A Study to Develop a New System Allowing Visually Impaired People to Utilize Smartphones

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Since communication services have become more readily available because of the emergence and spread of advanced mobile devices, such as smartphones, the information lifestyle of consumers has begun changing significantly. However, it is difficult for the visually impaired to operate smartphones equipped with touch-panel graphical user interfaces (GUIs); consequently, the information gap between those with and those without normal eyesight has widened. We developed a new text-entry method and conducted the user survey. We also explored, assessed, and tested a new communication method using vibration. The results from a hearing test we administered showed not only a strong interest in using smartphones, but also a deep anxiety about the inability to use touch panels such as bank ATMs. The newly developed three-point Braille input method showed higher values ($P < 0.05$, $P < 0.01$) for many items, compared with the existing two-point method, and the new method's benefits were confirmed. The evaluation study using the vibration patterns showed a strong interest ($P < 0.01$, $P < 0.1$), particularly in the emergency-alert and response-request functions, as well as in vibrational communication. In this study, we proposed and evaluated smartphone text-input and vibration sensing for the visually impaired, and found a new direction for text-input systems that would be easy for them to use. We also see a new direction for transmission systems.

Key words: visually impaired people, smartphone, braille text entry, vibration communication

1. Background of the study

It has been sometimes said that visually impaired people are informationally disadvantaged because they cannot fully receive information via visual perception. The information use environment surrounding visually impaired people has greatly changed, enabling them to carry around information because of the spread of braille text display devices [1] Information networking through the Internet has become indispensable, even for the visually impaired people.

With the emergence and spread of smartphones (multifunctional cellphones), people's lifestyles have begun changing tremendously. Directly pressing touch panels enables people to operate cellphones in a more sensory way, accelerating a rapid spread of Smartphones, even for those who are not familiar with the handling of the device.

On the other hand, operating the touch panels of smartphones based on GUI operating systems is difficult for visually impaired people, who have difficulty handling visual information, increasing the information gap between visually impaired people and those with normal eyesight. Studies designed to support their use of touch panels are few, so in this study, we have paid attention to this fact.

In this study, we have organized the problems involved in the actual use of portable information and telecommunication terminals to develop a new text-entry method via collaboration with Panasonic Mobile Communications Co., Ltd., which manufactures and sells smartphones. In addition, we have developed and promoted a technique involving vibration, which was our original idea.

2. Purpose of the study

In the present social environment, visually impaired people have a large handicap in terms of the acquisition of information as compared with those having normal eyesight. With the development of ITS technology, the touch panel is becoming a standard function of information and telecommunication devices. For this reason, the information gap between the visually impaired people and those with normal eyesight is becoming wider.

However, even visually impaired people cannot ignore the convenience of smartphones. If they can learn to use them, various problems will be solved. Therefore, we set up the following two points as the purpose of this study:

(1) We clarify the problems of text-entry methods and propose an easy-to-use text-entry method designed to allow visually impaired people to use a touch panel. In what follows, we refer to this as “the innovation in text entry.”

(2) To allow visually impaired people to use smartphones, we consider the possibility of creating communications by means of vibration. In what follows, we refer to this as “the possibility of introducing vibration communication.”

3. Method of the Study

3-1. Procedure

<The innovation in text entry>

- Select survey content and survey items via a precedent research survey and the like.
- Perform an audio survey and a text-entry evaluation experiment using a touch panel and several test subjects.
- Propose ways of improving the user interface based on the results of the survey of the test subjects.
- Perform a heuristic survey[2]that includes the proposed improvement content:

<The possibility of introducing vibration communication>

- Select the precedent research survey and the survey items.
- Perform the hearing survey and a feasibility test for the selection of vibration patterns when vibrations are used with the test subjects.
- Evaluate the efficacy of the vibrations for the test subjects. Study whether the daily use of such vibrations in emergency-alert and response-request functions is possible.
- Perform a heuristic survey using an application implemented with the proposed content.

<General proposal>

Confirm the adequacy of the proposed content via experiments and study the problems involved in using the text-entry method with touch panels for the visually impaired and communications using vibration.

3-2. Survey for test subjects

<The innovation in Braille text entry>

Implementation period: From Dec. 9 to Dec. 20, 2011

Implementation site: Kyoto Lighthouse, which is a general welfare facility for visually impaired people

Target people: 20 visually impaired persons

<Confirming the possibility of introducing vibration communication>

Implementation period: From Nov. 26 to Dec. 14, 2012

Implementation site: Kyoto Lighthouse, which is a general welfare facility for visually impaired people, Tokyo Chuo Industrial Hall, etc.

