18

Distance Feedback Travel Aid Haptic Display Design

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1. Introduction

This chapter introduces approaches of electronic travel (walking) aid (**ETA**) interface for visual information deficit and gives discussions on the high integrity design concept under restrictions of visual- tactile sensational characteristics in substitution process. Here, we start from the concept formulation of ETA. The concept of ETA human interface is based on the sensory substitution between visual and tactile sensation. If human has lost the visual information caused by some sort of environment interference or physical troubles, this ETA assist the subjects to obstacle avoidance self-walking with transferring some environment information (depth, image, object and so on).

Since the first prototype ETA model of TVSS (Tactile Vision Substitution System) in early 1960's, enormous number of research and commercial instruments are developed with visual sensory substitution. Some of these models are still available in markets with improvements (e.g. sonic torch/guide, MOWAT sensor and so on.).

The user with visually impaired using these devices claimed on the difficult understanding at complex environment like in crowds and '**sensory overload'** in use as complexity of understanding, inhibition to other sensory function.

Fig.1. Haptic Travel Aid Image

Source: Mobile Robots: Perception & Navigation, Book edited by: Sascha Kolski, ISBN 3-86611-283-1, pp. 704, February 2007, Plv/ARS, Germany

Applying sensory	Transfer target	Transfer method	Display device	Transfer part
Auditory Sense	Distance	*Sound modulation *Voice Guide/Alarm *osseous conduction	Headphone (speaker)	Drum membrane
	Obstacle	Voice guide/Alarm	Headphone (speaker)	Drum membrane
Tactile Sense	Distance	*Mechanical Vibration *Sound modulation *Voice Guide/Alarm *Electromagnetic relay *PZT actuator *micro vibro-Motor	*Electric cane *Vibro Handheld device *Tactile/haptic Display	*forehead, *back, *forearm, *palm, *finger, *fingertip, *tongue
	2Dimage	*Pin stroke *Voltage impression	*2D Electric-driven Braille display *2D Electrode Array	*Fingertip *Back
	Letter/ Texture	*Pin stroke *Voltage Impression	*2D Electric-driven Braille display *2D Electrode Array	*Fingertip *Back)
	3Dfigure	*Pin stroke *Sequential 2D depth contour *Touch /grasp object *Force Feedback	*2D Electric-driven Braille display *Pneumatic pressure *transform object (deforming object , balloon, actuator) *Haptic display	*Fingertip, *Palm, *Tongue)
Baresthesia (Pressure sense)	Distance	*Hydrostatic / pneumatic pressure	*Water /Air injection valve	*Palm)
Electric sense?	2Dimage	*voltage impression	*2D Electrode Array	*Fingertip *Back Retina, Cortex
Thermal /Chemical sense	N.A	N.A	N.A	N.A

Table 1. Visual Sensory Substitution Method (N.A: not available)

For the user-friendly ETA interface design, we should consider more direct operational method and transfer device. From the transfer target classification, ETA type is classified into 3 categories as (A) (edge operation processed) environment image, (B) Distance Information of surrounding obstacles, and (C) combination of (A) and (B). By comparison with ETA, other applications of vision-tactile sensory substitution are listed in character display with Braille display, 2-dimensional image display, Pseudo-3D object figure transfer, and surrounding state guide. (Shinohara et al., 1995), (Shimojo et al., 1997) From the aspect of using sensory classification types, they are listed as following: a) artificial vision with

surgery operation to implant electrode array on retina, b) transfer camera image to implant ed electrode on visual cortex (needs surgery operation), c) make use of auditory sensation with sound modulation or beep or voice announce correspond to depth or object, d) use tactile sense to display visual image or extracted information with tactile/haptic display device.
Furthermore, from the visual-tactile sense conversion method classification, representative ETA method are listed in 1) 2D pin/electrode image display (including pre-processed operation, difference, edge, so on) , 2) low frequency vibro-tactile stimulation based on depth, and 3) selective part haptic display are representative methods.
As mentioned above, current objective is to realize the (none sensory overload) user-friendly ETA interface and to give design guide. This chapter takes up the simple scheme distance feedback ETA using selective stimulation haptic depth display, which possess advantage in fast depth recognition in comparison to existing 2D tactile display type ETA and doesn't need **heavy** surgery operation and concentrates to discuss the adequate design guide for haptic sensational restrictions.
Following background of ETA section, basic characteristics and restrictions of tactile/haptic sensation are discussed, which are important for user-friendly haptic ETA design. Based on this consideration, we introduce a concept of selective skin part stimulation distance feedback ETA interface system and continue to the discussion of user-friendly and effective distance-tactile stimulation conversion and device design from the aspect of avoidance walk and environment recognition.

