

On Development of Assistance Tools for Hearing Impaired — Multi-modal Communication and Vibrators —

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Synopsis

In this paper, what kinds of assistance tools for hearing impaired should be developed is discussed. The aging society is coming soon. There are many kinds of problems unsolved for aged and handicapped. We should consider about what we should do and what we can do for maintenance of life environment and for development of welfare apparatuses. Especially in this paper, multi-modal communication for hearing impaired is described.

KEYWORDS: hearing impaired, hearing aid, multi-modal communication, media transformation, vibrator

1. Introduction

Every person grows old. Physical and mental powers are decreasing according to it. All the people are faced with the problem of hearing impaired sooner or later. The problems do not stay only in hearing impaired. But we focus on hearing impaired because there are too many problems to be solved at the same time. It is assumed that there are about 8,000,000 of hearing impaired persons in Japan. It is the time to consider what we should do and what we can do, that is, needs and seeds. Our standing point is neither doctor's one nor administrative one but engineer's one.

On the other hand, we can see in the investigation report of inconvenience questionnaire that "Amusement and entertainment" also is important at the same time as "Cancellation of the inconvenience". Daily life is in tension for aged and handicapped. A rest of body and a relief of mind are necessary. The important things are as follows:

- (1) Maintenance of the environment for safe living,
- (2) Making the space and time for heart-healing.

Here, it is thought that the key word to support healing the mind is "Communications".

A lot of works have been done to solve these kinds of problems, for example, a guide dog for handicapped. In order to make such toys that children with handicapped ears can play with children with normal, the Japanese toy society is devising by using vibration and light. The enjoyment through the sound might be felt even through light and vibration. The toys with "Rabbit mark" have increased to two times or more last year. Parties concerned are welcoming such a movement to support the mark. However, there is big room for device, and they are making the guideline to avoid the aural trouble. The dissatisfied points from the users are not few: "A lot of sounds which are made to be heard" and "Training so that weak hearing may be made use of to its maximum" are more important than "Giving up because of hearing difficulties" and "Enrichment of the functions to take the place of hearing". The teachers and parents of deaf schools demand toys making bigger sound. The toys from which such sound is emitted are positively adopted also in deaf schools.

The assistance dogs are playing the active parts such as lost article picking up, pulling a wheel chair, support of walking, opening the door, turning on/off the light and taking care of physically handicapped person's daily life. If we ask a person for such helps, we feel some constrained and it costs much. Furthermore, such various helps cannot be done by a machine. However, the dog helps willingly the owner whom it loves and by whom it is admired. The owner may feel at ease, and his mind is also healed. Then the expenses, that is, personnel expenses, can be reduced.

Public assistance for hearing aid dogs is needed as much as for seeing eye dogs. A hearing aid dog informs the hearing impaired person of chime, ring of telephone, alarm clock and so on as seen in Fig.1. There are a lot of problems for the spread, for example, the training method is different in each group. The total number of the

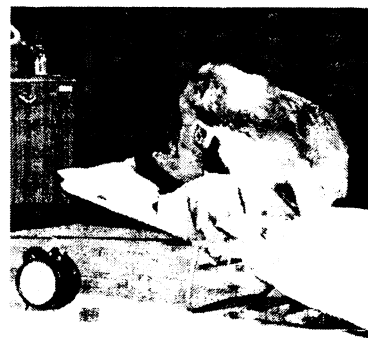


Fig.1 Hearing aid dog.
Waking up the sleeping master
reacting to the alarm sound.

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dogs is 2,000 in the United States. However, fewness in the training place and upbringing cost of 600,000-800,000 yen are barriers in Japan.

The telephone system by which hearing impaired person can communicate smoothly with another person, has been developed as one of new barrier free products. The voice of the telephone is converted into the characters by applying speech recognition technology, and displayed on the personal computer screen. It is more convenient than facsimile for urgent report and for order of delivering to home. Some speech recognition softwares have been developed. For example, in "ViaVoice (Millenium)" by IBM Corp. and others the accuracy has been improved from about 90% so far to 98-99%, and the time to register user's voice first is shortened at ten minutes from 30 minutes. Some improvements are made for easy to use in addition. Additionally, another software "AMI Voice" for speech recognition system developers is on the market.

