Pictogram Creation with Sensory Evaluation Method Based on Multiplex Sign Languages

Naotsune Hosono
Keio University,
Oki Consulting Solutions
Tokyo, Japan
naotsune@mx-keio.net

Hiromitsu Inoue
Chiba Prefectural University
of Health Sciences,
Chiba, Japan
cal32840@topaz.plala.or.jp

Miwa Nakanishi
Keio University
Kanagawa, Japan
miwa_nakanishi@ae.keio.ac.jp

Yutaka Tomita
Keio University
Kanagawa, Japan
tomita@z3.keio.ac.jp

***Abstract*— Human sign languages are originally designed for use by hearing impaired people, and they include semantic expressions in their scope. This paper discusses an original method to create pictograms based on multiplex local sign languages with the concept of "Context of Use" on dialogue, by applying Multivariate Analysis (MVA). Since pictograms are universal communication tools, Human-Centred Design (HCD) and context analysis with a Persona model are applied. The experiments consist of three steps with seven phases. The first step is to measure the similarity of a selected word among seven different local sign languages using MVA. The second step is to guide a pictogram designer to create a new common pictogram, by exploiting results from the first step result. The final step is to validate the newly created pictogram with MVA. Under the cycle of HCD, pictogram designers will summarize the expression of several local sign languages using this method. The acquisition of this experience is to be included as a pictogram design guideline within the context of universal communications, such as emergency and traveling situations. Through the proposed method, the relationship between selected words and local sign languages are initially explained by sensory evaluation of the subjects. The outcome of pictograms or icons of this experiment are implemented on smartphones with a touch panel. The final system is evaluated by hearing impaired subjects and foreigners, to compare qualitative measures of effectiveness, efficiency, and satisfaction based on context of use.**

Keywords- Context of Use; Computer Human Interface; Human-Centred Design; Pictogram; Universal Communication; Sensory Evaluation; Smartphone.

I. INTRODUCTION

Quite often a designer must face the challenge of developing a new machine or software without any guidelines. Often only conventional design processes provide a starting point, where the process tends to start from an initial perception of needs. The target specification are then created and measured only by the experts of the area. The original design resources are derived from proprietary technologies (Seeds). Then, subsequent experimental and manufacturing development stages are based on this predetermined specification. The prototype machine is developed to meet mass production standard of value engineering (VE) within resource constraints. This initial machine tends to be an origin or source of mass-production version neglecting market needs. Finally, the machine is refined and shipped to a predetermined market. This introduction into a market may be the first opportunity that the end users have to examine and determine the efficiency of the machine. Necessary feature requests and candid feedback from end uses (Needs) are only available to the designers after once the machine has been introduced into the real market.

Because of the initial lack of a specific requirement balance, computer based interface designers are required to measure and analyze the value of users' comfort level [1]. In order to improve such long an expensive cycles, the International Standard Organization (ISO) proposed an international standard (IS) 9241-210 for Human-Centred Design [2]. This standard is a revision of IS 13407, which was prepared by ISO/TC159 in June 1999 [3] and provides requirements and recommendations for human-centred design principles and activities throughout the life cycle of computer-based interactive systems. It is intended to be used by the manager of the design processes, and is concerned with ways in which both hardware and software components of interactive systems can enhance human–system interaction. The application of human factors and ergonomics to interactive systems design enhances effectiveness, efficiency, and improves human working conditions. The benefits can include: increased productivity, enhanced quality of work, reduction in support and training costs and improves user satisfaction. The aim of IS is to help those responsible for managing hardware and software design processes, and to identify and plan effective and timely Human-centred design (HCD) activities. It complements existing design approaches and methods. The major additional portion is that IS 9241-210 includes User Experience (UX) concept with emotional factors [4].

However, the above mentioned IS does not provide detailed coverage of the method and technologies for determining the design. Because of the lack of a specific requirement balance, computer based interface designers are required to measure and analyze the value of users' comfort levels. Because of generally scarce resources, designers must trade-off various elements of basic requirements by themselves. In the initial stages of development, designers will have little or no direct experience in developing a specific outcome to meet the exact requirement of icons or pictograms.

Sense, feeling, impression, and emotion are words of subjective notions, and deeply relate to happiness, anger, sorrow and enjoyment that are fundamental factors of UX. Sensory analysis [5] provides the basis for an examination of organoleptic attributes of a product by the sensory organs. This paper explores a sensory analysis method and discusses a method to create pictograms or icons to be used not only by hearing impaired, but also hearing people required to interpret a variety of local sign languages, with the concept of context of use on dialogue and Multivariate Analysis (MVA) [6].

The structure of this paper is as follows. Section II described the research motivation, which arises with hearing impaired people issues in the face of emergencies. Simple and easy to use pictograms or icons are assumed to provide a basis for an efficient language-independent communication tool. In Sections III, IV, and V, the design of pictograms or icons is discussed, by applying sensory evaluation methods. The validity of the newly created pictograms or icons is discussed in Section VI, where the outcome of the results is implemented on a smartphone with touch panel. Then the efficiency of the system is evaluated by hearing impaired and foreign subjects. Section VII summarizes conclusions.

II. RESEARCH PURPOSE AND ISSUES

The purpose of this research is to develop a method to create meaningful pictograms or icons [7] referring to several local sign languages [8]. Sign language (SL) is basically a communication method from one person to another for hearing impaired persons. A significant difference between sign language and vocal language is that characters are represented by a hand shape. Since there is no uniform SL in reality, and each SL expression is not exactly the same, and can vary from country to country because of their native cultures. Whereas sensory related expressions of SL such as happiness, angry, sorrow and enjoyment are tend to be universal regardless cultures. Those sensory related words are closely relating to UX.

The main factors of almost all sign languages consist of the hand shape, location, movement and additional face expressions. However, there is a dilemma that SL is a language with motion whereas pictograms or icons are static. The development and learning of current sign languages and their expression has drawn a lot of attention from both signers and sign language designers. Then hand shapes and locations are drawn by an animation and movements are done by arrows referring to a snapshot of the related local sign languages [9-20]. With this background, this paper discusses a method to create icons and pictograms by choosing and selecting the common features among several sign languages for a designer who has little experience. In this study, the referring seven sign languages are;

A: American Sign Language (ASL)
B: British Sign Language (BSL)
C: Chinese Sign Language (CSL)
E: Spanish Sign Language (ESL)
F: French Sign Language (FSL)
J: Japanese Sign Language (JSL)
K: Korean Sign Language (KSL)

III. RESEARCH PROCEDURES

This research scope covers not only linguistic studies of sign language but also HCD and context of use, since pictograms or icons are universal communication tools. The research was started in order to investigate the context of universal communication through local sign languages. HCD [2, 3] is based on the context of use [21], which is organized by four factors; “user,” “product,” “task,” and “environment” in use for goal (Figure 1). HCD and context analysis using the Persona model by Alan Cooper [22] are applied in this research.