2. Background and History of ETA

The background and history of ETA are shown in Table 2. In 1960s, TVSS(Tactile Vision substitution System) are studied at Smith-Ketlewell Labs. L.KAY' s Sonic Torch is produced as the first practical ETA device and continues in following famous commercial models, MOWAT sensor, Laser Cane, and so on. These ETA devices are basically surrounding distance transfer device, which gives distance information along pointed direction back to user with converted tone, sound modulation or mechanical vibrations. In addition, not only portable device, there exists travel guidance system in building as functional welfare facility, which gives voice announce about the important location and attribute information to the visually impaired by detecting sensor under the floor or street with electric cane. Beyond portable ETA concept, Guide Dog Robot, which scans the environment image and street line and precedes and guide subjects, has been developed in 1978 (TACHI, 1978)
For Image transfer, 2D electric driving pin array (electric Braille display, OPTACON) are developed and investigated on the static 2D image recognition of character and/or figures. Human's character and image recognition with millimetric order electric pin-array and electrode array 2D display recognition characteristics are investigated not only from physical aspect but also from the psychological one. The phantom effect and adequate display rate and method are summarized (Shimizu 1997).
For user-friendly ETA device design, Tactile Display Glove and Line Type Haptic Display, which project distance to selective skin part, was proposed and shown direct operational performance (SUMIYA et al, 2000)(SUMIYA, 2005)

Year	Device Name	Transfer Target	Transfer Method	Implementer/Planner
1960s	TVSS (Tactile Vision Substitution System) /The voice	Gray level camera Image	400 millimeter Solenoid activator array/ Soundscape	Smith-Kettlewell Institute (USA) Carter Collins Peter Meijer
(1965)	SonicTorch,	distance	Tonal pattern	Leslie KAY(UK)
	GuideCane			Johann Borenstein (USA)
1978	SonicGuide (KASPA)	distance	Tone	Leslie KAY(UK)
1978	Guide Dog Robot (MELDOG MARK I)	Camera Image, distance	Voice Annouce (precede subject)	Susumu TACHI, Kazuo TANIE,Yuji HOSODA, Minoru ABE (JPN)
1973	MOWAT Sensor		Vibration, Tone	MOWAT G,C, (USA)
1980s	Trisensor			Leslie KAY(UK)
	Radar on a chip			Lawrence Livermore Labs(USA)
	LaserCane (Polaron, Wheelchair Pathfinder)		Vibration, sound(+audible warning signal)	Nurion-Raycal (USA)
	Lindsey Russell Pathsounder	Obstacle detection	Audible Signal /silent vibration	Lindsey Russell (USA)
	Sensory 6		Tone pitch	Brytech Corporation
	(Proto-type)	Camera image	2D Electrode array (20*20 condensor discharge electrode,150Hz)	National Institute of Bioscience and Human- Technology (JAPAN)
	Miniguide			Greg Phillips (Australia)
(1984)	Sonic Pathfinder (Nottingham Obstacle Detector)		stereophonic	Tony Heye (UK)
1996		Cortical implant		Schmidt et al (GERMANY)
	(Dobelle Artificial Vision System)			(Dobelle Institute(USA))
1997	Artificial Retina	Implant on Retina		Ito, N. et al (JPN)

Table 2. ETA(Electronic Travel Aid) Development History

Artificial vision with implanting surgical operation technique have started in 1990s, the 1st type of artificial vision is implanting electrode on retina and connect with neuron to cortex

(Ito et al, 1997)(Rizzo et al, 2001). The 2nd type is 2D edge operation processed image information is applied to 2D electrode array implanted on the visual cortex. They are still in clinical testing, but reports the recovery of some part of visual function so that they can follow child and grasp objects.
As represented by the work of Weber E. H., Fechner G.T., Von Frey, Weinstein S., Schmidt R., and Verrillo, R. t. et al, enormous number of Tactile Sense analysis and brain projection are investigated. (WEBER 1978) These investigated result are closely linked to user-friendly ETA design and quoted in next section.

3. Problems of the Visual-Tactile Sensory Sybstitution

This section gives significant characteristics and restrictions on tactile sense.

3.1 Static Characteristics of Tactile Sense Recognition

Static Tactile Recognition Characteristics are investigated and derived numerical values by the achievements of our predecessors as follows.
(1) 2 Points Discrimination Threshold
E.H.WEBER has measured the 2 point discrimination threshold. Including this result, he summarized and published his famous book, 'The sense of Touch'.

Part	Threshold(mm)	Part	Threshold
Forehead	22.5	Dorsal hand	31.5
Apex of tongue	1.0	Fingertip	2.3
Lip	4.5	Dorsum of finger	7.0
Front of forearm	40.5	Anterior tibial(shin)	67.5

Table 3. (Statical Pressure) 2 Points Discrimination Threshold on Human Skin(Average).

(2) WEBER-FECHNER Law
In 'The sense of Touch', he wrote the concept of **WEBER-FECHNER Law**. The rate of sensitivity resolution vs. applied range takes constant value. If E is sensing event, S is caused sense.(sensitivity)

$$\Delta E / E = cons \tan t \qquad (1)$$

If the variation of output sense takes constant for the variation of given event.

$$\Delta S = \Delta E / E \qquad (2)$$

Solve this difference equation as differential equation, then sensitivity is expressed as next equation.

$$S - A \log_{10} E + B \qquad (3)$$

(Here, B is an offset value.)

