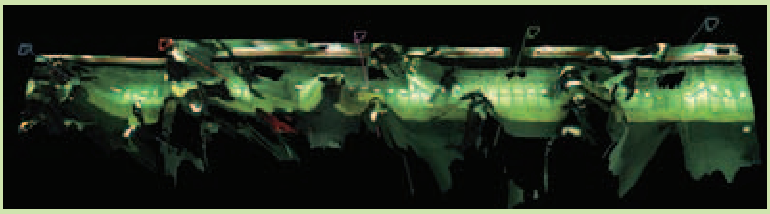
Increasing Convenience and Universality

Technology to Assist Humans

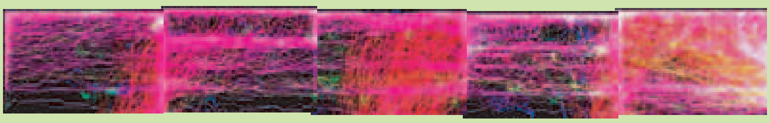
Technologies are progressing rapidly towards creating ubiquitous information societies where computers and networks exist universally.

The question is how people will use computers in such a vast information infrastructure. We hope that computers will be able to serve more directly as the "backbone" in people's life and become capable partners that provide unobtrusive, but firm support to us. They will be no longer mere tools which users need to take out of their bags or pockets or operate by using a mouse.

The computers will exert full potential in a variety of basic technologies that interface with people's activities. The application of these technologies will bring about the systems which enable hands-free control home appliances, ensure people's safety, gently assist the disabled, navigate directions, give guidance for working procedures, provide information as required, and so on. This feature article introduces AIST research projects on the technologies which support ubiquitous information societies, through the examples of practical application.



This is a momentary image of a train platform extracted from a series of 3D images shot at 12 frames/sec by five stereo cameras. As the subject's figure is captured three-dimensionally, the position, height and moving direction can be automatically calculated.



The paths of the passengers of ten trains (one train runs per hour, i.e. for ten hours) were recorded and color coded according to directions of paths. The diagram clearly represents the flows of the passengers getting off the trains and shows that most of the people use the stairs on the right hand side.

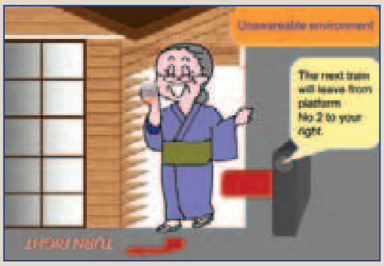
Invisible guardians

Tragic accidents at train stations are frequently reported. To prevent such accidents, AIST has developed a system to ensure people's safety in wider areas by installing many 3D sensors (ubiquitous stereo vision). By the use of 3D information, the system is able to select and track a target person in an extensive area with no blind spots and is unaffected by obstructive factors such as people's clothing, illumination, sunlight, shadows, background, congestion and so on. In practice, the research team successfully illustrates the paths of the people on the platform from the first train to the last train. Furthermore, it is possible to detect a critical condition before a passenger falls from the platform so that the technology can be applied to the system to warn and protect people who are in danger in public places. The system will realize the "ubiquitous information environment that ensures human security".

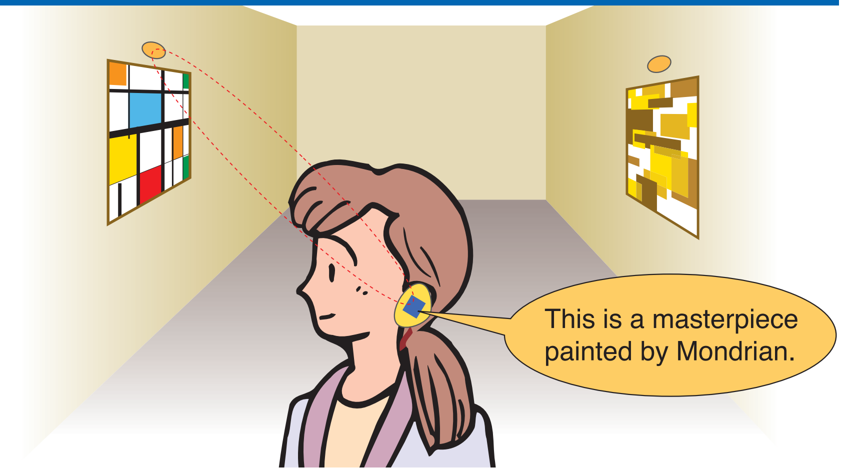
Reliable, low-key assistance for humans in everyday life

The elderly lady in the picture has a "My Button", an electronic universal pass. We aim at building an IT infrastructure which assists ordinary people carrying this device. With your schedule data stored in My Button, for instance, the station environment assists you to get the right ticket while automatically paying the right fare, to locate the right platform, and to take the right train. This is "Human Centered Ubiquitous Information Environment".