With this framework, the following three steps with seven phase research procedures are developed;

Step1:
Phase 1: Concept Generation
Phase 2: Persona Model and Scenario Creation
Phase 3: Key words extraction on the situations
Phase 4: Initial Sensory Evaluation with Seven Local Sign Languages
Step 2:
Phase 5: Summarized Pictogram Design.
Step 3:
Phase 6: Second Sensory Evaluation with Seven Local Sign Languages with a Summarized Pictogram to prove the outcome
Phase 7: Conclude the Method

Phase 1: Context Generation

Based on the framework described above, two context situations have been selected: 1) emergencies and 2) travelling.

Alan Cooper proposed the Persona Model related to HCD, where several situations representing Personas are imagined to be in certain contexts in order to simulate and find how they will behave. This method is highly accepted by manufacturers in the creation of new product plans and has also been applied to service science.

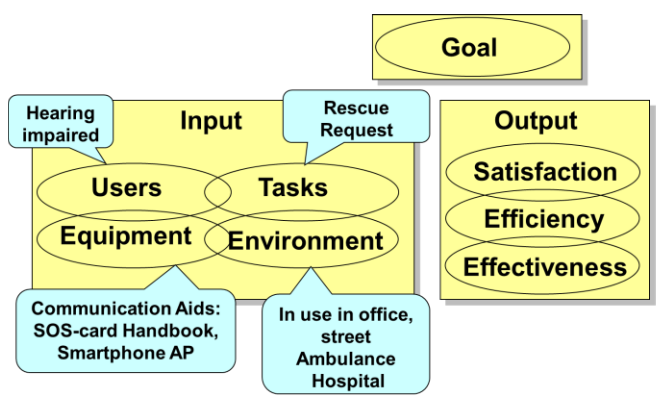


Figure 1. Context of use of ISO 9241-11

Phase 2: Persona Model and Scenario Creation

The first step is to create Personas by applying the Persona Model under HCD. A created Persona is a hearing impaired person in a situation where he suffers from a sudden illness while commuting in the morning, and is carried to the hospital by an ambulance (Figure 2).

Diary like scenarios underlying Personas are described from discussions with colleagues utilizing the Brain Storming Method. These scenarios mainly pay attention to the dialogues between the target Persona and people surrounding them. The main goal of the target Persona is to describe his emergency situation in order to solicit help. The scenario of the hearing impaired person in an emergency consists of about 600 words (equivalent to 3000 Japanese characters).