2. Multi-modal Communication

A MMC (multi-modal communication) system is shown in Fig.2. We humankind have many ways to communicate with other persons and to get information from circumstances. For example, we have five senses (sight, hearing, touch, smell and taste) corresponding to five sensory organs (eye, ear, skin, nose and tongue), the sixth one and so on. Usually a sense corresponds to an organ. But when one of such organs loses its function, what can we do? One solution is assistance by reinforcement in the same media, for example, hearing aid of sound amplifier for hearing impaired. The another is assistance by media transformation for using remained functions. The MMC tool is been developing for such a kind of work. The research and development concerning with the assistance of independence life for aged and handicapped include many things. The collaboration from various standing points are required. Here we focus on hearing impaired. The block diagram of a MMC terminal is shown in Fig.3. Table 1 shows functions and devices of each unit.

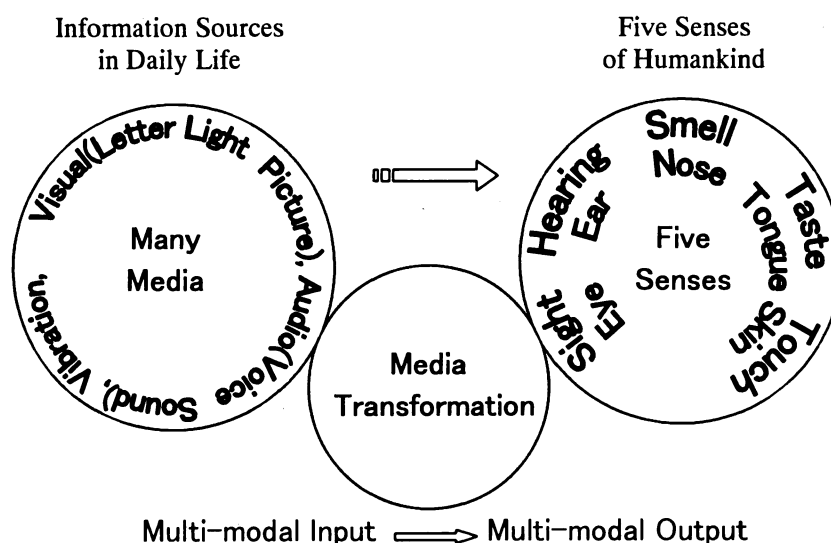


Fig.2 Multi-modal Communication System.

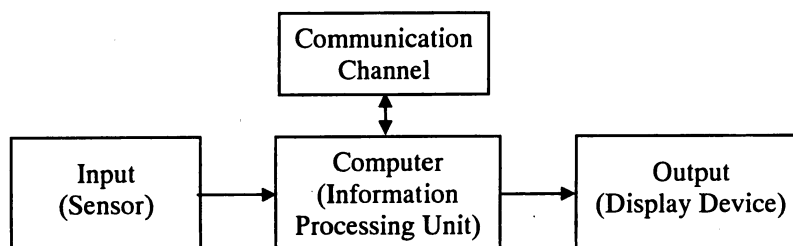


Fig.3 Block Diagram of a MMC Portable Terminal.

Table 1 Functions and Devices of Each Unit.