In good old days ↑
But recently··· ↓

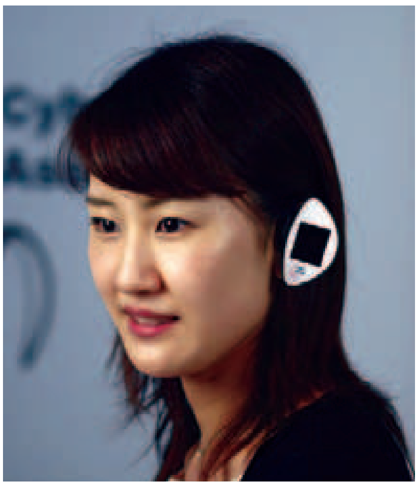


Get the Information "I NEED HERE NOW"!



My Button Ver.1

"My Button" is a mobile terminal device that observes the user's natural, unconscious movements and provides information according to the user's various conditions, such as preferences, locations and so on. This is a small, light-weight and wearable terminal, which is integrated in the ubiquitous computing environment self-contained with a variety of devices (sensors, actuators, CPU and other computing resources). Needless to say, the system is designed to protect personal information from leakage. For My Button Ver.1, AIST has developed a terminal device, CoBIT, that plays audio information when the user looks at an object of interest. The system operates on a solar battery and is small and inexpensive. It will be commercially available priced at several hundred yen or less.

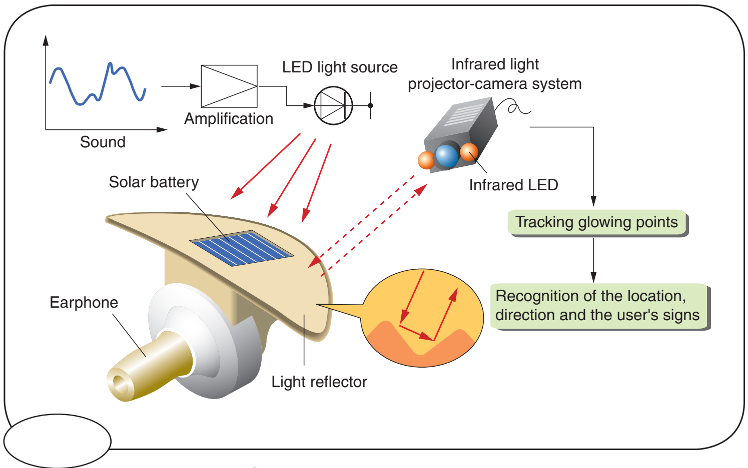


Mechanism of CoBIT

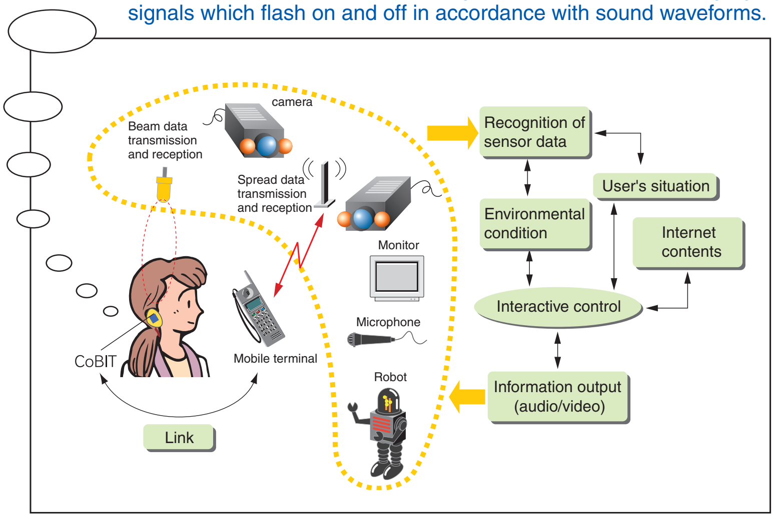
The electric current generated by a solar battery flows directly to the earphone. The device generates sound receiving light signals flashing on and off in accordance with the sound waveform. An infrared light projector-camera system makes only CoBIT visible as it is attached with a light reflector. It is possible to recognize the user's movement and signs, by analyzing the positions of these glowing points. This technology enables interaction between the user and the system. For example, in a museum, when CoBIT asks a user if more detailed explanation is necessary, the user can answer to the question by means of gestures. If the user says "No", the system suggests to move on to the next object.

Future information support system

CoBIT can transmit its identification number through a liquid crystal shutter fitted on a light reflector. The system instantly provides not only auditory information but also music, moving pictures and so on and meets the user's requirement on the spot. This function is operated based on various data such as the user's preference, schedule, previous actions and signals.



Mechanism of CoBIT: The device generates sound, receiving light signals which flash on and off in accordance with sound waveforms.



Future image: Information support systems that provide the most appropriate information based on the data of the user and the surrounding environment.