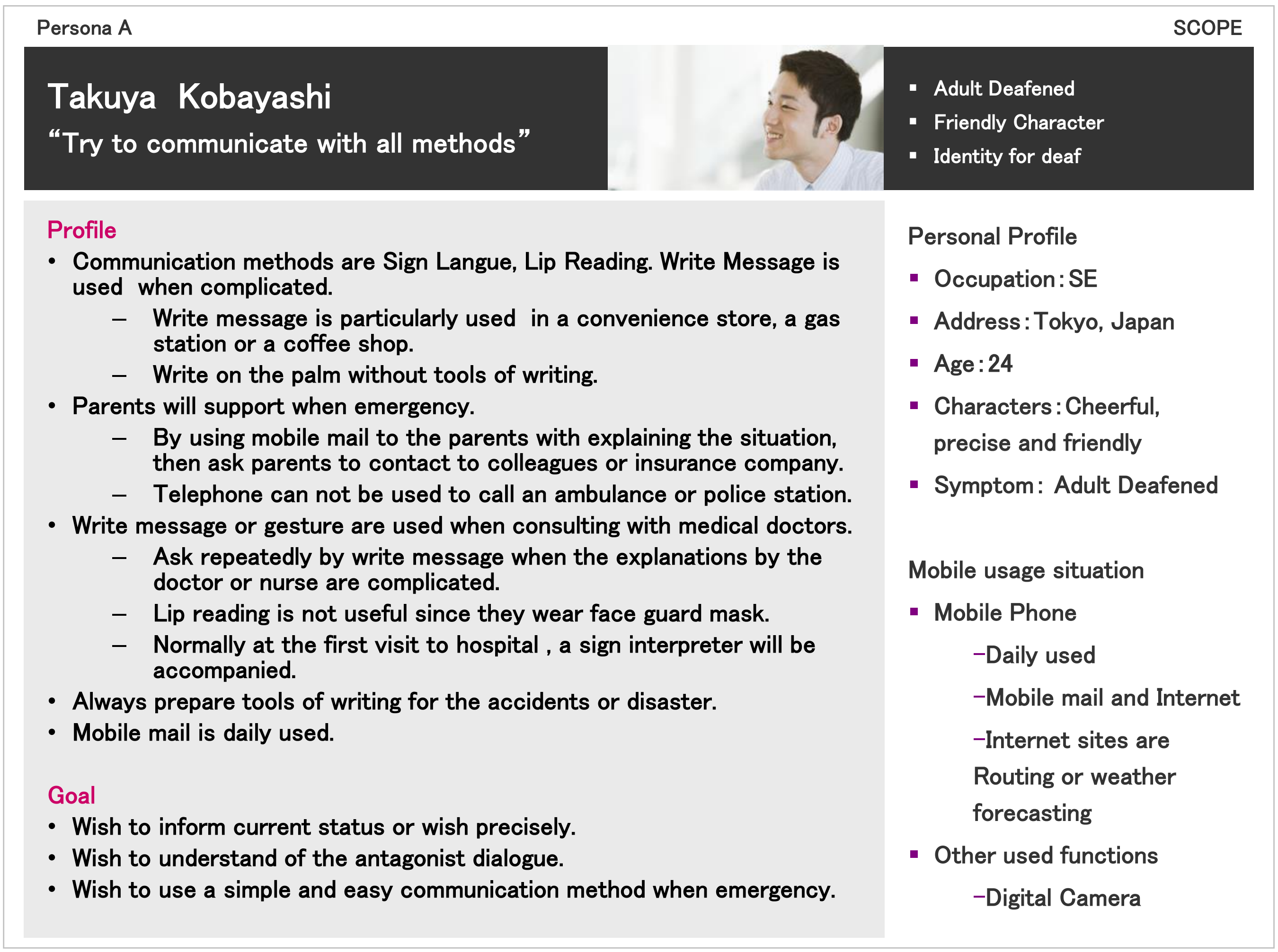


Figure 2. An Example of Persona Model

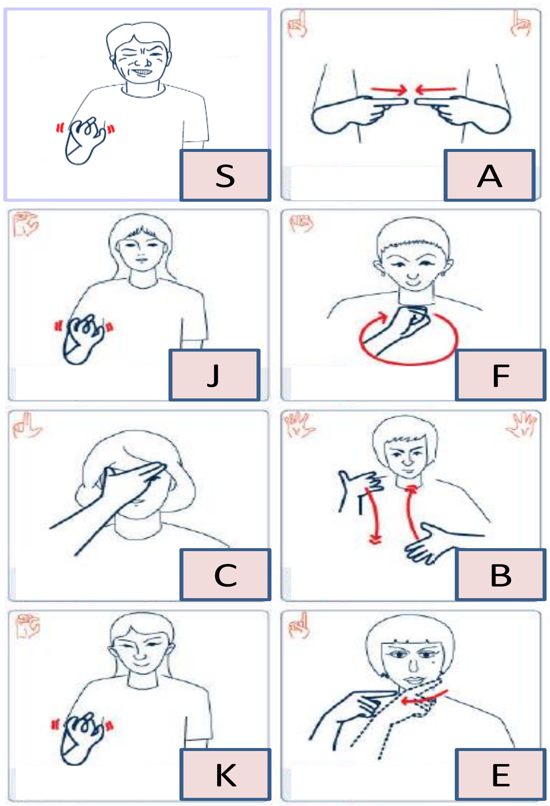
Phase 3: Key word extraction on the situations

The former phase is focused upon dialogues with several subjects and refers to observations from the view point of the provider and the receiver under the dialogue principle [23].

In this phase, the goal is to extract words that are fundamentally essential to establish the dialogues of the scenarios. In the context of a Persona in such an emergency situation, the most commonly used words are determined. In this case, 37 words were selected and categorized by the Brain Storming Method. Selected words are essential to the dialogues of the scenarios. The categorized 37 words were as follows;

・Ten greeting words that trigger the initial dialogues: thank you, hello, goodbye, indeed, yes, no, I am deaf, do not understand, sorry, please do.
・The next step of the dialogues start commonly with seven interrogative pronoun words: where ?, how much ?, how many ?, when ?, what ?, which one ?, who ?.
・Twelve associated reply words for interrogative pronouns are: toilet, country, numeric (0, 1, 2, 3, 5, and 10), yesterday, today, tomorrow, name.
・Three essential adjectives are: painful, different, expensive.
・Five essential verbs are: want to, go, come, buy, reserve.

A word "Painful" is a typical example among the selected seven words; Thank you, Goodbye, When? Where? Painful, Expensive, and Toilet through the Brain Storming Method by co-authors, representatives of the fire brigade and hearing impaired architects. This paper explains the development of our method by a selected word: "Painful" as a representative, since it closely relates to the usage context and UX concept and coincides to the survey results of Tokyo Fire Department and Keio University hospital (introduced in the next section).



Abbreviations:

A: American Sign Language (ASL)
J: Japanese Sign Language (JSL)
F: French Sign Language (FSL)
C: Chinese Sign Language (CSL)
B: British Sign Language (BSL)
K: Korean Sign Language (KSL)
E: Spanish Sign Language (ESL)
S: Summarized and newly designed pictogram

Figure 3. Sign Language Figures of "Painful"

Phase 4: Initial Sensory Evaluation with Seven Local Sign Languages

The overall research is initially focused on the creation of pictograms or icons to support dialogues, since the fundamentals of sign language are hand shape, location and motion. References are made to a collection of animation figures, extracted from seven local sign languages used by deaf architect. This architect provided enthusiastic support to the research by supplying and permitting reference to the database. The seven local sign languages are of American, British, Chinese, French, Korean, Japanese, and Spanish [8].

In the experiments, the subjects are first shown an expression with the collection of animation figures extracted from seven local sign languages (Figure 3). Subsequently, the subjects are informed of the meaning of the sign, and then they are requested to vote with 19 tokens to express which of the seven different local sign language expressions (samples) best coincides with the original image. They are asked to use all 19 tokens, but that they are permitted eventually zero voting on some samples (Figures 4 and 5).

This sensory evaluation method can easily make relative comparisons between the seven expressions of local sign languages and is more effective than the Ordering Method or Pair Comparison Method. Correspondence Analysis (CA) of MVA by IBM SPSS Statistics Ver.18 [24] is then applied.

The outcome is plotted on a plane such as similar local sign languages are plotted close together. The outcome of CA of MVA is fundamentally no name of Eigenvalue axes. Because of the characteristics of CA, the subjects who have general and standard ideas are positioned in the centre, whereas those who have extreme or specialized ideas are positioned away from the centre of position (0.0). The center crossing point of the first and second Eigenvalues is also called "centre of the gravity" or "average". Then CA establishes a way to graphically examine the relationship between local sign languages and subjects [25].

Figure 6 is an example of an outcome chart where "painful" is plotted. Focusing on Subject No.3 and looking at the voting sheet, the image of "painful" by the subject will be appropriate to Spanish Sign Language (ESL) and American Sign Language (ASL) since the subject put more tokens on ESL and ASL than other sign languages. In the plot chart of CA, the subject is observed to have extreme or specialized ideas from other subjects, since the subject plot position is remote from the centre in Figure 7. In practice, the subject is then positioned closed to Spanish Sign Language (ESL) and American Sign Language (ASL) whereas far away from French Sign Language (FSL), British Sign Language (BSL), Japanese Sign Language (JSL), Korean Sign Language (KSL), or Chinese Sign language (CSL).

On the other hand, in Figure 8, Subject No.8 is positioned centre, since the subject voted equally on all the sign languages of ESL, ASL, FSL, BSL, JSL, KSL and CSL (cf. Subject No.3). Hence, the above two plots provide examples of CA with the relationships between subjects and samples (sign languages), and explains the relations both between subjects to other subjects and between sign languages and other sign languages. Figure 9 shows the position of Subject.