Target people: 28 visually impaired persons

3-3. Survey method

This survey is conducted in a private room. Perform the following evaluations while operating a smartphone:

- Evaluate three prepared text-entry methods.
- For the evaluation of vibration, make a test subject shake a smartphone in order to evaluate it.

In both cases, we employed a method of filling in the answer sheet for the test subject after reading the questionnaire aloud. We set the total required time as 50 minutes and taped the voices on an IC recorder to prevent incomplete forms. The figure below shows the survey situation for a test subject.

Fig. 1 The survey situation for a test subject

3-4. Survey equipment

<The innovation in text entry>

In the survey, we used the iPhone4[3],Xperia acro[4]and Gallaxy S II[5]for the already-sold terminals.

A landmark designed to allow the user to understand the operation position was put in the smartphone. To explain the entry method, a plastic position guide and an explanation table with a braille text were used.

<Confirming the possibility of introducing vibration communication>

As a presentation method for vibration communication, Apple's iPhone4S[6]and iPhone5[7]terminals were utilized. The vibration patterns used in the experiments were created using the "custom vibration settings" of these terminals.

4. Results

4-1. <The innovation in text entry>

4-1-1. Visually impaired people and text entry

From the hearing survey, the following results were obtained regarding the problems involved with the presently used portable information devices, text entry, and the like:

- All test subjects use a cellphone, making it a daily necessity for visually impaired people.
- Most visually impaired people use a braille information terminal, Plextalk.

- Many visually impaired people are frustrated with the operation of the device.
- The response of the auxiliary audio function is slow.
- Kanji conversion is difficult to perform.
- The operation of the device is difficult in noisy environments because the auxiliary audio function's support is hard to use.

4-1-2. The following facts have been revealed from the audio survey:

- 95％ of the test subjects were inexperienced with smartphones.
- 90％ of them replied that they wanted to use a smartphone in the future.
- The following points were the reasons that they wanted to use a smartphone:

1. The device is convenient.
2. They want to use a device that many sighted people use.
3. They had anxiety about the fact that they could not use a smartphone.

4-1-3. Evaluation test of the entry method

To test the process of entering multiple letters, test subjects were allowed to actually operate the device in order to measure the time required for the entry and to evaluate the entry method.

(1) Survey content

- For the text-entry methods using three touch-panel operations, the [Double hand-tap method[8]], the [Three-point braille entry method[9]], and the [One-line entry method[10]], we performed a test that involved entering example texts.
- The time required for the entry and the number of entry errors were measured in order to perform a numerical evaluation of the evaluation items after the entry.

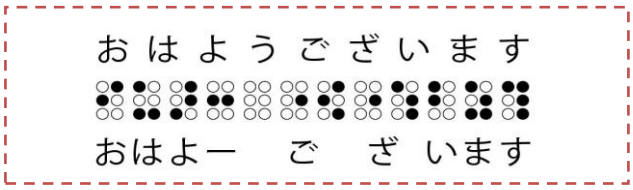


Fig. 2 Entry method evaluation test for example texts

4-1-4. Survey hypotheses

We set up the following survey hypotheses:

H1: Among the three input methods, the "double hand-tap method," the "three-point Braille entry method," and the "one-line entry method," the three-point braille entry method is the easiest to use.

H2: The method of performing the prompt text entry is easy to use.

H3a: The double hand-tap method is easier for those who feel that it is easy to use the toggle method.

H3b: The three-point braille entry method is easier for those who feel that it is easy to use six-point braille entry.

4-1-5. Survey results

(1) The ease of use of the text-entry method for the touch panel for visually impaired people.

A statistically significant difference in terms ease of use was found only between [One-line entry] < [Double hand-tap] (P<0.05), and although we cannot say so with absolute certainty, from the average evaluation value, we obtained the following result:

[One-line entry]3.6< [Double hand-tap]4.6 < [Three-point braille entry]5.2.

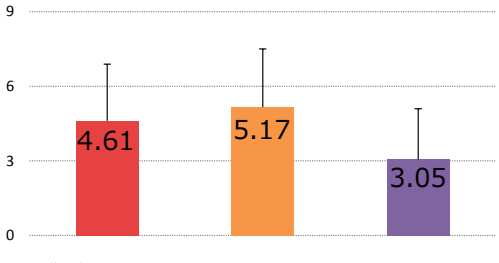
Therefore,

H1: It is considered that [visually impaired people feel that three-point braille entry is easiest].