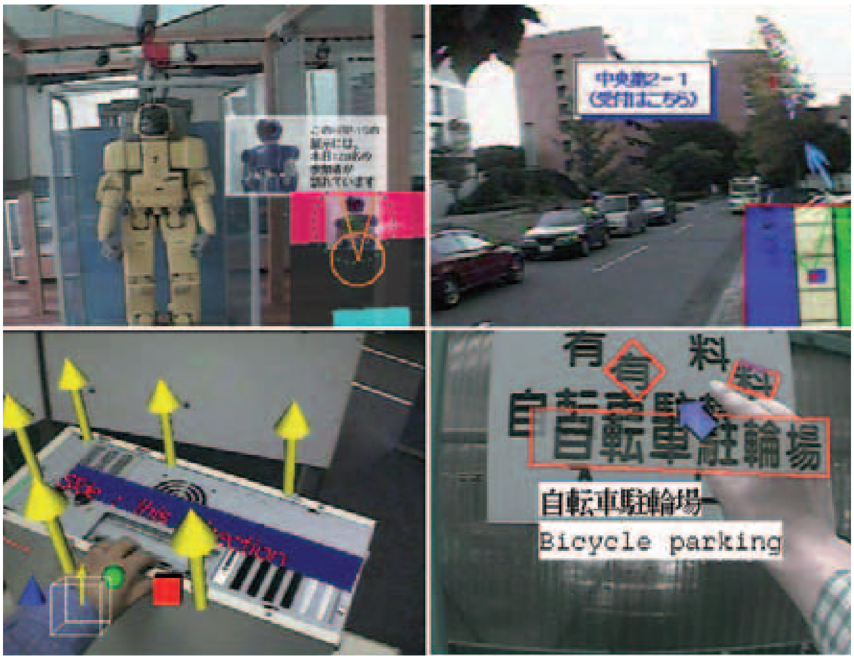
Weavy Wearable Visual Interface

Interface between virtual and physical spaces

Dead Reckoning Navigational System using accelerometers, gyro-sensors and magnetometers is combined with image registration to estimate absolute position and direction, enabling such applications as “Event AR (Augmented Reality) Navigation”, “Outdoor AR Navigation” etc. to become feasible without building a sensor infrastructure. It is expected that this technology will be applicable to the development of a personal navigation system which can be utilized in various environments, not limited to museums. Furthermore, the system will contribute to realizing 3D AR manual with a function of tracking objects in three-dimensional way. Both hand-gesture recognition systems and Real World Character Recognition (RWOCR) eliminate the need for keyboards and mice for making simple and instant instructions. It is also an advantage that the user can intuitively operate the systems.

Interface for Next Generation Mobiles Phones?!

AIST aims for the creation of a smart, wearable system which provides necessary assistance to users. Analyzing the context of the user and the surrounding environment with mobile/wearable cameras and sensors, the system is able to offer the most appropriate service for the user. The development of Weavy, a wearable visual interface between virtual and physical spaces is in progress, applying recent technologies in the fields of computer vision, sensor fusion and Augmented Reality.



Augmented Reality (AR) Navigation

Above : The additional information is superimposed on a wearable display monitor based on the user's position and direction he is facing (Left: Event information in the building; Right: Guide sign) .

Below left : 3D Augmented Reality Manual
The set-up and disassembly procedures are three dimensionally shown on the wearable display monitor.

Below right : Real world character recognition
The automatically extracted character region selected by "picking up" motion (hand gestures) can be recognized and translated.

Wearable components of Weavy

Towards the development of “independable” and dependable interface systems

In order to create a highly autonomous and dependable sensing system with wider applications, it is required to build a framework to ensure the functionality in the space with no sensor infrastructure. If the infrastructure is available, they are expected to contribute to the provision of information with a higher degree of accuracy. For this purpose, AIST has been promoting a research to incorporate Weavy with CoBIT, as well as the ultrasonic 3D tag for the integrated system.

Remote Assistance by Wearable Information Devices

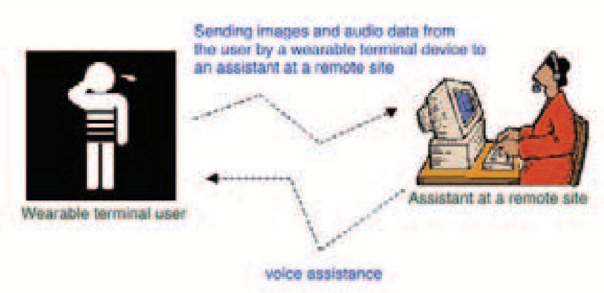
In Medical & Welfare Services

At emergency sites, it is essential to provide the necessary first aid and to be immediately ready for transferring patients to a hospital. Therefore, the doctors at the emergency center need to receive accurate information of the accident site and the patients' condition so that the severity of the damage can be assessed and appropriate instructions can be given to rescuers.

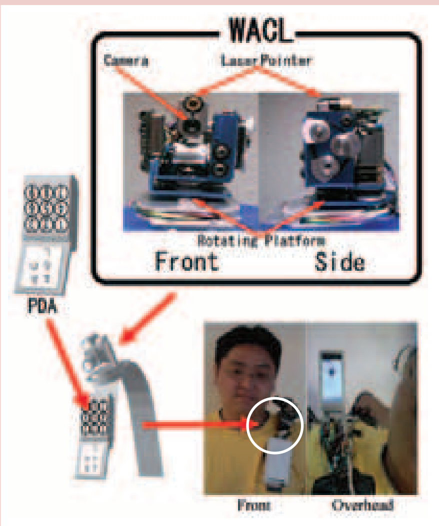
Visually impaired people sometimes may require assistance when they use an LCD monitor, a touch panel, check the indicator of a washing machine, choose frozen food, color and design of clothes, stockings etc., purchase something from a vending machine, read letters, and so on, even though it is difficult to promptly dispatch a human helper in these cases. In such cases where information assistance is required, a person who needs help will be able to receive appropriate information from a remote assistance provider wherever and whenever he/she may be.