(2) Baresthesia (Static Pressure Sensing Limit)
Frey, V., M. has measured the human's static pressure sensing limit on skin part.(Frey. 1896)

Sensing Part	Sensing Limit (g/mm^2)	Sensing Part	Sensing Limit(g/mm^2)
Apex of tongue	2	Abdominal Area	26
Dorsum of antebrachium (backside of forearm)	33	Lumber Division (pars lumbalis)	48
Front of forearm	8	Dorsal hand	12
Fingertip	3	Sura (calf)	16
Dorsum of finger	5	Planta pedis (sole)	

Table 4. Static Pressure Sensing Limit on Human's Skin Surface

(3) Spatial Positioning Error
Spatial Positioning Error is the error between the actual stimulating point on skin surface and the subject's recognized point. (Weinstein, 1968) (Schmidt et al., 1989) (Schmidt, 2001)

Part	Error(mm)	Part	Error(mm)
Forearm	9	Forehead	4
Upperarm	11	Abdomen	9
Shoulder	9~10	Distal thigh	11
Fingertip	2	Calf	11
forehead	4	Sole	7~8
Finger	2	Toe	2

Table 5. Spatial Positioning Error

(4) Sensory Representation in The Cerebral Cortex
For further work on brain function connected to tactile sense, the tactile sense projection map on the cerebral cortex studied by Penfield W. and Rasmussen T are the milestone in this research field and the projected area and relative position gives many hint on next issue. Even Penfield's Homunculus image still gives strong impact for every viewer. (Penfield & Boldrey, , 1937)(Rasmussen et al., 1947)

3.2 Dynamic Characteristics of Tactile Sense Recognition

(1) Dynamic Range/Sensitivity
Tactile sense frequency sensitivity and discrimination performance shows the different characteristics from stimulating contactor dimensional size. Bolanoski et al(Bolanoski et al., 1988) and Verrillo(Verrilo 1968,1969) investigated tactile sensitivity for vibro-stimuli with diameter rod with $2.9cm^2$ and $0.005cm^2$ correspondingly. The frequency discrimination result shows U-curve and highest sensitivity at 250Hz. Lav. Levänen and Hamforf studied the frequency discrimination value for the deaf subjects and the hearing subjects, and showed the smallest frequency difference at palm and finger are 21±3Hz and 28±4 in 160-250Hz (1s duration, 600 stimuli), correspondingly.
Sumiya et al reported the tactile vibro-stimuli recognition rate follows the WEBER-FECHNER Law in recognition for quick random frequency presentation, as seen for ETA sensing and the resolution is at most 20% of total area at a point on forearm. This means the resolution in high speed sensing at most 5 partition of the searching range. For the case of linear partition at 10m searching area and projected to frequency, the resolution segment is at most 2m or smooth recognition (Sumiya et al., 2000). That is also considerable to

introduce log partition in the aspect of WEBER-FECHNER Law, but in late section, Linear partition shows higher performance for ETA (blindfolded walk) with the reason of easy association of environment map.

Kyung has studied perceptual tactile frequency discrimination characteristics on finger with 0.7mm diameter small contactor, as popular size for Braille display. The subject's sensitivity shows almost 100% recognition rate at the frequency bands of 1-3Hz and 18-32Hz. As frequency increases up to 500Hz around, the frequency discrimination performance decreases gradually to 85% on abdominal finger. On palm, the discrimination characteristic shows flat curve through 1 to 560Hz at the value of 85±5Hz.(Kyung et al., 2005)

(2) Learning Effect

Learning effect of frequency discrimination at 20hz around is reported by Imai. (Imai et al., 2003). Learning Effect after daily training shows rapid gains within 2 weeks, and later within 4 weeks the improvement of learning effect shows still raise in a measure , but shows conversion.

Learning effect for distance recognition with distance-selective skin part stimulation ETA device has tested for the several distance partition methods. The result shows the linear partition shows best learning effect for blindfolded walk time performance. (Sumiya 2005)

(3) Fatigue effect/ Saturation from repetitive stimulation

Fatigue effect and Saturation of tactile sense has not tested precisely. For steady use as ETA device, this should be investigated.

4. Specific Requirement for Travel Aid Interface

Compared with other tactile/haptic image recognition device, ETA should satisfy the next factor.

(1) Fast response

Slow response brings interruption to user in operation and understanding. For human's reaction, response time should satisfy 15Hz or higher for mobility.

(2) Accordance between operational direction and spatial direction

Easy-to-use needs this coincidence to help user's intuitive operation for environmental grasping. Left-Right direction, close-far direction , rotation direction should match to operator-centered intuition. This also help fast and high adaptability. In addition, this is also important for learning effect when the first handling is not easy.