Unit	Functions and Devices
Input	TV camera (CCD camera, HMC etc.), microphones, supersonic sensor (for obstacle detection), eye camera (for glance estimation), keyboard, pen pad, mouse (pointing device), touch sensor (instruction device), joystick, data gloves (VR technology), 3D position measurement device and so on.
Computer	Main work of the computer is media conversion from input to output. The media for communication in the telephone is the voice through "Talking and listening". On the other hand, we aim here at the things like "Conversion from the voice into the character", "Writing the characters and listening them in the voice", and "Recognizing the sound and informing them by the vibration" and so on. The media conversion for such communications becomes the main work of the computer. There are various combinations in I/O media corresponding to man's senses and remaining ability. This is the reason for the word of "Multi-modal".
Communication Channel	Signal Transmission: wireless (portable telephone, PHS, etc.), cable (telephone and information outlet) Position Detection: GPS + gyrocompas
Output	Sight: liquid crystal, HMD (head mounted display), LED (for urgent blinking), and various sounds may be displayed by visual media (Example: the color and shape corresponding to the frequency spectrum of the voice), etc.. Hearing: earphone (both ear installation with frequency equalizer and delay adjustment) , bone conduction, etc. Touch: vibrator (portable telephone type oscillator, the tip of a finger vibration device, ring type and many other types), mechanical convex/concave (lightning bulletin board type braille, braille printer, etc.), stress gloves, balloons, and vibration ball, etc. The others: bodily sensation signal, supersonic wave, electricity stimulation (Example: low frequency treatment machine), etc.

Before media conversion, the computer works to identify the sound source and recognize the sound direction in daily life. Moreover, recorders and players of many kinds of sound sources and wireless facsimile (pen pad etc. for real time communication) are necessary. When waiting in a hospital and getting on a taxi, communication in writing and a wireless notification device are useful. The development will be done with note PC's though we aim at the device of palm top size at the final stage.

Some of the results of need extraction by the KJ method carried by our group are as follows:

- (1) Character display and speech recognition are effective.
- (2) Slowly speaking device looks effective (cf. investigation of existing product etc.).
- (3) Vibrator (cf. vibrating on summoning in a hospital) has the big possibility.
- (4) Lip movement is useful for comprehension (cf. real-time wireless videophone).
- (5) Many others.

3. Works of Other Groups and Makers

Some announced works are being introduced shortly one by one for the reference of the development in the near future. There are many other works non-described here.

- (1) Character communication device by portable telephone and PHS:

Information terminals for character communication (by Tomi Corp. and Toshiba Corp.) are put on the market. And Koroniiwaiz Corp. put the hand-written character communication tool by PHS for hearing impaired on the market. Moreover, the information service for the physically handicapped person who uses this PHS is started, for example, agency service of emergency report and facsimile information service. Toshiba Corp. developed the PHS jointly with Japan Communications Corp. The price is 74,000 yen. First of all, the urgent report service of the 110th and 119th (the police and the fire station) executed as a proxy begins soon. It is offered 24 hours gratuitously.

- (2) Telephone for hearing impaired using vibration:

One is the telephone (by Artwork Corp., ¥32,000) which tells the voice by vibration of man's skull. Another one is the portable headphone (by Temuko Japan Corp., ¥13,000) which tells the voice by bone conduction in the cheekbone of both ears.

(3) Wristwatch type terminal for hearing impaired:

It works usually as an ordinary wristwatch. When telephone ringing and so on, it informs the user by vibration. The price of the basic set (including one wristwatch type terminal, two sensors and installing) is 95,000yen (by Tokyo Sumitomo Corp.). The sensors may be connected with doorbell, telephone, alarm clock, etc. by cable. When a bell ringing, the faint radio wave is sent, and the terminal is vibrated. To display on the terminal screen like "Entrance" and "Telephone", etc. at the same time, we can know which bell is ringing.

(4) A new toy "Silent-shout" for enjoying teeth sound:

It is a toy which uses the mechanism of bone conduction and is shown in Fig.4 (by Bandai Corp., 1,480yen). When the candy on the top of the stick is held in one's mouth and the button is pushed, then the sound which is emitted from the main body is transmitted through our teeth, and can be enjoyed like as sounding directly in our head. The sound can be heard only by the person in question, and does not leak to surroundings. There are four kinds of designs such as "Relaxation" and so on.

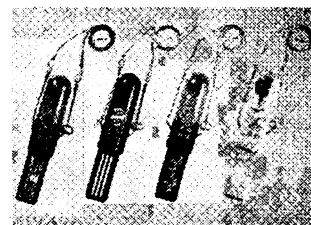


Fig.4 Silent-shout.