Furthermore, a unique shoulder-worn wearable robot (WACL) is now under development as an integral part of the Weavy system. The robot has an active camera with pan/tilt control and a laser pointer and is expected to play a major role in a wearable interface for remote collaboration systems. An instructor at a remote place observes pictures on a screen and gives directions for the next action directly to an operator wearing the robot, by spoken dialogue as well as a laser pointer.

A visually-impaired person chooses a drink following navigation by an assistant at a remote site, using an ear-phone type wearable camera system (with video camera, microphone and earphone).



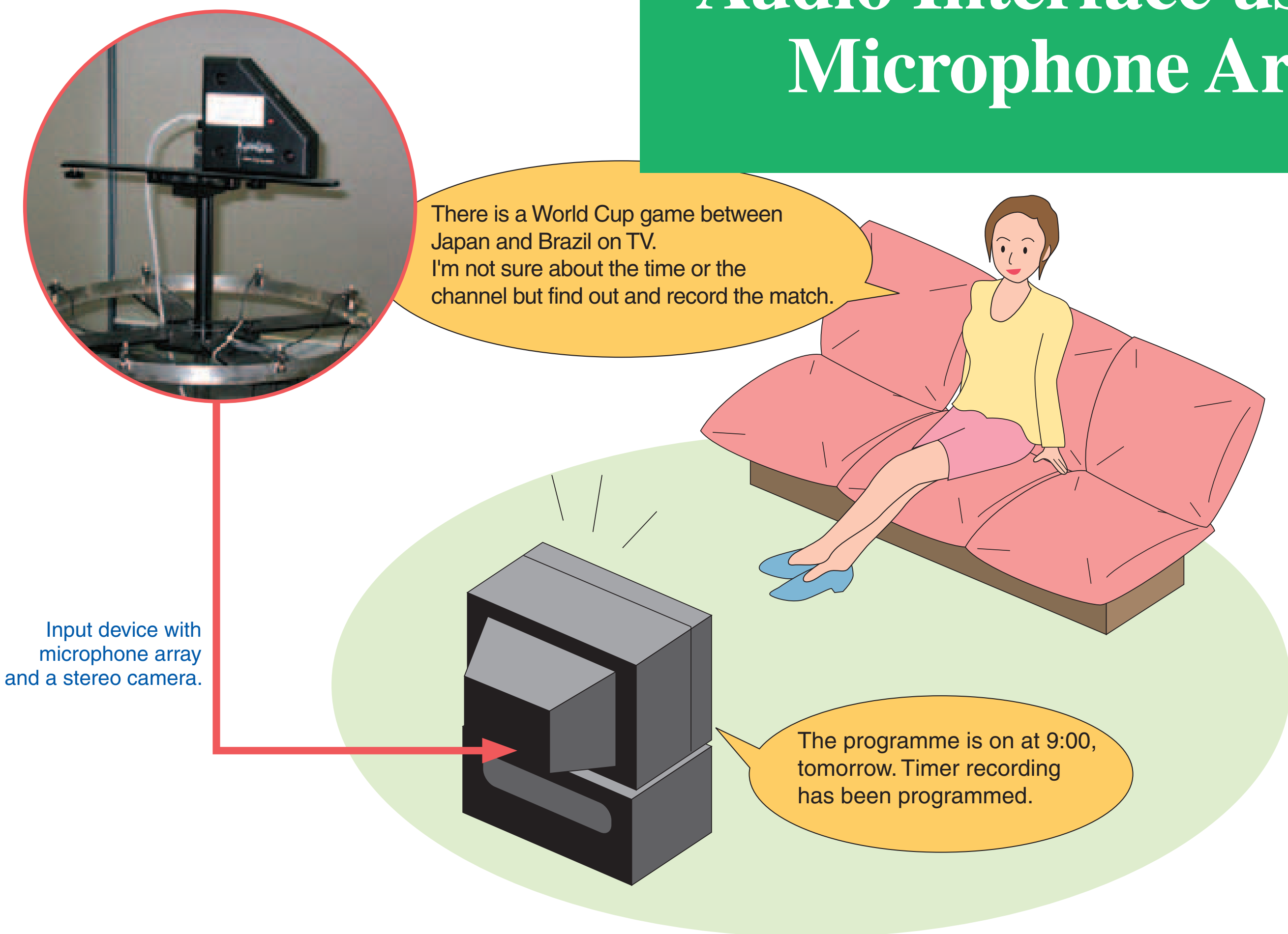
AIST is working on the development of a smaller, lighter, wireless wearable device and the application of the current communication infrastructure. The research efforts also focus on data expression methods that facilitate the improvement of information quality (image, sound etc.) from the assistant's point of view.



Assistance was provided to a person in an unfamiliar environment to feed paper to a printer in another room. It is possible to point directions/objects in the real place without being affected by the wearer's change in posture etc.

The device indicated with a white circle is the shoulder worn WACL (Wearable Active Camera with Laser Pointer) that is equipped with pan/tilt control and a laser pointer.

