A Remote-Support System for Visually Impaired Persons

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Abstract – This paper proposes a remote-support system for visually impaired persons that is capable of providing on-demand, prompt support at times of difficulty. The system consists of a very small attached video camera, which sends images of the visually impaired person' situation together with their assistance request to a remote supporter, and voice communication based on the wireless Personal Handy-phone System (PHS), by which the supporters can provide help at anytime, anywhere. By combining advanced technology and human abilities, our system can ease many of the difficulties that visually impaired persons often encounter, by providing prompt, on-the-spot support. The system also has wider application beyond the needs of the visually impaired, being useful in many areas such as security, education and entertainment. As the system is also capable of text-based communication, it can also be adapted to the remote support of auditory impaired persons.

I. INTRODUCTION

There are approximately 301,000 visually impaired persons (VIPs) in Japan, with some 179,000 being seriously impaired (Japanese Ministry of Health, 2001) and requiring support for their eyesight in daily life. As our modern high-information society is deeply dependant on visual information, instead of technological advances benefiting the visually impaired, in fact the information gap (digital divide) between the visually impaired and normal sighted is steadily increasing.

We propose a system which can provide prompt support to VIPs on demand.

In their daily lives, VIPs often need quick, on-the-spot assistance, but it is difficult to promptly dispatch a human helper in every case. The system proposed in this paper solves this kind of problem by combining advanced technology and human abilities. The remote-support system allows a VIP wearing spectacles with a very small video camera, a microphone and an earphone to send images of their situation to a remote supporter and to receive help via the voice communication network. The remote supporter can provide eyesight support to a VIP using our system.

Before a support system or product designed for disabled people can be realized, the following three criteria are very important.

Firstly, from the potential user's perspective, the support system should require no special training. It should also be light, small and inconspicuous, so that it is usable in a casual manner, as well as being inexpensive, tough, and easily maintained.

A second criterion from the manufacturer's perspective is for the support systems and products to be open to present and future developments and to be in line with the major trends in technology. As the market for support products for the disabled is limited, it is essential that these are based on the stable existing technology base in order to minimize the need for special development. Thus, the second criterion is important for rapid development, low costs, stability and adaptability to future technological advances.

Thirdly, support systems and products should have more universal application beyond the needs of the disabled. If the systems and products have such application potential, then it will be possible to market them more widely, leading to low costs and more stable production.

Our developed system satisfies these three criteria: in addition to satisfying the user and manufacturer's criteria, with its potential application to areas such as education and security, it also satisfies the third criterion.

Moreover, our system has further merits: as the system does not require a special infrastructure and all the system components are relatively independent, it is possible to enhance the system by incorporating the latest technological advances without complete system reform. As the system is not language-dependant, it also has the flexibility to adapt to a diverse range of needs.

In developing our system we have worked closely with Shirogame-Jyuku, a non-profit organization (NPO) devoted to supporting VIPs, which has provided us with access to many support specialists, engineers and to VIPs themselves. This has allowed us to conduct various experiments to develop and improve the system with fast and steady feedback. The NPO now has a three-year history, and this makes it possible for us to have direct insight into the real needs of the VIP.

II. PROBLEM ANALYSIS, NEEDS OF VIPs, AND OUR APPROACH

A. Analysis of VIPs' needs

VIPs encounter many inconveniences in their daily lives because they lack visual information. Here, we shall examine some of these inconveniences by looking at two areas of activity—walking outside and activities in the home—in order to demonstrate the validity of our approach to solving these problems.

Although there has been much industrial research into and development of products to support the VIP when walking outside, none of the devices are widely used. This is because they usually require long periods of special training, often provide unnecessary information to the VIP, and are conspicuous when worn. VIPs still rely on traditional methods, such as white walking canes and guide dogs. The ideal support is a human, but even with a human guide, the VIP is not totally safe for they can still miss their footing and fall. Accordingly, it is necessary to establish human guide techniques before developing guide products. For further discussion, see Ref [1].

In the home, VIP employ a variety of techniques to avoid problems, such as using Braille labels, putting things in fixed places, and only buying same color socks. However, VIPs frequently require prompt and on-the-spot assistance from sighted persons.

