Wearable computer for the blind – aiming at a pedestrian's intelligent transport system

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ABSTRACT

As contemporary transport systems including the developing Intelligent Transport System (ITS) is vehicle centered, pedestrians – especially elders and persons with disabilities – are always threatened. This paper proposes a new pedestrian-centered traffic system concept named "Pedestrian's ITS" (P-ITS) based on ubiquitous and wearable computing techniques. This paper focuses on the wearable computer for the blind, one of the weakest areas in traffic systems. As knowledge of surroundings is most important for the blind to walk safely, the paper presents a method to support "surrounding presumption" on the wearable computer.

1. INTRODUCTION

The concept of Intelligent Transport Systems (ITS) is first presented in 1996 (Tokuyama et al 1998). ITS is expected to give safer and more convenient environments for drivers through intelligent vehicles communicating with smart way. However, as ITS is vehicle centered concept, ITS benefits few pedestrians, especially so-called "the weak in traffic system" including the elders and the disabilities.

A wearable computer (Sasaki et al 1999) is a portable personal information aid, which enables users to access any kinds of information at anywhere anytime. Therefore, the wearable computers, which are strongly connected with the environments through wireless communication, like CyPhone media phone (Kuutti et al 1999) can realize advanced services for all users.

The paper presents the concept of "Pedestrian's ITS" (P-ITS) (Kuroda 2000). This P-ITS is a system to give safer and more convenient environments for pedestrians, especially the weak in the traffic system, with intelligent walk-aids (wearable computers) communicating with smart way.

P-ITS consists of various components. Especially, wearable computer has wide variation depending on user. This paper focuses on wearable computer for the blind, one of the weakest in traffic system.

The blind faces to many dangers while walking. Therefore, foregoing walk-aids try to give information of surrounding situation as much as it obtains. However, unnecessarily much information confuses user in many cases. This paper introduces the concept of surrounding presumption into walking-aid, and shows the results of the simulation.

2. PEDESTRIAN'S ITS

The basic Infrastructure of ITS is the communication between smart vehicles and smart way. The vehicle and the smart way obtain and exchange the surroundings and their own conditions through innumerable sensors and produce smooth traffic by fitting themselves to the surroundings.

The P-ITS is based on the same framework as shown in Fig. 1. The P-ITS consists of street terminals and the wearable computers and conventional ITS infrastructure. The wearable computers and the street terminals communicate via short-range wireless communication, such as Bluetooth (Bluetooth 2000). The street terminals and the wearable computers obtain the surroundings and its own or user's conditions respectively, and exchanges them each other. The wearable computer navigates the user considering the information from street terminals and itself. On the other hand, the street terminal changes the traffic infrastructure such as traffic lights and moving walks depending on the information given by neighboring wearable computers. Through this configurations, the P-ITS provides some services for smooth and comfortable environment for pedestrians.

The remarkable characteristic of this system is that the total infrastructure is applicable for other commercial and social applications not only for the disabled but also for any people. Therefore, the infrastructure can be realized under commercial requirements.