Audio Interface using Microphone Array



Audio interface

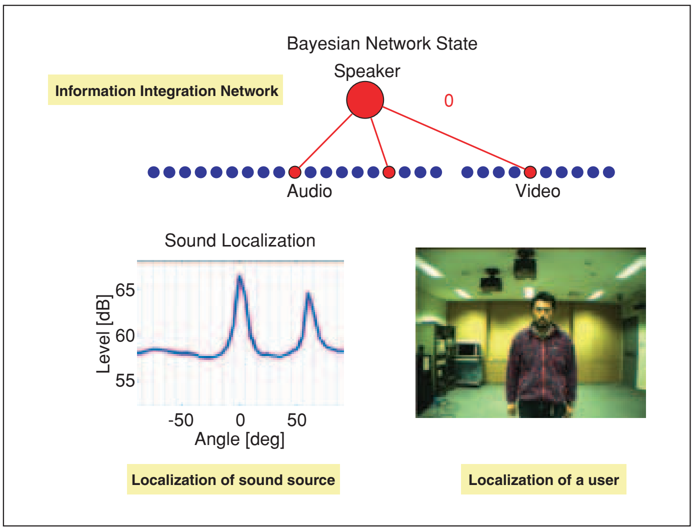
"There is a World Cup game between Japan and Brazil. I'm not sure about the time or the channel but find it out and record the match." This is an example of a rather complicated command based on conversational speech given to an information system. Speech recognition is often interfered in real environments with the background noise of electric appliances, such as TV sets. This study aims at the development of robust speech recognition system which understands free conversational speech uttered by a speaker 2-3 meters away from the system using microphone array.

Locating a speaker

For the accurate recognition of a speaker's voice under acoustic background noise, it is important to find out when and where the utterance was made. A microphone array is a system consisting of multiple microphones which can be used to detect the location and timing of a sound. Furthermore, by combining this acoustic information with visual data from a human tracking system, it is possible to specify when and where the speaker speaks.

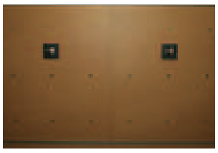
Robust Speech Recognition

By identifying the location and timing of speech, the microphone array system will be able to separate the speaker's voice from other undesirable auditory noises. The technology called Adaptive Beamforming is applied to process sound signals. This technology separates the speaker's voice from ambient noise by adaptive directivity, focusing on the target sound source and reducing the sound coming from noise sources. Moreover, robust speech recognition is realized by the adaptation of acoustic model in speech recognition. Integration of these technologies will deliver a sound recognition system that achieves about a 90% recognition rate in the environment where the sound of television 2 meters away is at the same volume as the speaker's vocal level.

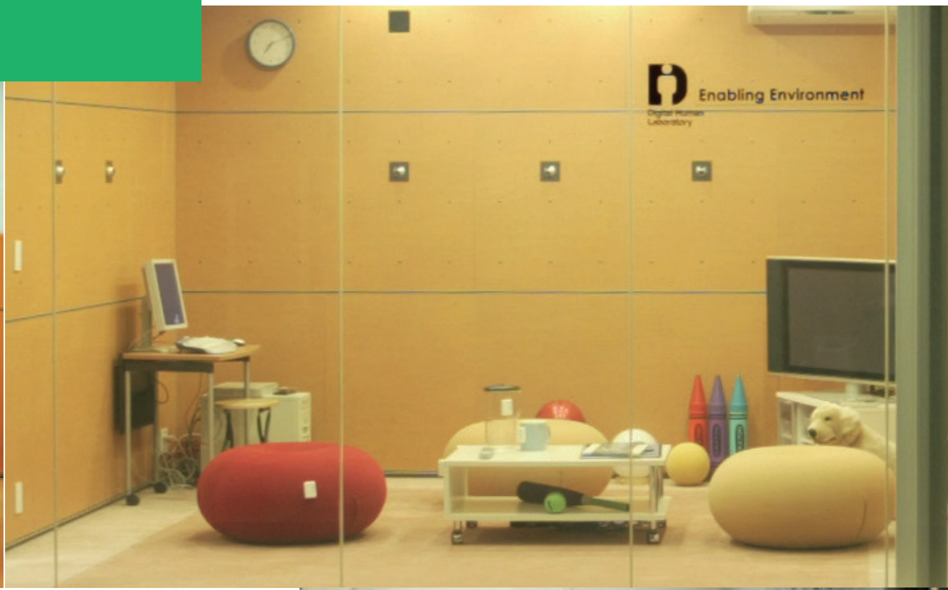


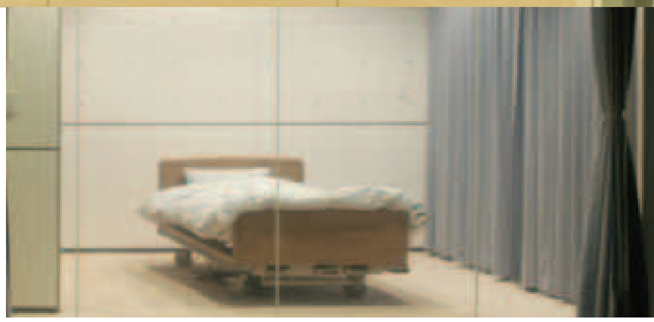
Estimation of the location and timing of speech based on sound and visual information.