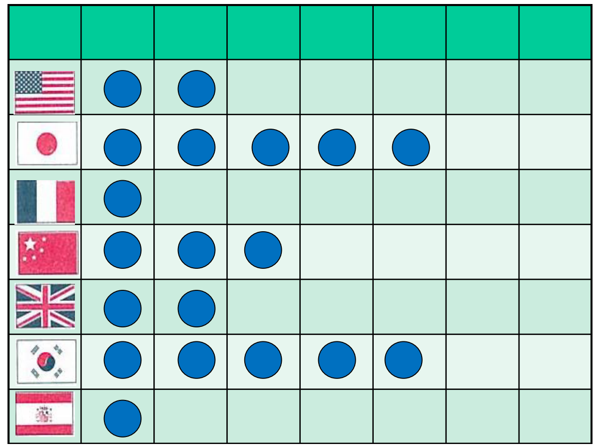


Figure 4. Inquiry Sheet Example of "Painful"

Figure 5. A View of Experiment by the Subject

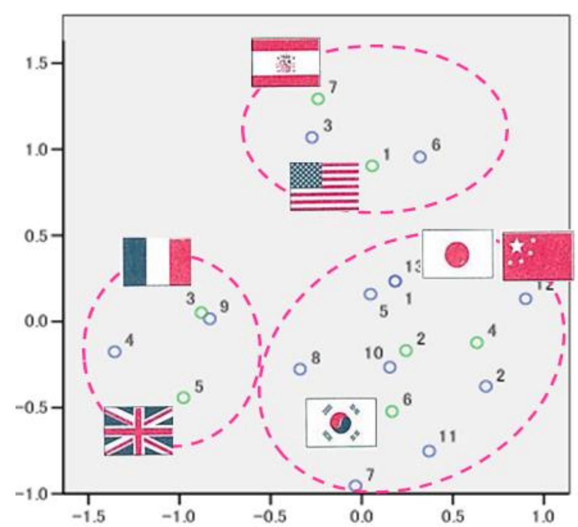


Figure 6. A Plot of "Painful" with 7 Sign Languages

No.3 is an outlier with respect to all other subjects and thus it is concluded that the subject idea is extreme or has specialized ideas compared with the others.

The first experiment subjects are 13 people in their twenties, including nine science course students, and four humanity course students. Some have experience living overseas and sign language interpreting. The reason to exclude hearing impaired people in subjects is that they are biased their own sign language. After voting with the tokens, all the subjects are asked about their confidence level using the Semantic Differential (SD) method [5].

Phase 5: Summarized Pictogram Design

The analysis of an outcome CA plot chart of "painful" is shown in Figure 6; with seven sign languages (SL), voted subjects create three clusters of "FSL and BSL", "ASL and ESL", "JSL, KSL and CSL" sign languages.

Following the cycle process of HCD [2, 3], an original designer is asked to summarize and design an original pictogram for JSL, KSL and CSL by reflecting of the outcome by the sensory evaluation mentioned above. Then the newly designed pictogram, which is "S" in Figure 10, is added to the previous seven local sign languages.

Phase 6: Second Sensory Evaluation with Seven Local Sign Languages with a Summarized Pictogram to prove the outcome

The first experiment is done with seven sign languages. The subject is permitted up to seven tokens for each sign language, for a total of 49 possible votes. Each subject is given 19 tokens, which is about 40% of total 49 voting locations. The second experiment is done with seven sign languages, plus one newly created sign language. Then the total voting locations becomes 56. Each subject is given 23 tokens, which are again about 40% of total 56 voting location.

After subjects are informed of the intended sign meaning, they are requested to vote with 23 tokens, which of the eight different local sign language expressions including the newly designed language, which has a pictogram "S" as show in Figure 10. This process was the same as the first sensory evaluation step of phase 4, and the Correspondence Analysis of Multivariate Analysis (MVA) by SPSS is once again performed [24].