(3) Transfer environmetal attribute information

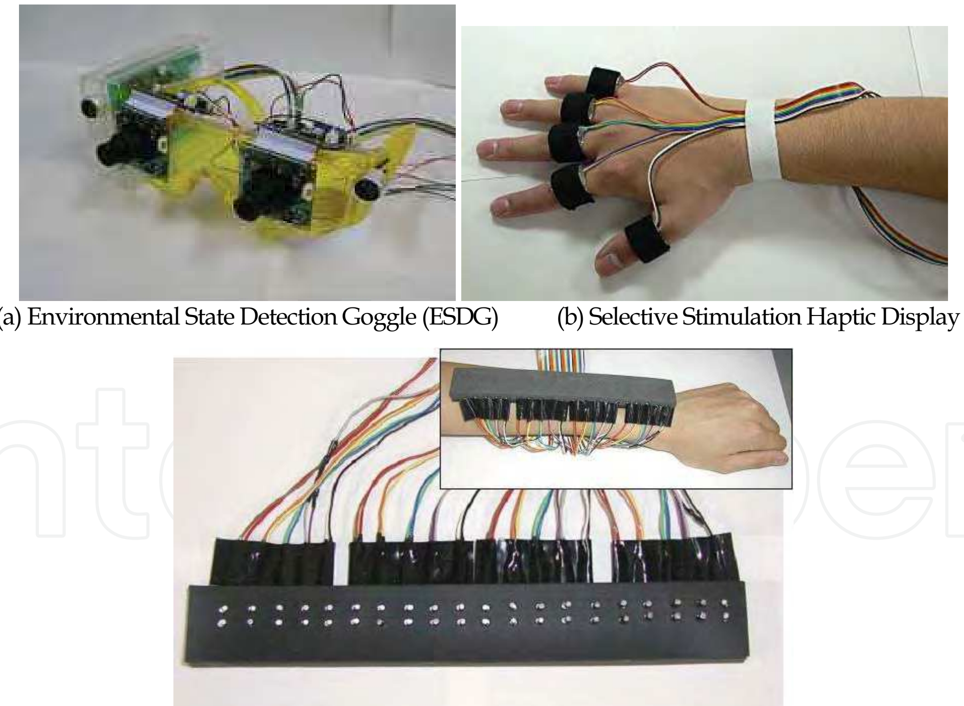
ETA user request the detected object's attribute information. For example, the detected object is whether person or still object. Color, Material, Moving Direction, Hardness, … and functional meaning. In introducing next research, using the stereo image and Nueral net scheme, several pattern has specified and send to user (human, stairs, rectangular form obstacle) to the assigned stimulating point. The combination of 2D tactile display and selective part stimulating haptic ETA device would cover this problem. Even single 2D tactile display, Shimojo et al proposed the unique approach for 3D information transfer with time sequence depth contour display.(shimojo et al. 1999) .

(4) reconstruction of environmental state (spatial relative position, forgetting factor)

It is important that the user 's mental image is close to real environment. Author has tried to questionnaire sheet to draw the obstacle position and ETA user 's image map after blindfolded walk with ETA. Without knowing global image around subjective, normally it is hard to grasp the global location of subject with simple one directional distance sensing. Gibson has proposed '**The theory of Affordance**' that subjects will sense envirionmental information and in accordance with self-moving.(Gibson) , That is to say, subject's motion it self help the grasp of environment. Simultaneously, however, this captured information fades away from forgetting. The questionnaire method can not respond to the real time image reconstruction. Although the mental (recognized) space is hard to estimate, but it will give some hint to know the projected map on visual cortex. PET: positron emission tomography, fMRI: functional magnetic resonance imaging, MEG: magnet-encephalography are impossible to monitor moving subject's inner brain activity from their structure. From the report that retina image is projected to primary visual cerebral cortex (Fellerman and Essen, 1991), it could be possible to brain activity of moving subjects with '**Optical Topography',** which will monitor the cerebral cortex activity, if the resolution will increase. (Watanabe er al. 1996) (Plichta et al. 1997)

5. Current Approach

The concept of walking aid human interface for visually impaired is based on the sensory substitution (visual sensation to tactile sensation conversion). A variety of electronic travel aid system (ETA) or sensory substitution system(SSS) have been developed, and some of these products are casted in commercial market :(Lenay et al. 1997).



(a) Environmental State Detection Goggle (ESDG) (b) Selective Stimulation Haptic Display 1

(c) Selective Stimulation Haptic Display 2

Fig. 2. Selective Stimulation Haptic ETAInterface

The distance display method of these systems are classified as distance-sound modulation (mono-, stereophonic), distance-tactile vibration (frequency modulation), distance-tactile pressure, distance-selective stimulation part mapping using mechanic vibration or electronic stimulation and so on. Recently, DOBELLE System and Artificial Retina System are developed and broadcasted in several media, but they need surgical operation and still cost high denomination. Simultaneously, this is the critical point, the tactile sensation would rather suit to 2 Dimensional sense with low resolution of force, frequency sensitivity. Therefore, vision to tactile sense substitution studies are still exploring the design of 3 dimensional depth display that vision transfers as seen in interesting literature: (Shimojo et al., 1999). Our main concern is to develop affordable price and direct operational feel walking aid human interface without surgical operation and long learning process. This study concentrates on the distance-selective skin part stimulation mapping method that known as high performance in absolute repetitive cognition : (Shinoda et al., 1998), (Sumiya et al., 2000), (Nakatani et al., 2003), (Kobayashi & Ohta, 1999).