Situations where a VIP may need prompt and on-the-spot support may be classified as follows:
(1) Reading characters or symbols; when wanting to sort mail, to read documents or manuals in a hurry, or to read displays on domestic appliances, etc.
(2) Distinguishing objects of same texture; when wanting to select clothes of particular color, to pair socks, to check contents of freezer, and to buy favorite brand, such as can of beer.
(3) Emergency situations; when wanting to search for something in the home, to check change at the supermarket checkout, or to find someone close by for help.

Over the last three years, we have been carefully analyzing the problems encountered in daily life by VIP and their support needs by observing VIPs in their homes. As a result, we have able to dispel an erroneous preconception about the support requirements of VIPs, namely, that VIPs want 24-hour support but this is impossible due to financial and other personal factors. While it is true that VIPs living alone have many problems both inside and outside the home every day and want assistance from sighted persons, clearly having a sighted helper constantly on hand is not the ideal answer. VIPs are quite capable of living independently, and excessive support can even be annoying. Consequently, if prompt on-the-spot support were available on demand, constantly present human helpers would not be necessary.

B. Our approach to analyzing of VIPs' requirements

From our extensive fieldwork at the NPO, it is clear that many of the assistance requests from VIPs can be solved with voice support if the human supporter is able to see the situation that the VIP is faced with. Moreover, in many cases, appropriate voice support can be given, even when the supporter is remote, as long as they can receive visual images of the VIP's situation and can hear their assistance request.

Having mentioned outlined the misconception concerning the needs of VIPs, we next describe a misconception held by engineers. Engineers tend to solve problems by technological means only without utilizing the human abilities available. In order to completely support VIP with only technological means would, however, require far more sophisticated AI, involving machine recognition and natural language based communicative competence, than is likely to be available for many years to come.

The uniqueness of our engineering approach comes from the facts that our system both fully utilizes human recognition and language abilities in response to a wide range of needs and successfully avoids the extra costs of developing a special infrastructure solely for disabled persons. The first aspect makes it possible to adapt the system many applications and all languages, while the second represents a major reduction in development and maintenance costs.

Accordingly, we propose the system represented in Fig. 1. In this system, when a VIP requires eyesight assistance, they can contact a remote supporter and send images of their current situation and receive voice communication support. The structure and characteristics of the system are explained in Section III.

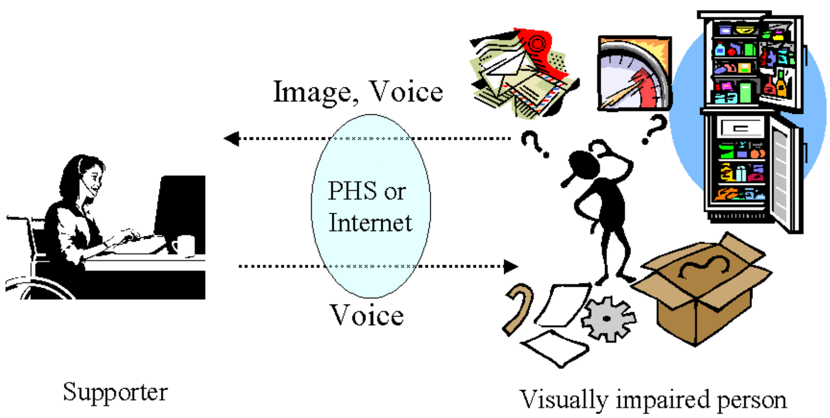

Fig. 1 A visually impaired person can receive help from a remote supporter via PHS network.

III. REMOTE-SUPPORT SYSTEM

A. Outline

Our remote-support system can be broadly divided into a system for VIPs (Fig. 2) and a system for supporters.