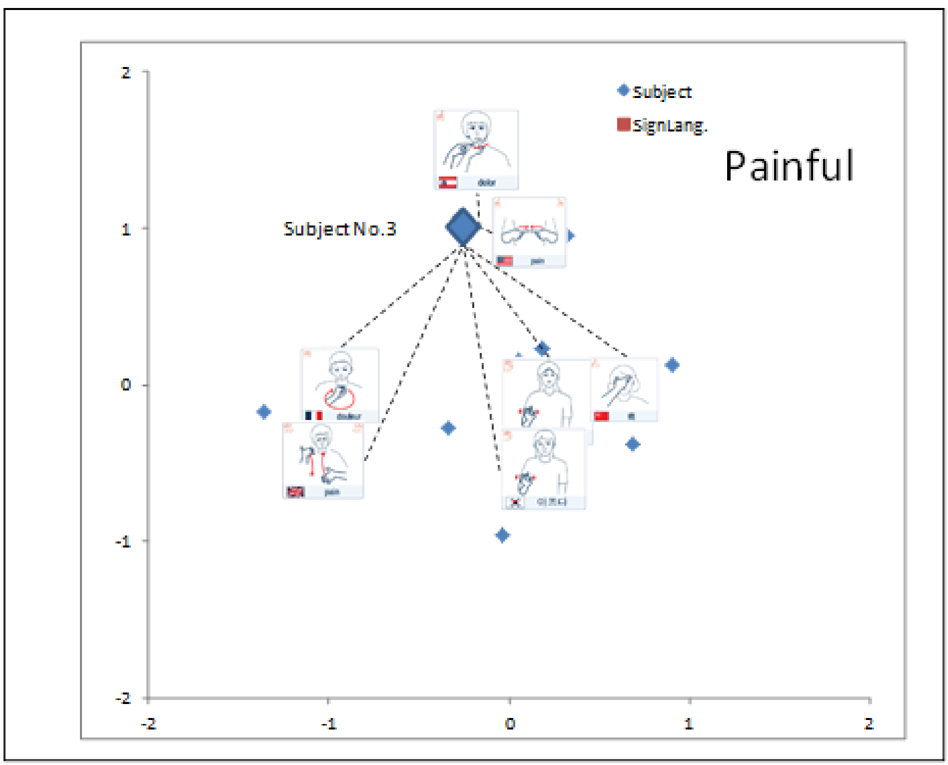


Figure 7. Subject 3 is plotted near to ESL and ASL

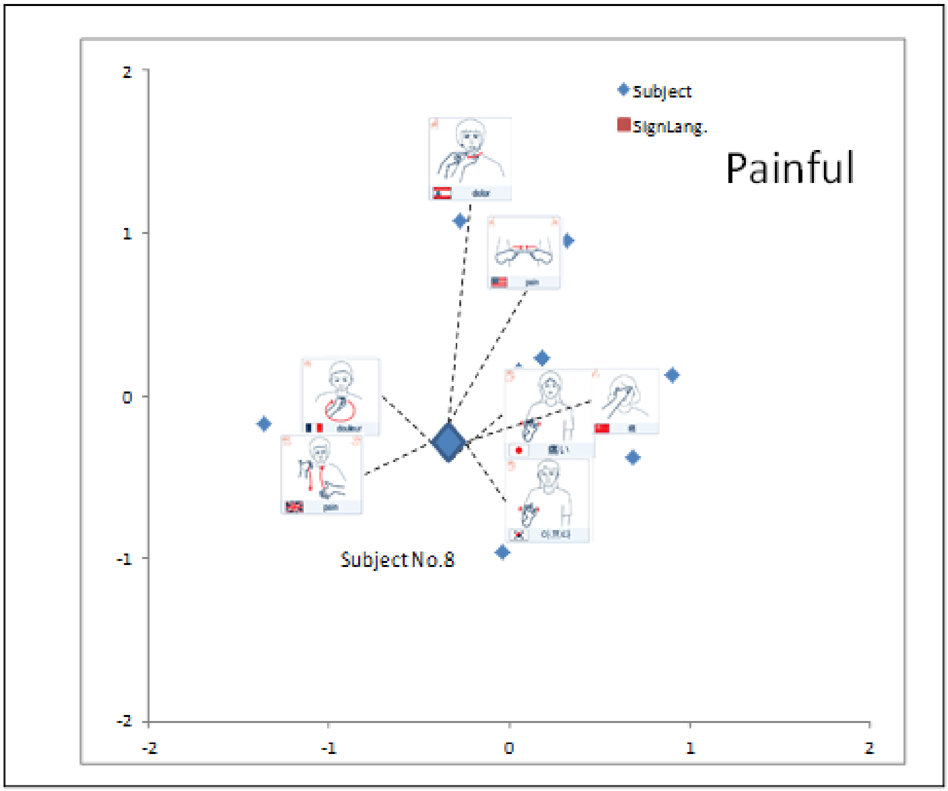


Figure 8. Subject 8 is plotted further from all SL's

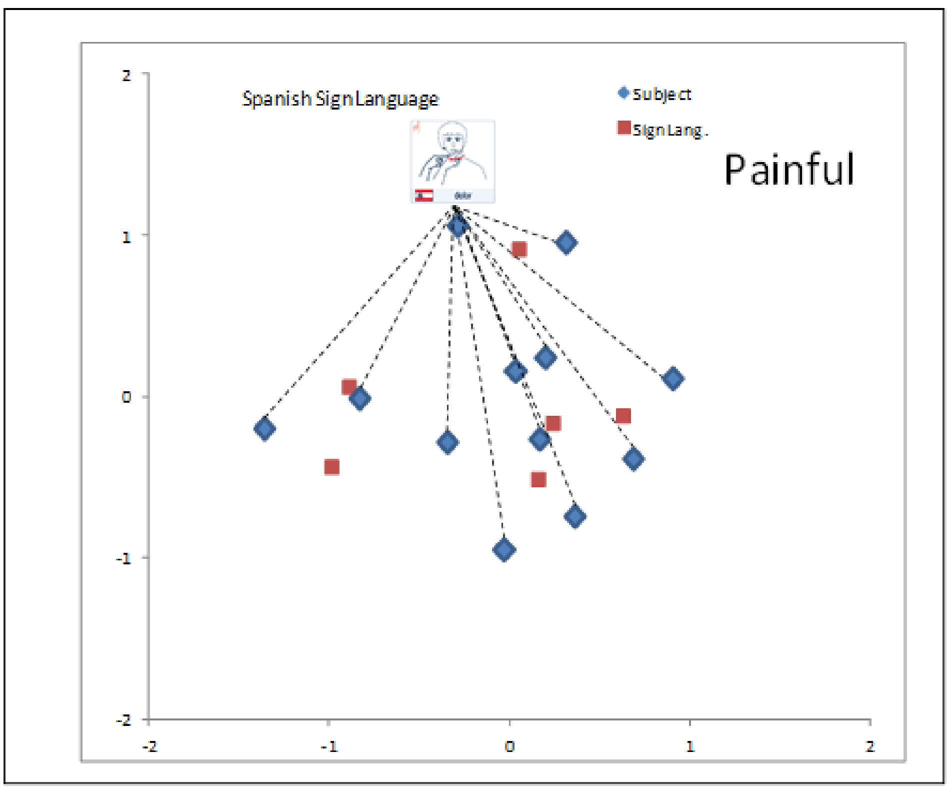


Figure 9. Subject 3 is plotted further from all other Subjects

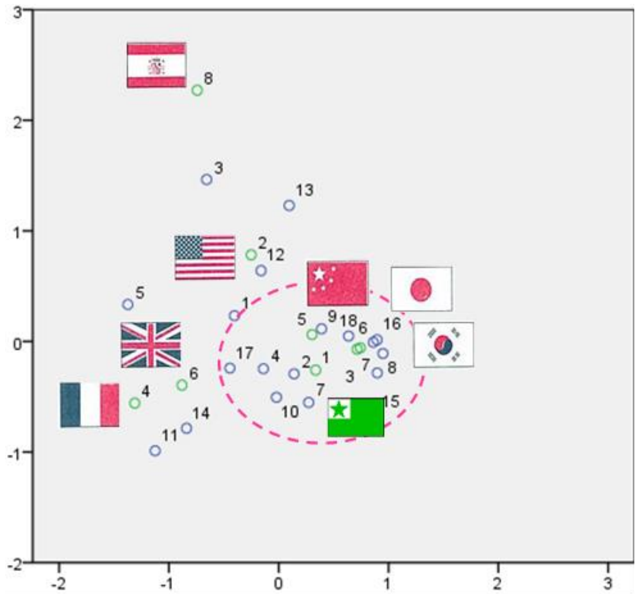


Figure 10. A Supplementary Treatment Plot of "Painful" with 7+1 Sign Languages, where S is a summarized one.

The outcome, including the newly designed pictogram, is plotted with other seven local sign languages in order to measure whether the newly created pictogram is representative of the dominant cluster. The second experiment subjects are 20 engineering department students in their twenties including two female students. Almost all except three are different subjects from the first experience. After voting by the tokens, all the subjects are again asked of their confidence level using the Semantic Differential (SD) method [5]. Figure 10 is an example of outcome chart where "painful" is plotted. The newly designed symbol with a coloured green flag will represent JSL, KSL and CSL sign languages since it is plotted closer to those three sign languages. Whereas FSL, BSL, ASL and ESL are plotted further down.