First, we show the concept of our distance-selective skin part mapping type tactile walking aid interface. Secondly, this paper discusses the basic concept of the stimulation point number and design of the selective skin part mapping interface with the consideration of tactile sensation characteristics and restriction of human being. At the third stage, we propose different types of distance display interface that takes a count of absolute distance value priority display method and relative distance priority display method. Through the blindfolded walking experiment, we inspected the performance in spatial perception and direct operation factor for these proposed interfaces with their direct recognition accuracy and learning Effect.

5.1. System Concept and Configuration

(1) Distance Display Walking Aid Tactile Interface

This paper concentrates on The walking aid system with the distance-selective skin part stimulating. User wears the Environmental State Detection Goggle(ESDG) .

This sensing unit installs one ultrasonic distance detection sensor unit and stereo camera unit. This plural detected signal are sent to the signal processing unit in personal computer to produce target pointed distance and 3D-depth map for further surroundings state and object information feedback with surround state transfer tactile display through Surrounding Attribute estimate Neural network Scheme[4]. This detected target-pointed distance information in the user-facing direction is converted into depth transfer tactile display signal. Briefly, the detected distance information is classified into some range because of the selective stimulation part number restriction. In the case of tactile Display Glove installs 5 selective stimulating point on root of each finger. If detected distance would classified in range i, then i-th finger's stimulator activated and applies vibration.

Then user acquires the information of the detected distance range in facing direction. With the danger priority consideration, closest range mapped to first finger stimulator and mapped each finger to corresponding distance range in upwards. The issues are distance-selective points mapping.

(2) Distance Display Walking Aid Tactile Interface

Then user gets the information of the detected distance range in facing direction.

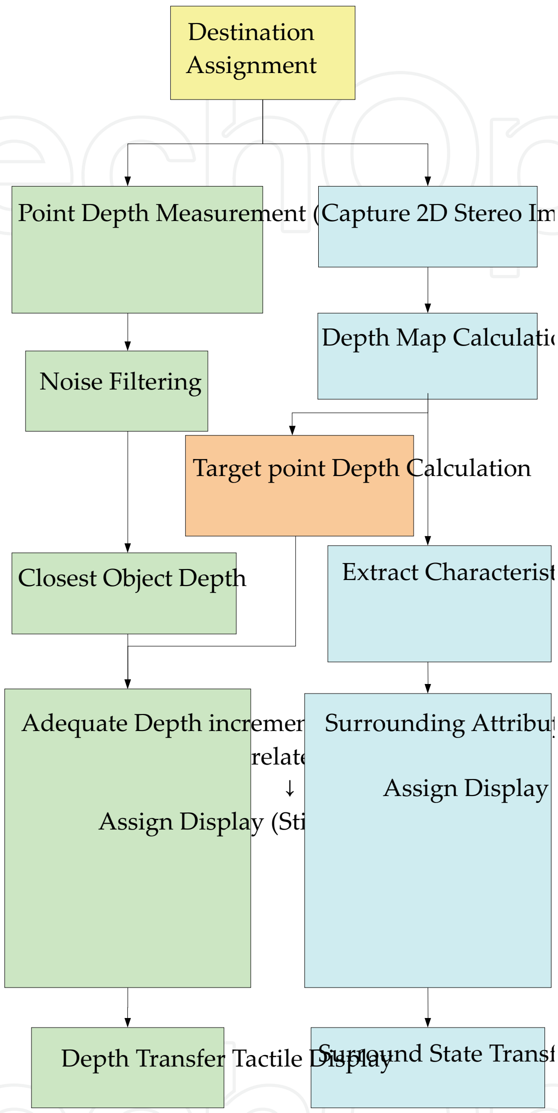


Fig. 3. Haptic ETA operation Flow

(3) Distance Display Method for spatial perception
Then user gets the information of the detected distance range in facing direction.
(4) Consideration on Selective Stimulation Part Number
Humans' discriminative resolution on spacial perception, especially along depth direction, are not constant.(WEBER-FECHNER Law). For the walking circumstance, the mainly influencing distance range could be assumed from 0 to 10m (or less 5m in slow exploring walk in complex circumstance) for path-finding purpose. In this range, as seen in space cognitive resolution characteristics, we can assume that the distance cognitive resolution also possesses linear characteristics with depth(target distance).