Ultrasonic Sensors for Human Behavior Observation and Human Support



The living room for the foreign language learning assistance system and the enlarged figure of the sensors on the walls (dots arranged at intervals) and the cameras (right and left squares)



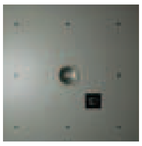


The ultrasonic transmitter and the inside of the sensor room (upper left)

Three types of ultrasonic transmitters have been developed: ultra small type (left; 11mm x 11mm x 20mm), small sized type (middle; 27mm x 20mm x 14mm) and long-lasting type, which runs on a mobile phone battery (right; 65mm x 44mm x 22mm). The long-lasting one can operate for up to 2 months without recharging. These transmitters are attached to the objects in the room, such as chairs, glasses and a remote controller of the television set.

Full view of the sensor room in which at least 300 ultrasonic sensors and more than 10 cameras are embedded

The upper right photograph is the living room for the foreign language learning assistance system. The figure below is the bedroom with care assistance system and physiological measurement functions for the elderly.



The bedroom with the care assistance systems and physiological measurement functions for elderly residents and the enlarged figure of the sensors installed on the ceiling (8 surrounding dots) and a camera (the square on the right bottom corner)

Distributed sensor environments

Sensors are usually used for observing people as well as environment. However, there is no single sensor that can acquire all the necessary information by itself. Visual sensors such as cameras fail to monitor objects behind obstacles. AIST has developed a distributed sensor environment, "Sensor Room," in which a number of sensors are embedded. More than 300 ultrasonic sensors and over dozen cameras are installed on the walls and the ceiling in the room, eliminating blind spots. The sensors measure and observe the positions of objects by small ultrasonic transmitters (ultrasonic 3D tags) attached with an accuracy of a few centimeters.

Many home electric appliances are controlled by built-in computers and sensors. But they are controlled individually and do not always comply with the conditions of the inhabitants. Our research efforts are focused on the development of the following technologies: 1) observing individual activities and the environment, 2) modeling human behaviors by the collected data, and 3) providing support for inhabitants based on their observed conditions and developed human models.

Human Supports utilizing the data obtained by Ultrasonic Sensors

The innovative "Language Education Assisting System" has been developed as an example of the applications of human support using our ultrasonic sensor system (patent pending). In this system, the user's behavior in the sensor room is observed by the ultrasonic sensors and the audio description of actions and gestures is provided in a foreign language. As the user's actions are described directly in the foreign language, the system is expected to be more effective than conventional passive language lessons based on text books. AIST is presently developing a new language teaching method and materials in cooperation with an English school.

Another project is in progress with a nursing home and a related company aiming at development of technologies for ensuring the nursing home residents' safety and for saving work and time of the staffs. These include the prediction and early detection of accidents as well as the identification of wandering elderly by use of numerous ultrasonic sensors installed in the rooms.

Ubiquitous Stereo Vision (USV)

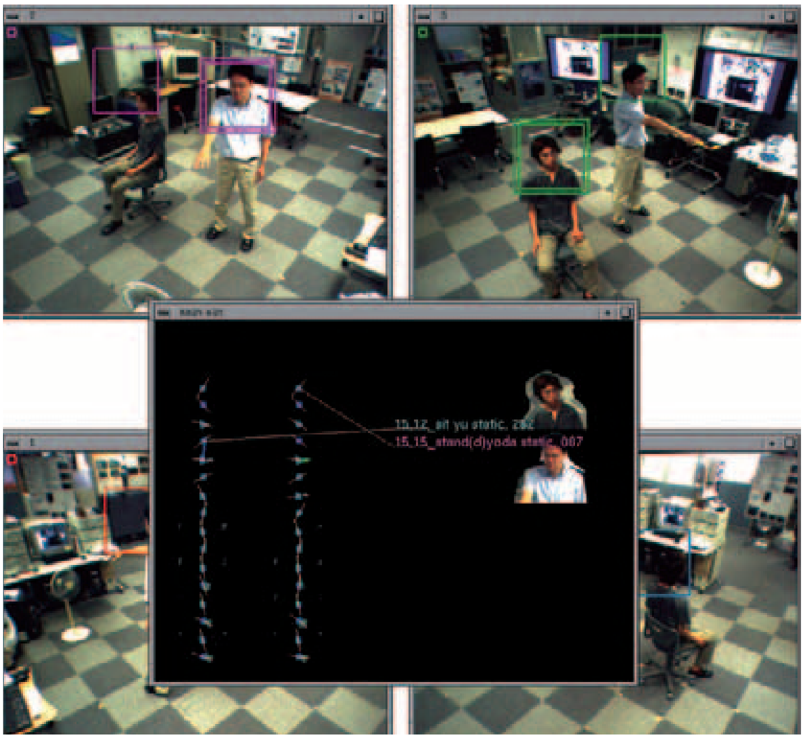
Contact-free, position-free, human interface - Manipulation by actions

AIST develops technologies able to detect and identify multiple individuals, to perform real-time recognition of their intentions indicated by gestures. This is accomplished by using stereo cameras arranged at multiple points (ubiquitous computing environment) and a high-speed network system. The aim of this research is to realize a real-time human centered interface, by simply placing stereo cameras at suitable points in the environment. The system permits the user to be at any position or to perform natural movements, and requires no contact with any object in the environment. To implement the system, four stereo cameras are placed in the four top corners of an experimental room (4.5 m × 3.6 m). The objective of this research is to develop technology able to detect and identify a specific person from others who enter and leave the area, to recognize the person's actions, thus providing real time personalized interaction through specific gestures.