(5) The brain perceives the supersonic wave:

It is found that our brain seems to be able to perceive the supersonic wave without using aural organs. This phenomenon is found by the research group of The Electrotechnical Laboratory (ETL), Kinki University, The University of Tokyo and Doshisha University. They start the development of the hearing aid and the audio device which use this new perception function. As the results of the examination of the brain activity by touching the supersonic wave of 20k-40kHz which man's ear can't hear, to the muscle of neck, it is found that the area of brain which activates on hearing sound, do reacts. Even the hearing impaired person had the same reaction. Up to now, it has been said that there is an unknown mechanism and our brain can perceive sound without aural organs. The research group announced the research result to the biology magazine of the United States thinking that the existence of such a phenomenon had been able to be proven by their experiment. Many techniques by that the sound vibration is transmitted to the bone of skull and jaw, have been put to practical use. Even in this case, the auditory nerve has been necessary. Even the person who can not perceive sound by vibration have reacted in their experiment. When the language sound "Airplane" etc. is overlapped with the supersonic wave, the testee can recognize the word neatly. Using this mechanism, it may become possible to inform the danger signal to the person with trouble in the auditory nerve. However, the mechanism about how our brain feels the supersonic wave is unelucidated. The research group has the plan to work on the mechanism elucidation and the development of the application device.

(6) Activity in the aural area of brain by dactylology:

The group of Dr. Nishimura in Osaka University ascertained that the aural area of brain which is used usually to understand talking words, is reactive to the sight stimulation of dactylology in an inherent hearing impaired. It seems to be useful also for elucidation of the working of the aural area of brain. The result is published in British science magazine "Nature". The video of dactylology was showed to the man in his fifties who had lost hearing by meningitis after his birth. They examined which area of the brain was activated, when the words of dactylology such as "Father", "Elder brother" and "Television" were shown. The area of brain called as "Aural union field" which took the role to understand the spoken languages, was activated.

(7) Concert for hearing impaired:

Pioneer Corp. held "Let's listen the music by the body" concert, and the vibration devices were installed in the seats. On the other hand, NTT starts the concert from '87, and is sponsoring mainly classics and rock music 30 times a year on the average after '94. The bone of ear and head is vibrated by a special headphone, and the sound is directly transmitted to the brain.

(8) Dactylology dance with beat feeling:

The dancer shows rhythmically the lyrics by the dactylology dancing to the tune of the popularity groups such as "SPEED" and "MAX". The spectators can feel the bodily sensation by holding a balloon in advance and the beat by vibration. Lyrics can be enjoyed by dactylology at the same time.

(9) Hearing device used only at necessary time:

It has the shape like the receiver of a telephone, and is touched to the ear only at necessary to hear. The highly sensitive microphone picks up the sound.

(10) Exchange about "Safe town making":

The exchange among hearing impaired is held to discuss about the danger of streets of town. It is useful to make future towns. At the earthquake the lifeline stopped, and the facsimile of asking safety could not be used. Enough consideration to the disaster weak is needed. In emergency all televisions should have the subtitle and the dactylology.

Ten articles have been carried above as long as the space is permitted because it seemed that these news give a lot of hints to devise the presentation method in the near future.

4. Research Subjects of Each Unit

The main subjects of the MMC tool described in Chapter 2 are shown in **Table 2**. The recognizing process is shown in **Fig.5**. The method of presenting information is one of our main problems should be researched and developed now. The important thing is the entire examination of specification which includes I/O and development of small parts. It is necessary to develop the hardware and software including algorithms in parallel. Using the prototype, the improvement of convenience is done from feedback by the questionnaire survey etc.

It is important to consider "Town making for physically handicapped and foreigners" and "Development of comprehensible pictographs and sign characters in an emergency, which have the united description method of them (standardization) and familiarity with them". We aim at the exceeding the concept of a current hearing aid, and the new tool and system that can really support the hearing impaired person.

Table 2 Research Subjects of Each Unit.