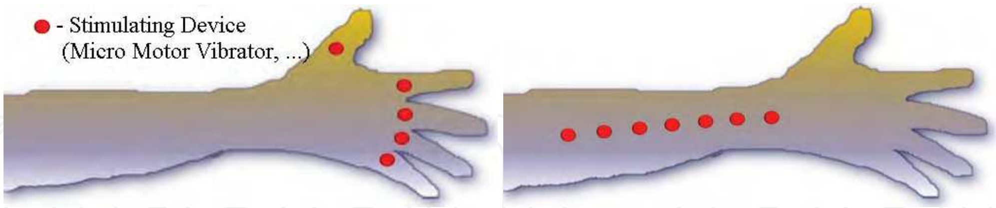


Fig. 4. Selective Stimulation Contactor Alignment

If we assume the distance resolution as Δy =1cm at y = 1m depth, from the above linear resolution hypothesis, the resolution in all travel of target range keeps Δy/y= 0.01. If we set the starting detection distance and the ending distance as ds, de correspondingly. The necessary number of selective stimulator number is calculated as follows.
The first stimulator's sensing depth d(0) is

$$d(0) = d_s \tag{4}$$

If we assume the incremental value right to reference point would proportional to resolution, then the mapped distance to the n-th stimulator as described in eq.(2)

$$d(n) = d_s(1+\Delta y / y)^{n-1} \tag{5}$$

Necessary number of stimulator should satisfy next eq.(6).

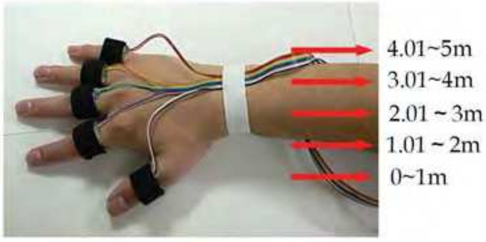
$$n > d_e / (d_s \log(1+\Delta y / y)) \tag{6}$$

This is the realization of Weber-Fechner law in suit to logarithmic sensitivity.
In latter section, the performance comparison among linear distance partition and other partition method projection method are discussed.

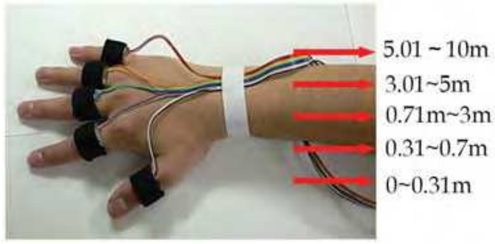
5.2. Distance Transfer Tactile Display

(1) Linear Mapping
Distance-Selective Stimulation Mapping using A-TDG
Mapping as written in section 1-3-2, a detected signal converts corresponding selective skin part stimulation. In this section, we tried 3 types of linear discrete depth range division and distance transfer display using mapping into corresponding selective finger part stimulation.
(2) Personal Space Based Mapping
Personal Space is psychological concept that human being keeps their own social territory in other people's communication. range1:closest relation as holding each other as family touch each shoulder to 30cm, range2:friend relation holding each hands to make a familiar greeting closer one reach 70cm, range3: acquaintance region to exist situation in street until both opened reach 1.5m, unknown person that if other person enters room where main person stays, then should feel attention on each other, room size,5m or more. This range is mapped to each finger stimulator. This conversion methods is psychological factor priority conversion
(3) Stride Based Mapping
As every person has experienced in growing process, the different feeling of space perception in childhood and after grown up sometimes cause the ponder of the scale-based

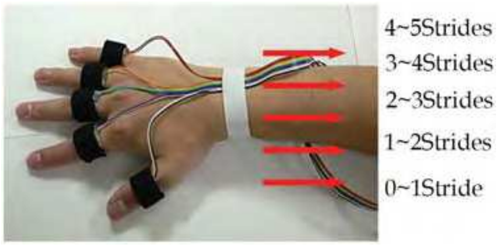
space perception idea. Stride Based Mapping is the humans' physical factor priority mapping based on the stride length as a representative physical dimension. This Base mapping is linear mapping but is not divided by constant Number for each user. Each user takes one depth division taken from their own stride size. The issue is whether this method will fit each user and cause the smooth walk to erase the unfit feeling caused by the personal physical size factor.



1)Equidistance Mapping



2)Personal Space based Mapping (Mental Factor Priority)



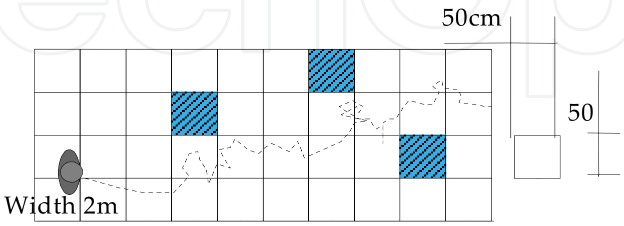
3) Stride-based Mapping

Fig. 5 Distance - Selective Part Mapping

5.3 Blindfolded Walking Experiment

(1) Comparison Between Linear Discrete Mapping

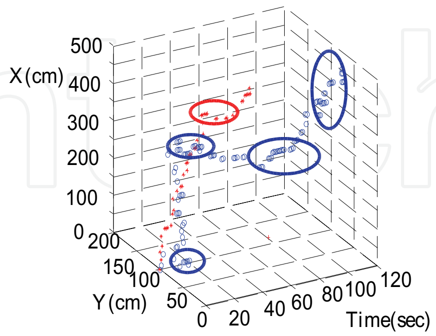
Distance-Selective Stimulation Mapping using A-TDG Mapping as written in section 1-3-2, a detected signal converts corresponding selective skin part stimulation. In this section, we tried 3 types of linear discrete depth range division and distance transfer display using mapping into corresponding selective finger part stimulation. While blindfolded walking experiment, subjects walking motion is recorded in video camera. Subject location is derived from the captured video image. The obsctacle alignment position is changed for each trial . Afer walking experiment, subject draw the target image on right-questionnaire map.