In order to demonstrate the outcome more precisely, supplementary treatment of MVA by SPSS is also applied by adding a newly designed supplementary category to the seven sign languages (active categories). Supplementary categories do not influence the analysis but are represented in the space defined by the active categories. Supplementary categories play no role in defining the dimensions. These versions of the plots are similar in seven sign languages and those created from summarized pictogram experiments.

Phase 7: Concluding the Method

Phase 4 explains how to determine similarity amongst seven sign languages. Then the newly created icon or pictogram provides a basis to measure the similarity. Phase 7 explains how that outcome is confirmed, since it plotted closed to the referred sign languages.

Table I. Complains Survey of Tokyo Fire Department and Keio Hospital

	Tokyo Fire Dept.	Keio Univ. Hospital
	290,471	2,421
Pain problems	30.10%	38.30% Contents of Keio Univ. Pain Data – Stomachache: 22.7% – Headache: 19.7% – Lumbago, backache: 11.9%
uncousciousness	11.20%	15.90%
breath trouble	8.40%	5.10%
fever	8.10%	2.30%
vertigo	6.60%	6.50%
convulsion	5.40%	3.00%
vomit	4.80%	2.50%
hard of standing	4.60%	2.40%
malfunction in cardiac and lung	N/A	2.30%
injury	N/A	21.60%
others	20.80%	0.10%

Comparing the two outcomes of Phase 4 (Figure 6) with seven local sign languages and of Phase 5 (Figure 10) with seven local ones plus one, one can conclude the following,

- Seven summarized pictograms are created for seven aggregated words respectively such as "painful."
- Then newly designed pictograms by a designer are all positioned in the centre of the related local sign languages cluster.
- Even though most subjects are different in the first and second experiments, the outcome plot patterns by CA hold similar patterns in space.
- the oriental sign languages of JSL, KSL and CSL are plotted closely together.
- The outcome is confirmed by Supplementary Treatment of MVA by SPSS.

IV. CONCEPT AND SYSTEM DESIGN OF THE SMARTPHONE WITH TOUCH PANEL

The data of patient issues collected by Tokyo Fire Department (TFD, 290,471 patients) and Keio University hospital (2,421 patients) were analyzed (Table I). The collected data were not only hearing impaired, but all kind patients. From both datasets, more than 30% of complaints were determined to be about pain problems. Ten selected patient complaint items were pain/ache/grief, unconsciousness, difficulty breathing, fever, faintness, convulsions, vomiting, difficulty standing and walking, cardiopulmonary problems and external injury.

The "Context of Use" referring to ISI9241-11 [21] is composed of four factors: user, product, task and environment for the goal. At the time when a designed is to create icons or pictograms, it is necessary to bear in mind how such symbols are to be used under the context; otherwise the outcomes will be hard to be recognized by the users. They must be useful, effective and particularly efficient for both the hearing impaired and language dysfunction people and foreigners. Here the research intended to particularly focus on the communication method [23] of complaint of pain/ache/grief by hearing impaired patients.

The pain or ache sources were assumed to be positioned in either the head, face, chest, back, belly, waist, arm/hand and leg/foot. In addition, three ache depths come from surface skin, visceral and bone. The hearing impaired and language dysfunction people complaint of pain/ache/grief and external injury was to be drawn by pictograms and icons that were easy to understand, even in emergency situations with help of minimum selected key words with MVA. Aching places were drawn in two dimensions. Ache depth and severe pain were in the third dimension. The hearing impaired and people will simply touch the designated icon or pictogram to communicate to support people in such emergency situation by ubiquitously carrying a smartphone with touch panel.

The modern smartphones with touch panel are primarily equipped the following functions 1) tap to select, 2) double tap to do scaling, 3) drag to jump, 4) flick or swipe to move next page, 5) pinch in/out with double fingers, 6) accelerate sensor to position upright, 7) photo browsing to display icons or pictograms, 8) backlight for dark place usage, 9) GPS/Wi-Fi positioning, and 10) wireless function to download the new contents and applications.

The framework is implemented on the smartphones of with touch panel applying functions above such as iOS and Android devices to enable hearing impaired or language dysfunction people to communicate the remote supporter place of the nearest fire brigade in such urgent situations through the ICT clouds. The smartphone with touch panel will produce a text message for e-mail through simply tapping on icons or pictograms. The mail text is to be instantly sent to the remote supporters.

Currently, 31 screen contents on the smartphone are implemented by the Software Development Kit (SDK) of MIT APP Inventor [26] and distributed onto Android touch panel terminal by DeployGete [27] for the evaluation (Figure 11). JAVA and Eclipse are used for the detailed programming part. It is also implemented on iOS using Objective-C with Xcode. The screen transition process is based on the telephone dialogues of the command console of the Kasuga Onojo Nakagawa Fire Department in Fukuoka Prefecture. The overall process is analyzed and drawn by Freeplane by Mind Mapping [28]. The touch panel includes the cognitive design method on Automated Teller Machine (ATM) for elderly people since under such an urgent situation, people would be upset and find it hard to communicate just like a cognitive decline [29, 30]. The repertoire of possible actions is as follows:

(1) Simple selection with limited choices
(2) Explicit sliding at the time of screen change
(3) Step by step procedures after selection

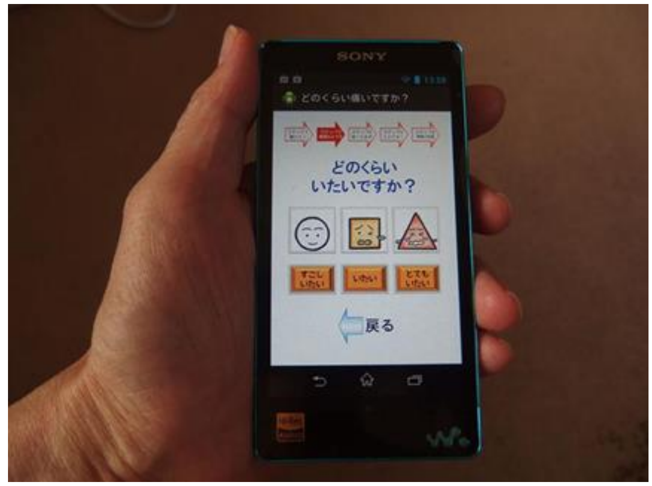


Figure 11. Pictograms on the Smartphone with Touch Panel representing Degree of Pains

Figure 12. The Evaluation Experiment Scene by the Hearing Subjects

V. EXPERIMENTAL EVALUATION

The proposed smartphone with touch panel was evaluated by hearing impaired people in a manner similar to the usability test under the working hypothesis related to desire of communication outcome. The communication method for hearing impaired people or language dysfunction depended only on the sign language. Nowadays, since hearing impaired people are starting to use smartphones with text messaging. This improves their communication behaviour and quality of life (QOL) [31].