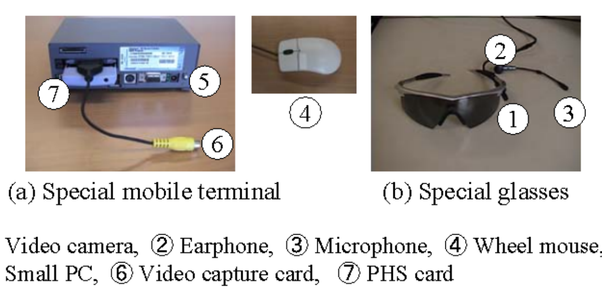

Fig.2 The system for visually impaired persons

The system for VIPs (Fig. 2) consists of special glasses (Fig. 2(b)), a special mobile terminal (Fig. 2(a)) with network equipment. The glasses have a small video camera (Fig. 2(b)(1)), a microphone (3) and an earphone (2) inconspicuously attached. The camera and microphone are used to send images of the VIP's situation and their voice message. The earphone is to receive voice assistance from the supporter. The special mobile terminal is a personal computer (PC) specially designed to be small and lightweight, and has a wheel mouse for software operation, video capture equipment, and a device for PHS or radio-LAN communication.

As alternatives to the glasses-attachment, Fig. 3(b) and (c) show earphone and helmet attachments, respectively.

(a) Glasses type (b) Earphone type (c) Helmet type

Fig.3 Alternative attachment methods for the mobile video camera.

The supporter's system consists of a PC connected to the network, with monitor to display the images from the VIP as well as a speaker and a microphone for voice communication with the VIP.

Remote support is carried out as follows: The VIP wears the special glasses (Fig. 2(b)) and carries the special mobile terminal (Fig. 2(a)). When they require eyesight assistance, the VIP can establish contact with the remote support by double-clicking on the right mouse. The supporter is advised by a bell and message on the monitor that an assistance request has come, which they can acknowledge by pressing a button to inform the VIP that assistance is available. Once the connection has been confirmed, the supporter can see the images from the VIP and ask about the nature of the problem. The remote supporter is able to adjust the images, such as resolution, as necessary to provide voice assistance to the VIP. Once their request for sight assistance has been fulfilled, the VIP can exterminate the connection with the remote supporter by again double-clicking the right mouse.

As bandwidth will greatly influence the content, the speed and the appropriateness of support, a broadband network can obviously offer improved quality in terms of both image and voice signal over a PHS network. A wireless broadband network can be realized by using a radio-LAN network. If the VIP uses a radio-LAN card instead of PHS in their home, they can send high-quality images at high frame-rates and receive more appropriate support from a supporter.

B. Characteristics of the system

(1) Hardware

The system for VIPs has the following two characteristics: 1) The special glasses (Fig. 3(a)) can transmit video images and voice signals inconspicuously. 2) The special mobile terminal does not include an LCD or keyboards in the interest of being lightweight. Moreover, ROM is used rather than a hard disk, so that terminal can easily be switched on/off when needed/troubled without delays for disk scanning.

A characteristic of the supporter system is that it can be set up on an ordinary PC, allowing any PC users to be a potential supporter without extra expense.

(2) Software

The three main characteristics of the system software are as follows:

1) The supporter can adjust settings controlling image quality, image size, frame-rates, etc. according to transmission conditions and the nature of the assistance request.

When using the PHS network, the communication-band is greatly influenced by location and level of traffic, etc. Also, as assistance requests vary in nature, from requests about approximate locations of objects to reading small characters, supporters need to be able to adjust image setting as appropriate.

2) Video images and voice signals from a VIP can be transmitted to a supporter by PHS.

As PHS can be used over a wide area of Japan and with a maximum communication bandwidth of 128 Kbps, this is a useful communication tool for VIPs.

3) Other software applications can easily be incorporated within our system, to extend the functionality of the system when required.

Because our software runs on a widely-used operating system, other software can easily be run at the same time, making it simple to extend the functionality of the system.

We note here some of the software characteristics in terms of VIP and supporter functionality.

An important software characteristic from the VIP's perspective is the fact that several operations are executed using a wheel mouse. Establishing and terminating a communication connection are both executed by the right mouse button. The left mouse button is for checking on the radio condition, while the volume of the incoming voice signal is controlled by the mouse wheel. If necessary, automatic connection and reconnection functions following signal loss are also available.

From the supporter's perspective, an important characteristic is the ability to adjust the images according to transmission conditions and the nature of the assistance request. Specifically, the supporter is able to adjust the size, quality, brightness and contrast of an image, the volume of the incoming voice signal, as well as giving priority to frame-rates or image quality, and the voice signal quality. The supporter can also receive high-quality still images in a separate window, and although usual moving images cannot also be shown, voice communication can be maintained until the VIP's request as been satisfied.