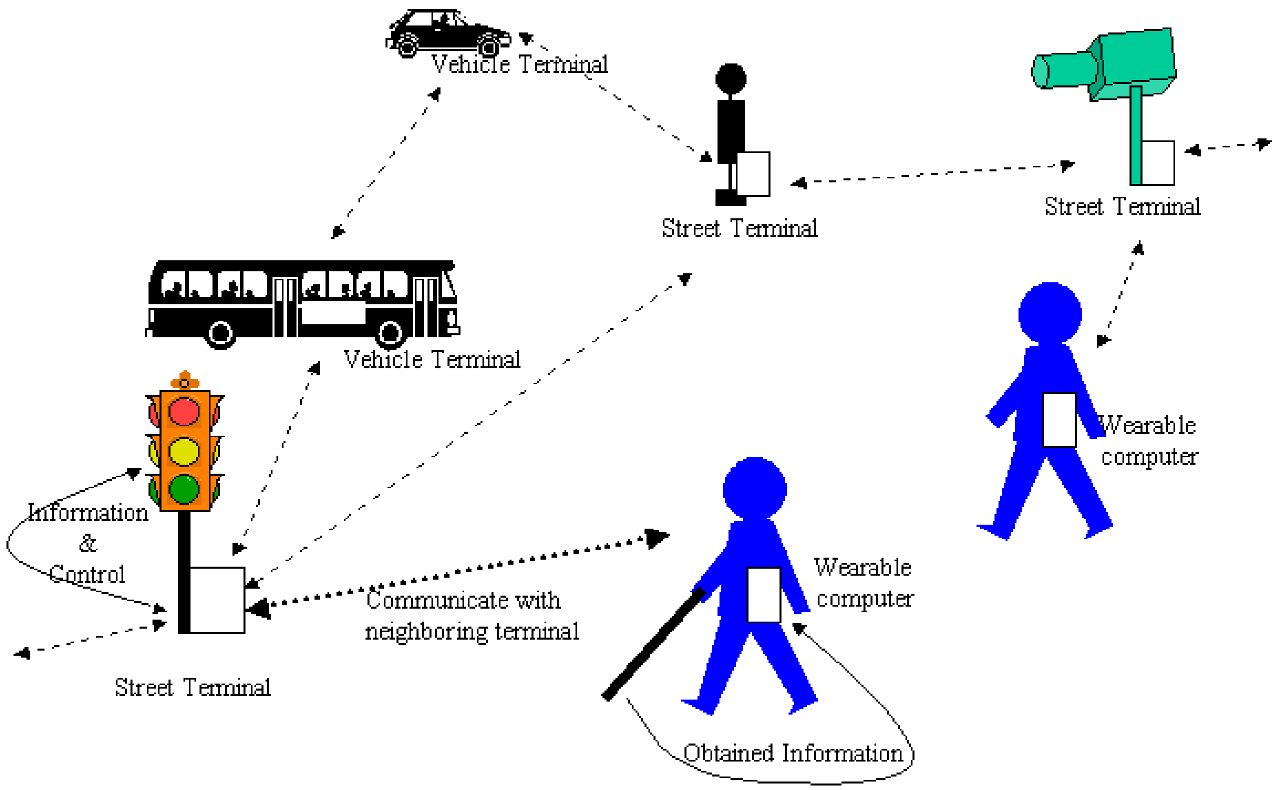

Figure 1. *The Infrastructure for Pedestrian's ITS.*

3. TYPICAL SERVICE MODELS

This section shows three typical service models available under P-ITS infrastructure.

3.1 Expanding "five senses"

The audibly and visionary disabled people, including the elderly people, have a certain amount of difficulties while they are walking, because they may lose fatal information such as noise of approaching car. Therefore, various types of information and walking aid devices are developed. However, ability and sensor range of such devices are hardly limited because the devices realize all sensing, conversion, and display procedures within its portable size body. Nevertheless, the devices are still too big and heavy to wear. Moreover, most of them confuse its user by giving enormous raw data that is just a direct conversion of data obtained by certain sensors.

P-ITS utilizes street terminals with certain sensors, such as CCD cameras or microphones, as external sensors of pedestrian's terminals. This service enables the hearing impaired to know a bicycle or vehicle ringing his/her behind, and the vision impaired to know a obstacles in front of him as shown in Fig. 2. The street terminals around a certain user can provide information, which a single conventional walking aid device cannot. This means that a user can reinforce his/her five senses by wearing a gigantic aggregate of sensors named "city".