The five tasks were prepared to compare performance with and without a service to call ambulance and fire brigades. This evaluation focused on efficiency by comparing two task groups; those that apply tapping icons or pictograms on the smartphone, and those that send text message by e-mail by means of personal computer (PC) key board. The evaluation test was performed by four hearing impaired subjects as described in the following five tasks. All experiment instructions are introduced to hearing impaired subjects by a sign interpreter (Figure 12). Subjects are permitted to use memo notes.

· Task-1: Fire report by tapping icons on the smartphone.
  This scenario was that "The forest is on fire. I recognize a flame but no smoke. I am safe since I am away from the fire spot. There was no injury. Please help".
· Task-2: Fire report by e-mail text message
  The scenario was "This building is on fire. My floor is different from the fire spot. I cannot recognize flame but see smoke. There were some injuries. Please help".
· Task-3: Ambulance request by e-mail text message
  The scenario was "Please call ambulance since I was run over by a car. I am middle aged male. I am conscious but my leg is broken and bleeding. It is quite painful. Please send an ambulance soon".
· Task-4: Ambulance request by tapping icons on the smartphone
  The scenario was "My daughter is severely sick. She is a pregnant adult. She may have a preterm birth. She is conscious but indicates severe pain in the belly. She was once suffering from gallstones. Please send an ambulance soon".
· Task-5: Interviews after four tasks
  An exercise to fill out a personal data sheet such as name, address, age and issues of input methods by a soft key board or hand writing.

VI. EVALUATION RESULTS

The results must be analyzed under "the Context of Use" [21] whose result was measured by the effectiveness, efficiency, and satisfaction. This evaluation focused particularly on the efficiency with comparing two task groups, and found applying tapping icons or pictograms on the smartphone was about three times quicker than text message by e-mail (Table II).

It is natural that simple tapping icons input must be quicker than text input, however, the purpose of the evaluation is to measure how much quicker on the speed ratio utilizing smartphone comparing to text e-mail. In practice, it must be much quicker than three times since to input texts by telephone dials of ten keys is more complicated comparing to PC keyboard. For instance, it is necessary to push the "2" button three times to input single "c" character in 3G type mobile phones. The smartphones are equipped the soft keyboard on the touch panel. However, the character array is the same as PC keyboard, key widths are narrow and sometimes without any feedback. The current technology is not really effective yet.

During interviews after the evaluation, many hearing impaired people pointed out that this smartphone service would ease their predicted mental anguish during any emergency. This concept is closely aligned to the Satisfaction in the Context of Use or User Experience (UX) [4].

Table II. The Evaluation Result on Efficiency

Subjects	Task-1	Task-2	Task-3	Task-4
MKS	12"82	3'40"07	2'45"28	53"26
YNY	24"20	1'34"08	2'23"72	59"85
SZKM	19"52	1'54"84	2'02"72	49"72
SZKK	20"87	1'06"68	2'01"68	N/A
Average	19"35	2'03"92	2'18"35	54"28

VII. CONCLUSION

This paper consists of two parts. The first part of this paper discusses a method to extract the summarized expression of several local sign languages in order to draw pictograms or icons by applying the sensory evaluation with MVA. The experiments consist of three steps. The first step is to select a pictogram as a majority common expression upon a word among seven local sign languages. Considering this first step, this method seems valid in practice since oriental sign languages, Japanese, Chinese and Korean are similar by historical background, and in fact and they emerge as similar to each other. The second step is to confirm that the experimental characteristics of the pictogram represent the meaning of the word. The final step is to validate the newly created pictogram by MVA. Since almost all of the newly designed pictograms were positioned close to the cluster it can concluded that they were representative of the clusters.

In the example of the concept of "painful" taken from seven sign languages, and analysis with the supplementary treatment of MVA, the newly designed pictogram was close to those oriental sign languages since it was plotted close to those sign languages on the plane. The last part of this paper discussed how the use of the outcome of pictograms or icons of this experiment was implemented on a modern smartphone with a touch panel display for computer-human interaction. Through the proposed method, the relationship between selected words and local sign languages were initially explained by sensory evaluation by the subjects. Under the cycle of HCD, the pictogram designer will perform to summarize the expression of several local sign languages by this method. We showed how the acquisition of user experience can provide design guidance, for instance, in the context of emergency and traveling situations.

In order to show stability and repeatability, the experiments were done twice. The first one was to confirm the similarity among seven sign languages for any selected word. The second experiment was done with different subjects, in order to demonstrate independence of outcome. This is confirmed in the second experimental results. By applying the method, the selected seven words; Thank you, Goodbye, When? Where? Painful, Expensive, and Toilet were analyzed. All the summarized outcomes were positioned close to the referred ones on the plot. The results of the second experiment confirmed the outcome design by supplementary treatment of the CA procedure. The proposed method was quite an original one and thus provided one of the guidelines to create pictograms by referring to several sign languages. The relevant methods can be considered as a ranking method and a pair comparison method. A ranking method is relatively simple, however, when increasing the number of items to more than ten, it becomes hard to do ranking in middle: e.g., the seventh or eighth is hard to distinguish. A pair comparison method requires a large number of comparisons, e.g., 45 comparisons for ten items [5].

The second part of this paper introduces an experiment to implement the outcome of icons or pictograms on the smartphones with touch panel. At the beginning they were printed in the form of a booklet to be used the communications between hearing impaired and hearing people as well as between foreigners and Japanese. The suffixes were created and translated into English, Spanish, Korean, Chinese and Portuguese for the foreign people use referring to nationality population composition in Japan. The results by the foreign people with the booklet were that the time to collaborate was 20% shorter and the messages of the dialogue were 20% more precise than simple gesture communication. In practice, the booklet was published 6,000 copies and currently mounted on several ambulances in the local fire departments to aid to collaborate between the hearing impaired patient and emergency response personnel. The current prototype terminal was implemented on the smartphone with touch panel. The system then connects over a network to remote supporters of the nearest fire brigade. It was implemented on both iOS by Apple and Android mobile terminals with GPS positioning technology.