A variety of real world applications

Regarding daily-assistance in indoor environments, AIST has succeeded in the development of human interface with personalized identification abilities. The function of the system is effective at any place in the room and not limited to any particular space. The system enables the user to manipulate the electric appliances in an ordinary room by arm pointing gestures without any touching and special devices.

Furthermore, safety enhancement in public places such as on train platforms is another important area to which the technology can be applied.



Human interface with a personal identification function

The system captures and utilizes 3-D images of the human body to recognize the posture and arm pointing gestures of the users. The image closest to the full-face view is automatically selected for each individual and used for personal identification.

Real time, 3D integrated images via next generation cameras

The figure is a 3D view of a room constructed with 3D data sent by four network-linked stereo cameras and integrated at a rate of 12 frames per second. This is applied to the real time recognition of body postures and movements.

Infrastructure of Ubiquitous Computing

"Grid" Technology and Network Transparency

Grid, as well as ubiquitous computing, is an important concept and technology which supports future information society. Our life is already surrounded by numerous computers. However, what we need is not really a computer, but functions provided by a computer network or an information service which enables the user to predict the future. This would be realised through the collection of data from the web sites, road information etc., building a database with necessary information and easy data retrieval. As far as these functions are available, the shape or the location of the computer does not really matter.

In order to meet this requirement, AIST is proceeding with research to establish the Grid technology that ensures a certain quality of service regardless of by whom, where or when the request is made.

Ubiquitous computing and Grid technology

Through ubiquitous computing, the optimal service is sought to be provided to the user in consideration of time, location and the environment.

Ubiquitous computing and grid technology have common characteristics in terms of the transparency of information systems (computer, storage, network, sensors etc.). The function to provide information services, regardless of place (ubiquitous computing) and the features to access the computing capabilities and database wherever situated globally are complementary to each other.

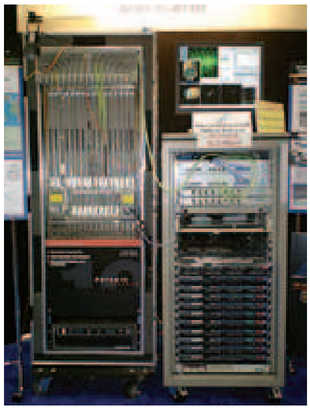
Ninf Project

With the aim towards the establishment of the grid technology, AIST is currently promoting the Ninf Project with the Grid Research Center as its hub of the research. The objective of this project is to provide a function that enables a user to access other computers when his/her computer goes down, even without any particular computer skill. This mechanism is called "Grid-enabled Remote Procedure Call (Grid RPC).

Furthermore, by exploiting the local storage of computers distributed over the world-wide network, AIST focuses on the development of Grid Data Farm (Gfarm), the grid software to create a virtual computer with high capacity data storage architecture and peta-scale data intensive computing system. Users can retrieve the required data, accessing the virtual mass storage wherever they are. In order to utilize this system from all over the world, it is required to use the high-speed network efficiently. AIST achieved high speed data transfer at 741Mbps between Japan and the U. S. in November 2002.

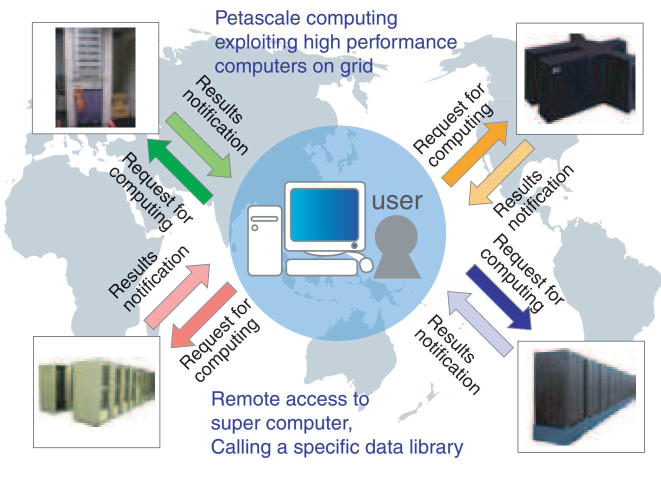
Standards for integration of single function sensors

Grid technology has been developed based on general purpose computing systems. However, in ubiquitous computing societies, it is necessary to integrate a large number of single function sensors. This requires the standardization of interfaces and protocols to communicate between devices in a co-operation with an international standardization organization, such as Global Grid Forum (GGF). AIST is involved in the standardization activities and promotional events organized by GGF. The Institute has set up Grid Consortium Japan and been active in technology exchanges with industrial and academic sectors.



Large file

High speed data transfer at 741 Mbps was achieved between Japan and the U.S.



Grid-enabled Remote Procedure Call (Grid RPC)

Users can call computers on the world wide network.