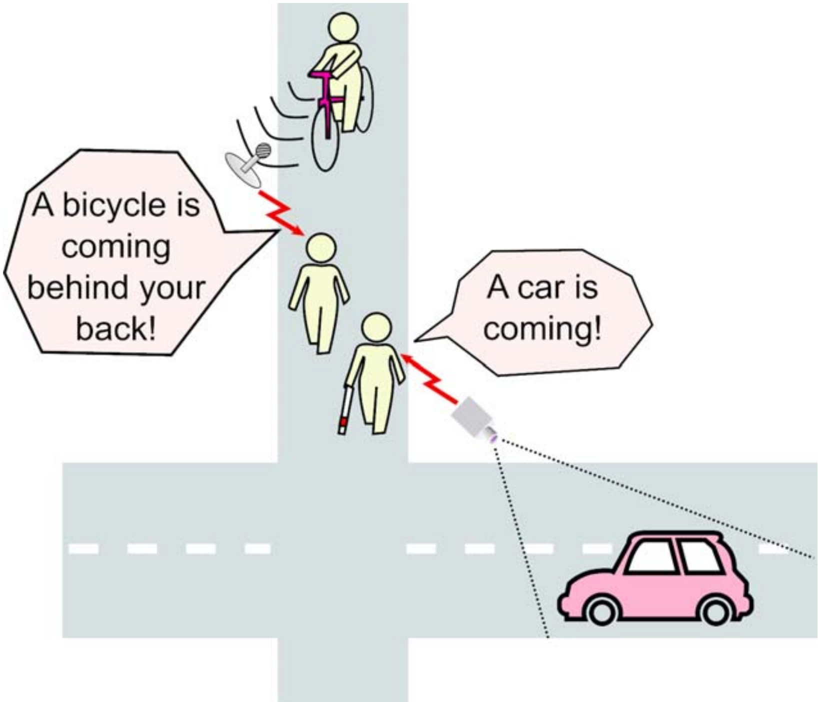

Figure 2. *Expanded "Five Senses".*

When all the street terminals provide obtained information directly to the pedestrian's terminal, the flood of information may confuse user. The street terminals must presume surroundings of the user cooperatively to give necessary and sufficient information to the pedestrian's terminal. This "surrounding presumption" enables the user to pay much attention to other dangers and important affairs for his/her walk by outsourcing a part of presumption process. Additionally, the information from various types of sensors of streets terminals and pedestrian's terminal itself enable advanced circumstantial judgment, which a single pedestrian terminal cannot realize.

P-ITS enables the pedestrian's terminals without many sensors and powerful processor to provide required information by outsourcing the sensing and processing tasks. Hence, the pedestrian's terminal can concentrate its computational power to provide better interface for its user.

3.2 Producing smooth traffic

As developing ITS is vehicle centered system, ITS benefits few pedestrians. In order to provide truly barrier-free walking environment, pedestrian-centered reconstruction of whole traffic system is unavoidable.

Global positioning system (GPS) terminal can navigate its user through barrier-free route, such as the stairs with escalator, and the pavements free from bumps. The extended five senses mentioned above may tell better route, which avoids the crossing over heavy traffics and the crowded sidewalks. However, this approach cannot provide pedestrian-centered traffic system, as it requires the additional efforts of pedestrians.

P-ITS realizes pedestrian-centered traffic system with dynamic control of traffic infrastructure, such as traffic signals or moving walks. For example, a traffic light changes its duration of green light, and a escalator or a moving walk changes its direction when elderly people with difficulty in walk approach as shown in Fig. 3.Among this scenario, the traffic light control is partly realized (Nippon Road 2000).

Additionally, the P-ITS may navigate pedestrians through pedestrian's terminals to realize smooth traffic. For example, a certain pavement can be divided into several routes depending on the walking speed of pedestrians. Like this example, cooperation among terminals may provide better environments for pedestrians.

The "extended five senses" service mentioned in section 3.1 is realized on the passive usage of the P-ITS infrastructure. On the other hand, the "promoting smooth traffic" service provides barrier-free environment and efficient use of the infrastructure through dynamic change of the infrastructure.

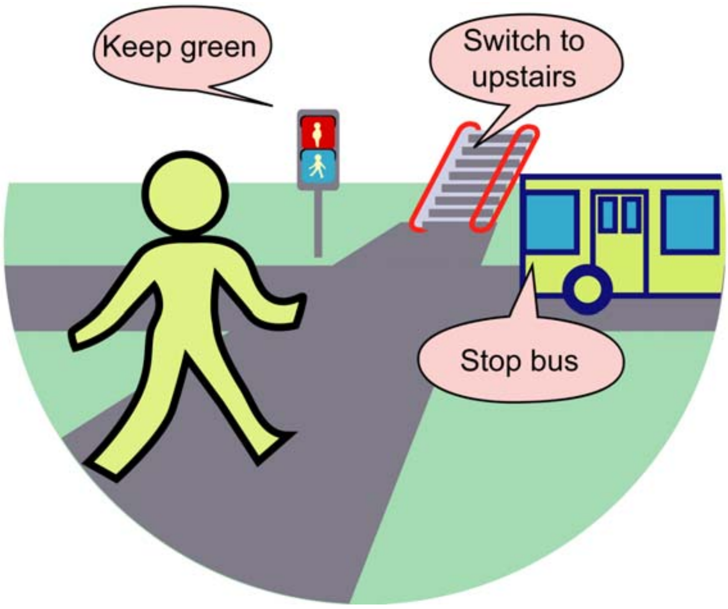

Figure 3. *Smooth Walking Environment.*

3.3 Promoting mutual help

The lack of knowledge sometimes derives rude behavior, and the knowledge may derive warm care.