IV. EXPERIMENTS

As we are constantly developing our system, please note that the data presented here based on experiments conducted during October 2002. Our experiments can be divided according to basic and applied experiments.

A. Basic experiments and results

When providing support, it is important to be able to differentiate between image speed and image quality as appropriate to the nature of the assistance request. Accordingly, we have evaluated (1) artificial eye accuracy (image quality of transmitted image) and (2) transmission delays.

For evaluations of the artificial eye accuracy, three types of cameras (two very small cameras and one normal camera) and five image qualities (extra fine, super fine, fine, normal, economy) were used, as well as two image size/resolutions (320 x 240, 640 x 480). The quality levels and sizes can be selected by a supporter in our system.

The results indicate that image quality is strongly dependant on the camera's field of vision: When the field range was about 50 degrees, accuracy was 0.1 with a 320 x 240 resolution and normal or higher quality and between 0.1 - 0.2 with a 640 x 480 resolution and normal or higher quality. However, when the field was about 4.5 degrees, accuracy was 0.7 - 1.5 with a 320 x 240 resolution and normal or higher quality and between 1.5 - 2.0+ with a 640 x 480 resolution and normal or higher quality.

For the evaluation of transmission delays, two identical clocks were used, so that one clock, present in the transmitted image, could be compared to a second clock with the supporter. Communication bandwidth was also observed.

The results indicated that transmission delay is dependant on the communication bandwidth, the specifications of the video capture card using kinds of Application Program Interface (API) as well as the size, quality and content shift images. When a radio-LAN performing at 0.8Mbps was used, no transmission delays were observed with a 320 x 240 resolution, extra fine quality and 15fps. Note that this experiment was conducted using a USB video-capture-cable rather than a video-capture-card, which gave the high frame-rate of 15fps, but cannot handle images at a resolution of 640 x 480. The radio-LAN based experiment shows that transmission delay due to the software is very small. In contrast, in the experiments based on the PHS, with a bandwidth of approximately 35 Kbps, frequently changing images at a resolution of 320 x 240 with fine quality, the delay was between 1 to 4 seconds, although it was less than 1 second at 160 x 120 with economy quality.

B. Applied experiments and results

In our applied experiments, we tested our system in daily situations to evaluate its performance. Specifically, we conducted the a number of experiments including a variety of tasks, such as identification of cans, identification of frozen food in plastic bags, reading LCD figures, and sorting of mail.

Although an identification task for beer cans and a color-sock-matching task were successfully performed, in the identification tasks for cans and plastic bags of frozen food, light reflections sometimes caused white patches in the images making characters unreadable.

In the mail-sorting task, we found that small characters were difficult to read when the items were too close to the camera and out of focus, which underlines the importance of having a multi-focus camera.
In the character-reading tasks, the ability to obtain very high-quality images is particularly useful, which can be done by first roughly setting the position of the camera in economy image mode and then taking a still image to reduce shudder due to delayed shutter action. In contrast, the ability to adjust image brightness is useful when reading LCD characters.

These experiments clearly demonstrate the usefulness of our system for VIPs, who are able to receive sight assistance for many needs via a telephone without having to make an appointment with the supporter. The experiments also indicated that our system gave the VIP a sense of relief. The ability on the part of the supporter to control the quality and brightness of the images received is useful for providing various kinds of support according to the VIP's situation. Although some problems remain—such as communication stability, simpler and more compact equipment, and higher compression levels for image and voice signals—we continue to research for their solutions.

V CONCLUSIONS

This paper has proposed a convenient remote-support system for VIPs. Although the quality of this remote support is influenced by radio conditions, the system infrastructure is not limited to the needs of VIPs, and further development is expected. Limitations with voice support can be overcome by optimizing representations and procedures.

Aged persons and physically disabled persons can become supporters. We want to develop a network server for 24-hour VIP-support based on our proposed system. This system can be easily extended as a system for auditory-impaired persons, emergency medical service and security guard personnel. The former two systems are already under research and development.

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