Multi-agent Architecture CONSORTS for Ubiquitous Computing Environment

A variety of research projects on ubiquitous computing are ongoing all over the world. There are, however, few examples that provide a total formulation of architecture to integrate the entire layers from communication network to end users. For ubiquitous information societies, we find it essential to build a multiagent architecture that allows several kinds of agents to function individually in ubiquitous computing environment. This is the fundamental concept of the research project to design and implement "CONSORTS." The key concepts are as follows.

1. Grounding

Information that is highly abstract "object" should be grounded in the real physical world by using sensory information.

2. Service Coordination

Physical and computational resources should be structured as agent framework where we can flexibly access information services.

3. Mass User Support

To support users as mass in order to realize innovative services that coordinate users' preference and plans. One of the service image is dynamic resource allocation, that is, coordination among users' behaviors in traffic system or appointment system for public services by spatio-temporal resource allocation.

A prototype system of CONSORTS has been implemented for museum scenario where several kinds of users visit a museum and the CONSORTS service agents navigate the users and provide suitable information to them (Fig.). The system uses FIPA-ACL based communication protocols and consists of spatio-temporal reasoner, personal agents, CONSORTS service agents, and device wrapper agents.

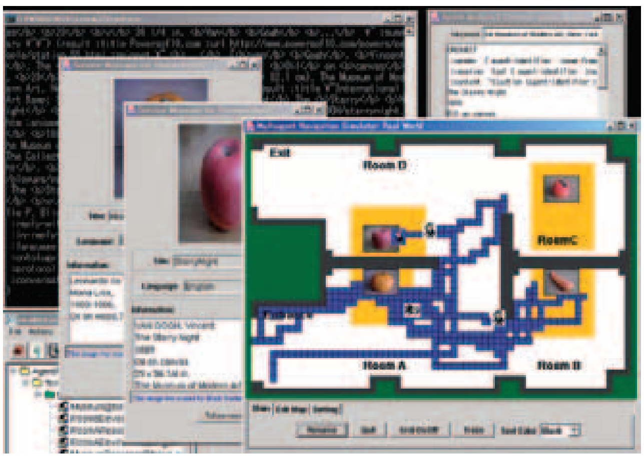


Fig. CONSORTS Application Image – Museum Scenario.

What is "Ubiquitous Computing Society"?

The term "ubiquitous computing society" is often used in every day life. However, to publish this leaflet, researchers at AIST held a debate over the definition of this expression.

Various topics were brought up: the importance of using small devices, the necessity to solve problems locally and the involvement of high-speed computing, high-speed networks, virtual reality and pattern recognition technology in realizing the "ubiquitous computing society".

We reached the conclusion that all these technologies are essential elements for this purpose. This leaflet is intended to introduce the new technologies for ubiquitous computing societies, offered by the AIST's research units specialized in the information field.

For ordinary people who must face "information society" with little knowledge of information technology, it is significant to acquire the "lighter, more compact" devices and related technologies. At the same time, "massive" computing power is required to develop the smart identification technology. A truly "transparent information society" will be achieved only when these technological factors are integrated harmoniously.

Authors

Advanced Semiconductor Research Center

E-mail : shien@m.aist.go.jp
URL : http://unit.aist.go.jp/asrc/asrc-5/

●Remote Assistance by Wearable Information Device
Tetsuya HIGUCHI
Iwao SEKITA

Cyber Assist Research Center

E-mail : info@carc.aist.go.jp
URL : http://www.carc.aist.go.jp

●Get the Information "I NEED HERE NOW"!
Takuichi NISHIMURA

●Multi-agent Architecture CONSORTS for Ubiquitous Computing Environment
Hideyuki NAKASHIMA
Koichi KURUMATANI

Grid Technology Research Cetnter

E-mail : grid-webmaster@m.aist.go.jp
URL : http://www.gtrc.aist.go.jp/

●"Grid" Technology and Network Transparency
Satoshi SEKIGUCHI

Digital Human Research Center

URL : http://www.dh.aist.go.jp/

●Ultrasonic Sensors for Human Behavior Observation and Human Support
Toshio HORI
Yoshifumi NISHIDA

Information Technology Research Institute

E-mail : it_staff@m.aist.go.jp
URL : http://unit.aist.go.jp/it/

●Chief editor
Kazuhito OHMAKI

●Audio Interface using Microphone Array
Futoshi ASANO

Intelligent Systems Institute

E-mail : is-office@m.aist.go.jp
URL : http://unit.aist.go.jp/is/

●Chief editor
Katsuhiko SAKAUE

●Weavy Wearable Visual Interface
Takeshi KURATA
Takashi OKUMA
Masakatsu KOUROGI

●Ubiquitous Stereo Vision(USV)
Ikushi YODA

AIST NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Edition and Publication :

Publication Office, Information & Publication Division, Public Relations Department
National Institute of Advanced Industrial Science and Technology (AIST)

AIST Tsukuba Central 3, 1-1-1, Umezono, Tsukuba, Ibaraki 305-8563, Japan
TEL: +81-29-861-4128 FAX: +81-29-861-4129 Email: prpub@m.aist.go.jp URL: http://www.aist.go.jp/