The outcome of this research will be proposed to the Japanese government to make easily available, and to be used such a crisis for urgent communication or to be used during the next Olympics, to be held in the year of 2020 in Tokyo.

ACKNOWLEDGMENT

This research is supported and funded by the Project organized by Fire and Disaster Management Agency under Ministry of Internal Affairs and Communications (MIC) of Japan. The original idea of the booklet was proposed by a hearing impaired architect, Mr. M. Suzuki. A collection of local sign language database is supplied and permitted for research use by Mr. M. Akatsuka of Architectural Association of Japanese DEAF (AAJD). Dr. H. Akatsu of Oki Electric Ind. Co., Ltd. introduced the cognitive design method on ATM for elderly people. Mr. T. Inaba and Mr. F. Miyajima of Kasuga Onojo Nakagawa Fire Department in Fukuoka Prefecture and Mr. M. Nishijima of Oki Consulting Solutions Co., Ltd. for the implementation on the smartphone in this research. Special thanks to Prof. Dr. R. Goebel, Alberta University, Canada who supported to perform the native check of the article.

REFERENCES

[1] N. Hosono, H. Inoue, Y. Nagashima, and Y. Tomita, "Sensory Evaluation Method to create Pictograms based on Multiplex Sign Languages," in Proc. ACHI, 2013, pp. 13-16, Nice, France.

[2] International Organization for Standardization: ISO9241-210: 2010, "Ergonomic requirements for Office Work with Visual Display Terminals (VDTs)." Available from: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52075, 2015.11.8.

[3] International Organization for Standardization: ISO9241-210 (former ISO13407:1999), "Ergonomics Human-centred design processes for interactive systems," 2010.

[4] R. Hartson and P.S. Pyla, "The UX Book: Process and Guidelines for Ensuring a Quality User Experience," Morgan Kaufmann Publishers, 2012.

[5] H. Inoue, "Sensory Evaluation," Juse-P, ISBN978-4-817-9435-0, Japanese version, 2013.

[6] A. Field, "Discovering Statistics Using SPSS 3rd edition," Sage Publications, 2009.

[7] W. Horton, "The Icon Book," John Wiley & Sons, Inc., 1994.

[8] M. Akatsuka, "Seven Sign Languages for Tourists: Useful Words and Expressions," Chinese-Japanese-American Working Group, 2005.

[9] N. Hosono, M. Suzuki, S. Hori, and Y. Tomita, "SOS Placard for the Hearing Disabled," in Proc. IEA2006, Maastrecht, Netherlands.

[10] N. Hosono, M. Suzuki, S. Hori, and Y. Tomita, "SOS Placard in Universal Use," The 2nd International Conference for Universal Design, IAUD, Kyoto, Japan, 2006.

[11] N. Hosono, M. Suzuki, R. Kimura, H. Miki, and Y. Tomita, "Emergency Communication Service on Mobile Phone for Universal Ubiquitous Use," in Proc. AHFE2008, Las Vegas, USA.

[12] N. Hosono, H. Miki, M. Suzuki, and Y. Tomita, "Urgent Collaboration Service for Inclusive Use," in Proc. HCII2009, San Diego, USA.

[13] N. Hosono, H. Inoue, H. Miki, M. Suzuki, and Y. Tomita, "Universal Communication through Touch Panel," in Proc. AHFE2010, Miami, USA.

[14] N. Hosono, H. Inoue, H. Miki, M. Suzuki, Y. Nagashima, and Y. Tomita, "Universal Communication Service for Inclusive Use," in Proc. SICE2010, Taipei, Taiwan.

[15] N. Hosono, H. Miki, M. Suzuki, and Y. Tomita, "Universal Communication System for Urgent Use," in Proc. IAUD 2010, Hamamatsu, Japan.

[16] M. Hirayama, M. Suzuki, and N. Hosono, "An Emergency Communication Pad for Hearing Impaired Persons," ICCIT 2010, Soeul, Korea.

[17] N. Hosono, H. Inoue, and Y. Nagashima, "Context Analysis of Universal Communication through Local Sign Languages applying Multivariate Analysis," ICCHP2010, Vienna, Austria.

[18] N. Hosono, H. Inoue, H. Miki, M. Suzuki, Y. Nagashima, Y. Tomita, and S. Yamamoto, "Service Science Method to create Pictograms referring to Sign Languages," in Proc. HCII2011, Orland, USA.

[19] N. Hosono, H. Inoue, H. Miki, M. Suzuki, Y. Nagashima, Y. Tomita, and S. Yamamoto, "Service Service Method to create Pictograms referring to Sign Languages," in Proc. HCII2011.

[20] N. Hosono, F. Miyajima, T. Inaba, M. Nishijima, M. Suzuki, H. Miki, and Y. Tomita, "The Urgent Communication System for Deaf and Language Dysfunction People," in Proc. HCII2013, Las Vegas, USA.

[21] International Organization for Standardization, ISO9241-11, “Ergonomic requirements for Office Work with Visual Display Terminals (VDTs), Guidance on usability,” 1998.

[22] A. Cooper, “About Face 3,” Wiley, 2007.

[23] International Organization for Standardization, ISO9241-110, “Ergonomic requirements for Office Work with Visual Display Terminals (VDTs), Dialogue principles,” 2006.

[24] SPSS, “Categories in Statistical Package for Social Science ver.18,” 2009.

[25] N. Hosono, H. Inoue, and Y. Tomita, “Sensory Analysis Method applied to develop Initial Machine Specification,” Measurement, vol. 32, pp. 7-13, 2002.

[26] MIT, “APP Inventor,” Available from: http://appinventor.mit.edu/, 2015.11.8.

[27] Deploygate, Available from: https://deploygate.com/, 2015.11.8.

[28] Freeplane, Available from: http://freeplane.sourceforge.net/wiki/index.php/Main_Page, 2015.11.8.

[29] H. Akatsu, A. Komatsubara, “Auditory and Visual Guidance for Reducing Cognitive Load,” in Proc. HCII 2007, Beijin, China.

[30] H. Akatsu, H. Miki, and N. Hosono, “Designing Adaptive ATM based on universal design,” in Proc. The 2nd International Conference for Universal Design, IAUD, Kyoto, Japan, 2006, pp.793-800, Kyoto, Japan.

[31] H. Miki, and N. Hosono, “Universal Design with Information Technology,” Japanese version, Maruzen, 2005.