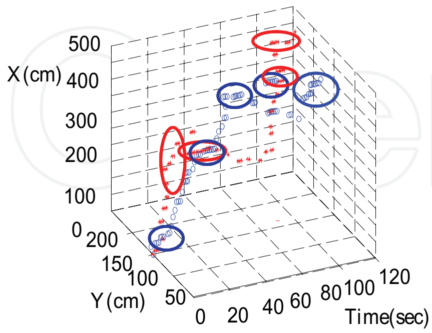
Forward direction 5m

Fig. 6. Blindfolded Walking Experiment

5.4. Walking Aid Interface Performance

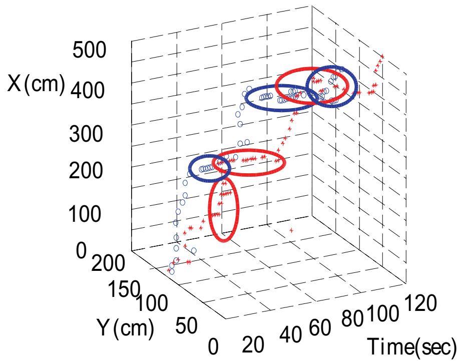


(a) Linear Mapping



(b) Personal Space Based Mapping –Mental Factor

o –first trial
* - second trial



(a) Stride Based Mapping - Physical Factor

Fig. 7. Walking 3D Trajectory in time-line

Walk Time(sec)	No1	No2	No3	No4	No5	Average
Relative Indicator	65.4	77.9	135.7	103.8	56.1	88.8
Relative Indicator (sensitivity prior.)	116	152.3	135.7	107.8	61.8	118.2

Table 6. Walk Through Performance (Absolute Indicator Value as 100(%))

(1) Spatial Reconstruction after Walking Performance
Mapping as written in 5.2, a detected signal converts corresponding selective skin part stimulation. In this section, we tried 3 types of linear discrete depth range division and distance transfer display using mapping into corresponding selective finger part stimulation.
(2) Learning Effect
From the walking performance time performance, Learning Effect is explicitly detected only for the linear (equidistance) mapping. (This signal conversion may already too simple to activate the humans' ability. This method still does not have enough transfer function about fast 3-Dimensional space perception.

6. Environmental Attribute Transfer

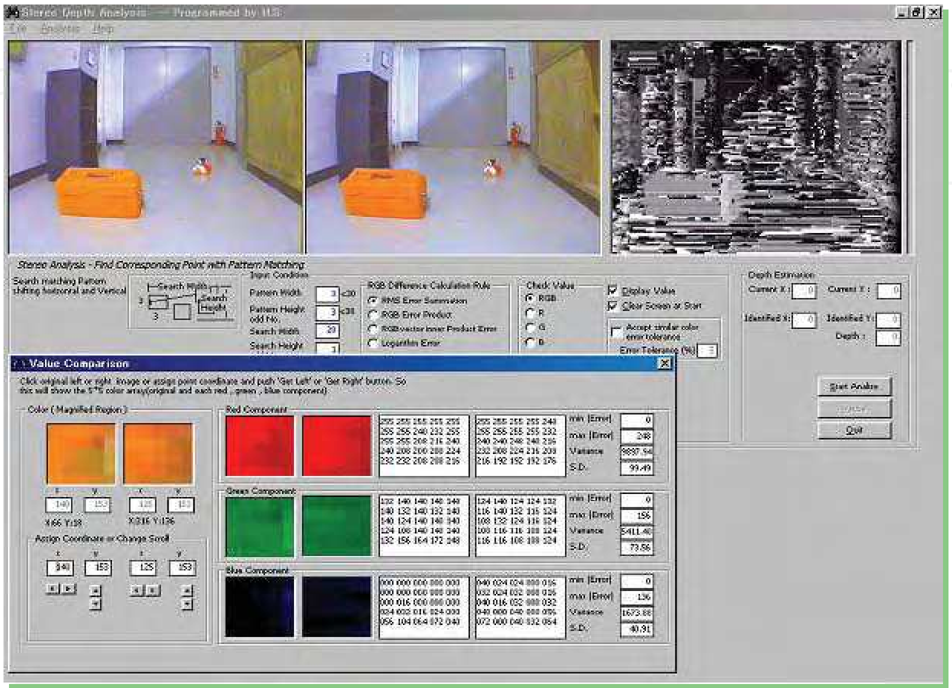
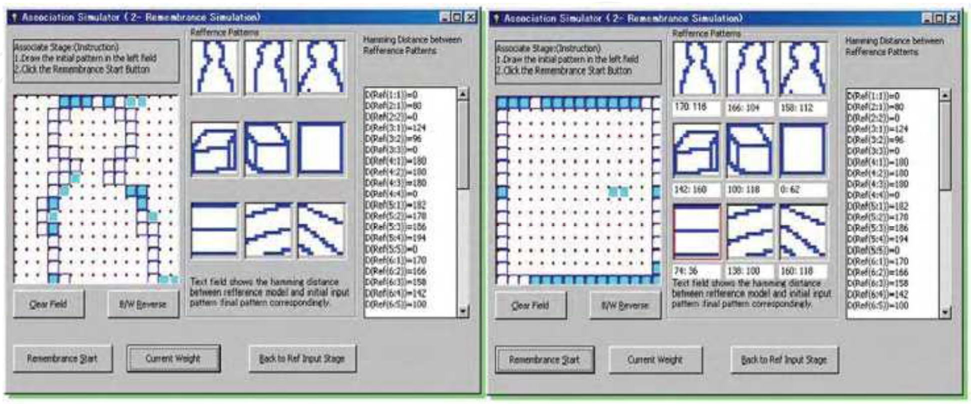