Unit	Subjects
Input	Method of recording, playing and setting microphones
Processing Unit	Development of the algorithm for sound identification and angle recognition, extraction of information presented, sound source (water dripping, ventilation fan, alarm, telephone ring, chime, alarm clock, etc.), loudness (deep, low, big, etc.), algorithm for learning and difference calculation
Output	Method of presenting information (five senses and others), development of vibrators, psychological experiment, place, method and mean of stimulation, movement (movement of eyes and gesture)

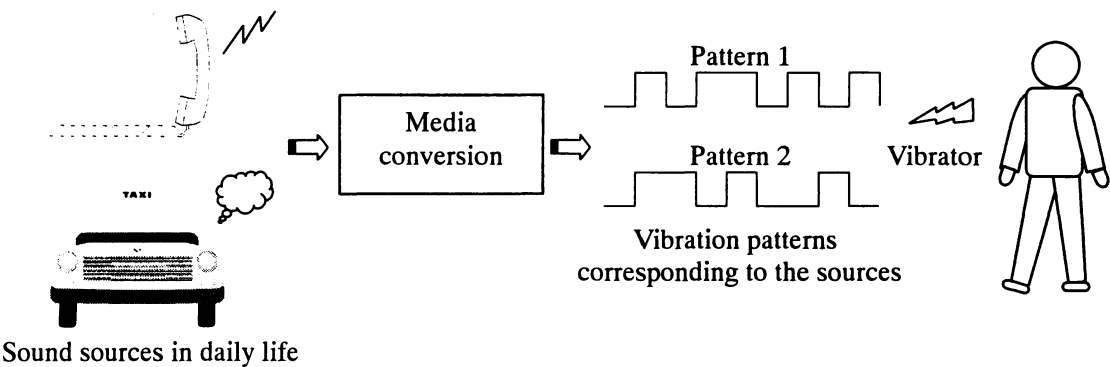


Fig.5 Informing the results through several vibration patterns.

5. Conclusions

Development for assistance tools for hearing impaired has been described. In the near future, we expect that we can make the prototype for product at the next stage, which has the following features:

- (1) Meeting the demanding basic performance:
High reliability, High recognition rate of environmental sound source, Fail safe, High freedom and flexibility, High applicability, Learning ability and User customizing power.
- (2) Invention for enjoyable, familiar and friendly device:
Shape (plane/solid and size), Feel (softness, material and weight), Tones, Behavior and movement, and Lovely characters as shown in **Fig.6**.
- (3) Easiness and comprehensiveness of usage and operation:
Device of other various presentation methods such as screen, sounds, vibrations and so on beside the above-mentioned .

- Problems are as follows:
- (1) Needs: Questionnaire survey, Hearing investigation and so on,
 - (2) Seeds: Existing elemental technology + Newly developed technology,

- (3) PL (Product Liability) : Influence investigation to human body,
- (4) Achievement possibility: Economy, Product, Profit, Market, Common goods, and Welfare administration,
- (5) Intellectual property: Patent and so on.

As it is said that the brain is the last field never trodden, the cerebral activity has not been known well enough. But various and interesting phenomena are announced though what are occurred is not understood well. There are big hints for the presentation method as seen in the work about supersonic in Chapter 3. The phenomena can be used even if the fundamental elucidation does not advance. First of all, the algorithm for the identification of sound sources and the recognition of its direction should be developed. After that, it becomes a big problem how to convey the information, and there are many methods as described above. The proposed one of promising and potential ones is using vibration, so the development of small vibrators may be the next work. The project must be promoted with the feedback by psychological experiment and hearing impaired. Another possibility is the usage of supersonic sound. With many trials and efforts, we hope our society and environment will become barrier free gradually but steady.

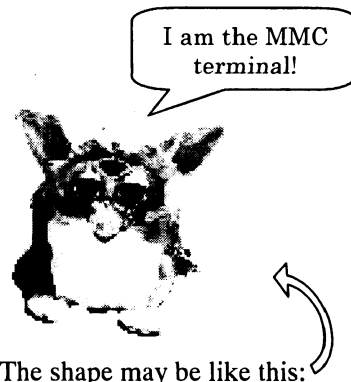


Fig.6 Stuffed animal 'Furby'.

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