P-ITS can notify that a person walking in front of your car is the hearing impaired to make you avoid horn crazily and tell the hearing impaired that a car is approaching behind him to make way for your car.

When the pedestrian's terminal knows the ability and situation of its user, P-ITS enables to match the needs between two users. For example, the hearing disabled can meet a person who can translate his/her sign language to English on the streets. It is difficult to realize without the matchmaking service.

4. THE WEARABLE COMPUTER FOR THE BLIND

P-ITS consists of various components. Especially, the wearable computer has wide variation depending on its user. This paper focuses on the wearable computer for the blind, one of the weakest in traffic system.

Japanese law requires the blind to have a cane with them whenever they go out. Therefore, foregoing walking aids with many sensors requires its user to hold two items, that is, the walking aids and a cane. It is troublesome for the user to wear two items appropriately. Additionally, most of foregoing walking aids, which gives the raw data obtained by certain sensors, may confuse its user with the flood of information as mentioned before. This paper proposes to compose all the walking aid into a cane and to give "surrounding presumption" function on the cane-shaped wearable computer (Tateishi et al 2000).

P-ITS provides the surrounding presumption function on the cooperation among street terminals and pedestrian's terminals (wearable computers). However, to provide minimum safety information, a pedestrian's terminal should know its surroundings and presume surroundings with this minimum information.

The most possible danger for the blind is obstacles, which cannot be obtained through a cane, that is, downward gaps and objects, which isn't connected directly to ground like signboards and load-carrying platforms of tracks as shown in Fig. 4. To obtain these obstacles, the wearable computer equips several ultrasound range sensors.

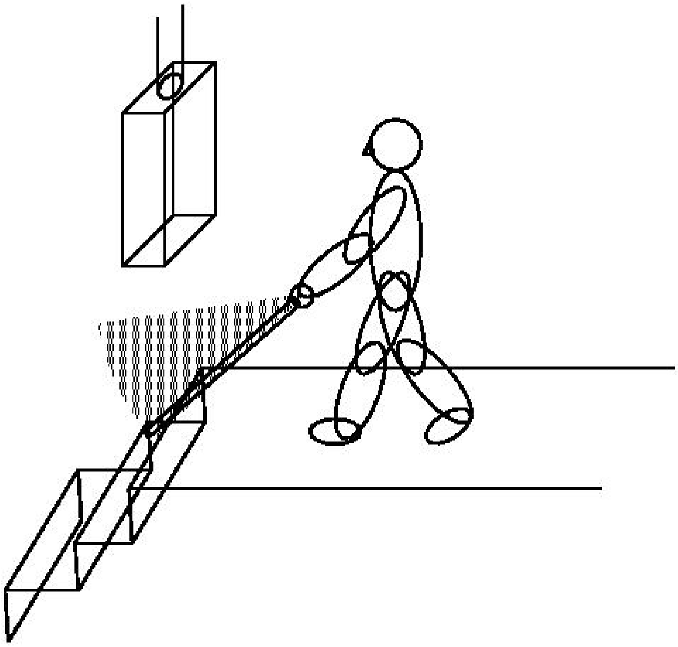

Figure 4. *Obstacles, which cannot be obtained through a cane.*

As a first step, this paper concentrates to obtain the downward gaps. The wearable computer equips three ultrasound range sensors as shown and 6D sensor for surrounding presumption. Ideally, these sensors and processor should be installed in a cane as shown in Fig. 5.