Fig. 8. Stereoscopic 2D Depth Image Instrumentation

This system generates the 2D distance (depth) map in VGA size using L-R image pattern matching with continuity of surface. The inner product vector similarity is proposed for the L-R pattern shift calculation and additional algorithm improvement is processed for Speed-up.

Generated depth map information is also used to estimate detected object and state. Extracted outline with the consideration of depth and colors pattern is normalized as fit to 16*16 bit image, then set to the inter-connected Neural Net scheme. For the estimation accuracy improvement, this system adopt combinational learning and estimating algorithm. See (sumiya, 2005) for more details.



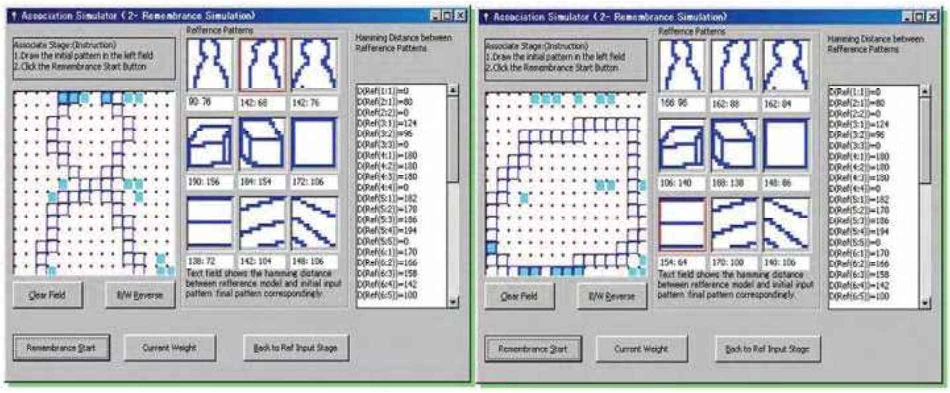


Fig. 9. Estimated Searched Object and State Attribution

7. Conclusion

This chapter aims at the user-friendly ETA design. As a preliminary information, several tactile characteristics including sensing range, sensitivity, dynamic factors are introduced, which are critical to design tactile/haptic device. In the latter half of this chapter, an example model of recent ETA design is introduced along the user-friendly real-time operation. Current ETA system are still on the process to gives satisfactory level of environmental reconstruction for user. Even under restriction of tactile charcterists, this design concept will give some hint to create new device to activate human's sensitivity. (e.g. magnification of sensing resolution, extending human sense). Recent studies of sensory substitution system has another aspect to extend human original sense. These approach would be called as 'Hyper sense'. Currently, the most popular user of ETA is the visually impaired. But this applicable area is more extensive. ETA technique will take the certain role in 'Hyper Sense' technique.

8. Consideration (Current Unsolved Problem)

As discussed in section 4., visualization of constructed mental map /image is next interesing issue. Especially for human in motion, the portable brain activity monitoring system should be introduced. If starting with the cortex neighbor activity monitoring , Optical topography technique is a possible candidate , if resolution will increase up to mm order.

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10. Refernces

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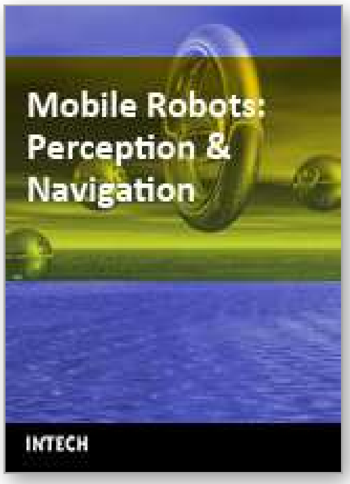

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