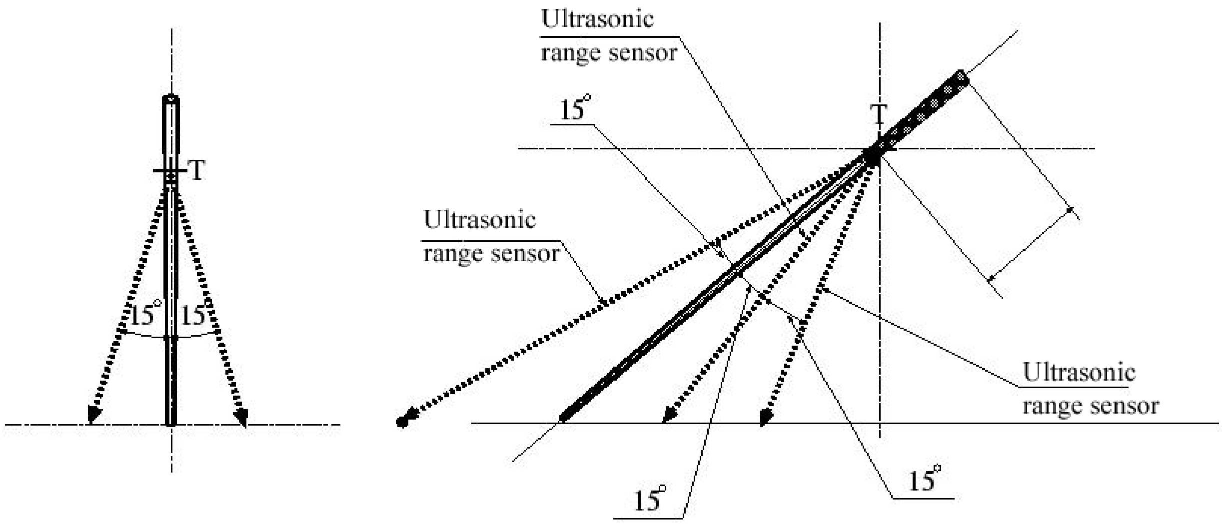

Figure 5. *The sensor configuration of the cane-shaped wearable computer.*

5. SURROUNDINGS PRESUMPTION

To reduce computational task for surroundings presumption is important to make the entire wearable computer compact. The authors developed simple algorithm to obtain 3D map of floor.

The cane can obtain its own position and orientation by 6D sensor, and distances from the grip to certain three points on the floor by ultrasound range sensors. The wearable computer can plot the obtained points into 3D map. The three points give the easy estimation of the floor plane. If the normal vector of the estimated floor plane leans more than a certain threshold, the wearable computer may recognize a slope or gap in front of the user.

However, this estimation cannot tell whether there are a gap or slope. The wearable computer makes additional estimation utilizing the history of the plotted points. The continuous three floor points obtained by a certain sensor *a(i), a(i+1), a(i+2)* give a normal vector of *a(i)* as shown in Fig. 6. If continuing points have similar normal vectors, the points may be on same plane. Hence, the points, which has similar normal vector, form a group. Here, as the two points on the border, *n(i)* and *n(i+1)*, cannot have the appropriate normal vectors, the normal vectors of them is replaced by the normal vector of following point *n(i+2)*.

According to the average normal vector, the wearable computer classifies the groups into two categories, that is, floor and wall. This “floor-wall strategy” enables to retrieve rough 3D map of the floor. Consequently, the system presumes the user’s situation whether he is heading a downstairs, a down slope, or a pit. Through this presumption, the system may not give unnecessary information to confuse the user.

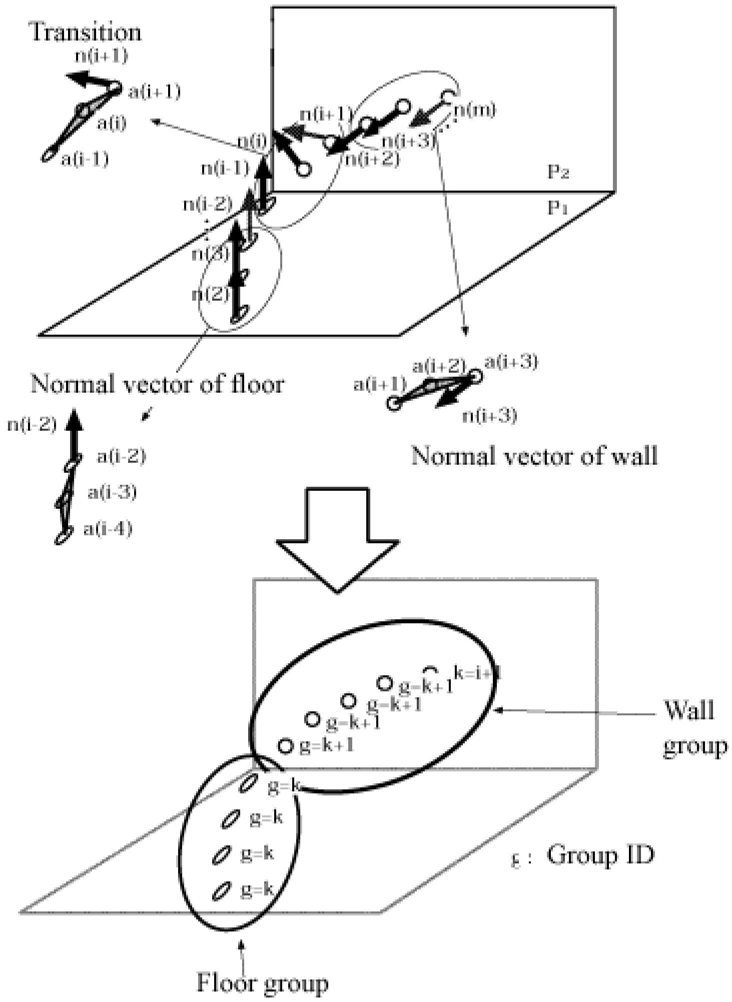

Figure 6. *The floor-wall strategy.*

The VR simulation of this surrounding presumption is performed. Fig. 7 shows a snapshot of the simulation. This simulation clears that the surrounding presumption works properly with small amount of range sensors.

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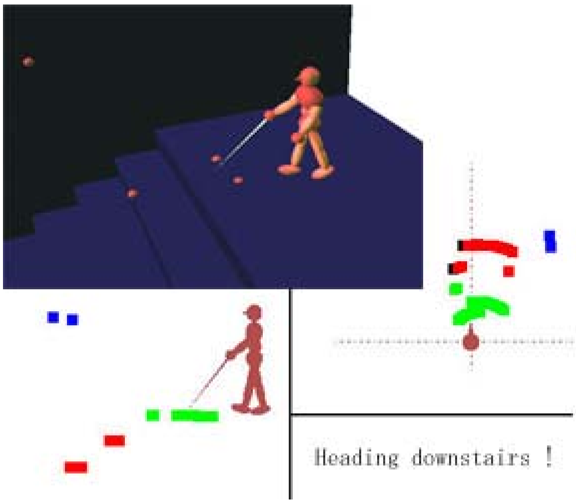

Figure 7. *The simulation result of surroundings presumption for a downstairs.*

6. CONCLUSION

This paper presents the concept of Pedestrian's Intelligent Transportation System (P-ITS). P-ITS provides several services for barrier-free and smooth environments for pedestrians under the cooperation of street terminals and pedestrian's terminals.

This paper introduces the conceptual design of a wearable computer for the blind as one example of pedestrian's terminal. The wearable computer presumes surroundings to provide minimum safety information using several range sensors and a 6D sensor. The simulation clears that a quite simple algorithm enables to presume the situations of the floor in front of the wearable computer.

The authors are continuously developing the P-ITS system including several wearable computers and street terminals equipped with traffic infrastructures such as traffic signals. The authors believes that this continuous development realizes the P-ITS system in a very near future and provides the environment, which makes human beings friendly.

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8. REFERENCES

Bluetooth (2000), *http://www.bluetooth.com/*

Nippon Road (2000), Hammyo Voice, http://www.nipponroad.co.jp/lineup/bfree/010.htm (Japanese)

H Sasaki, T Kuroda, Y Manabe and K Chihara (1999), HIT-Wear: A Menu System Superimposing on a Human Hand for Wearable Computers, *Proc. ICAT'1999*, Tokyo, pp.146-153.

T Tateishi, T Kuroda, Y Manabe and K Chihara (1999), A study on walking support of the visually impaired with situation presumption, *Proc. ISCIE2000*, Osaka, pp.93-94, (Japanese).

H Tokuyama, Y Iwasaki and K Kato (1998), Smart Way 2001, Nikkei Press, Tokyo (Japanese)

T Kuroda (2000), The future of barrier-free living environment of an information-oriented society, In *The prediction of the future technology*, Japan Business Report, Tokyo, In Print (Japanese).

K Kuuti, P Pulli, T Pyssysalo, S Hicky and P Antoniac (1999), CyPhone Mediaphone Project –Taxi Trip Scenario-, *Proc. ICAT'99*, Tokyo, pp.50-52.