(2) The correlation between comprehensive ease of use and the evaluation items

Three-point braille entry　Double hand-tap　One-line entry

Fig.3 Comparative evaluation of the text-entry methods



Double hand-tap Three-point braille entry One-line entry

Fig.4 Comprehensive evaluation of the text-entry methods

A correlation between the ease of use for the prompt text entry and comprehensive ease of use can be found for three-point braille entry (P<0.05), but such a correlation cannot be found for the double hand-tap and the one-line entry methods.

Therefore,

H2: [The method for easily performing the prompt text entry is judged to be comprehensively easy to use] was partly supported.

(3) The relationship of the touch-panel method and the already-existing methods in terms of ease of use.

For [Comprehensive ease of use] and [Ease of understanding the operation method], no statistically significant correlation was found between the existing method and the touch panel method. Therefore,

H3a: Those who feel that it is easy to use the toggle method feel that it is easier to use the double-tap method.

H3b: It is rejected that those who feel that it is easy to use the six-point braille entry method feel that it is easier to use the three-point braille entry method.

4-1-6. Improvements after the heuristic survey

Based on the points of improvement obtained via this survey, we propose the following improvements in the three-point braille entry method:

(1) Proposal for the entry cognition method and the audio aid – we propose the following points of improvement:

- Only touching the panel creates a state in which the entry is not performed.
- Accompany the vibration with data entry.
- Add an audio aid when an entry of [a key without an entry] is performed.

(2) Proposal for the screen display

People with low vision have a large handicap in terms of sight as compared with sighted people. Because they live based on the information obtained via visual perception, we propose the following improvements.

2-1 Enhance the contrast by reversing the display of black and white.

2-2 Enlarge the display of each text string.

4-1-7. Summary

7.1 The present state of and problems regarding the use of portable information and telecommunication devices by visually impaired people

In this study, we paid attention to visually impaired people's actual use of portable terminals, which has recently been attracting increased attention, resulting in our being able to organize the present state and problems.

- For the use of information and telecommunication devices:
- Usable functions are limited, and people carry multiple devices in many cases.
- Because cellphones depend on audio information, they cannot be operated in a noisy place or in a place where the use of voices is limited.
- The accuracy of audio entry is insufficient, and most audio entry is not used because using it in front of people is felt to be uncomfortable in many cases.

7-2 For the operations

- The operations of cell-phones have a time lag in terms of the reaction of the audio aid, and this may cause confusion.
- The Kanji read-aloud function of cellphones is insufficient, making it difficult to perform the Kanji conversion.

7. 3 For the text entry

In this study, we can confirm the efficacy of the three-point entry method: [One-line entry] < [Double hand-tap] < [Three-point braille entry] and find proposals for improvement.

4-1-8. Problems and prospects in the future

In this study, we understood the actual use state of the information and telecommunication devices used by visually impaired people, investigated the usability of smartphones, focused our attention on text entry in order to realize touch panel operation, clarified their problems, and made proposals for improvement.

An advantage of smartphones is that people can select their favorite method from multiple methods and use it as an application. In addition, the three-point braille entry method is considered to be helpful in learning braille, and it would be very useful if it could help to increase the percentage of the population who can use braille.

However, the operations of smartphones extend beyond text entry. Function assignment by gestures is considered to be effective. Nevertheless, there remain problems that should be solved, such as making guidelines for creating applications that even visually impaired people can use.

4-2. "Confirming the possibility of introducing vibration communication"

Here, we paid attention to the tactile vibrations on which visually impaired people rely in order to verify our hypotheses that visually impaired people can use portable information terminals more conveniently if we can add information, such as emergency-alert and response-request functions, to the vibration patterns and that visually impaired people can use them as new communication tools if we can add emotional information to the vibration patterns.

4-2-1. When performing the experiments

At first, when setting the vibration patterns, we used Morse code as a reference by combining short points and long points. Morse code is composed of two types of signals, short points and long points, and the ratio of their lengths is internationally defined as 1:3. In addition, because the perception rate was high at 250 ms for the short points and 750 ms for the long points in the haptic perception in the research by Ota[11] et al., we adopted these conditions. Furthermore, when we investigated the number of the vibration patterns built into the already-existing portable information terminals, the mode value was five, so we set five patterns.

4-2-2.Conditions for conducting the experiments

- In this study, we used the vibration patterns shown in Fig. 1. In addition, we used the vibration patterns built into the already-existing cellphones.
- We divided the information used in this study into three types: emergency, function, and feeling. We chose the information by assuming that it would be used when performing communications using email or the like. We used tags and flags used in existing mails as a reference for the function and used preceding studies[12] as a reference for the feeling (see the figure below).

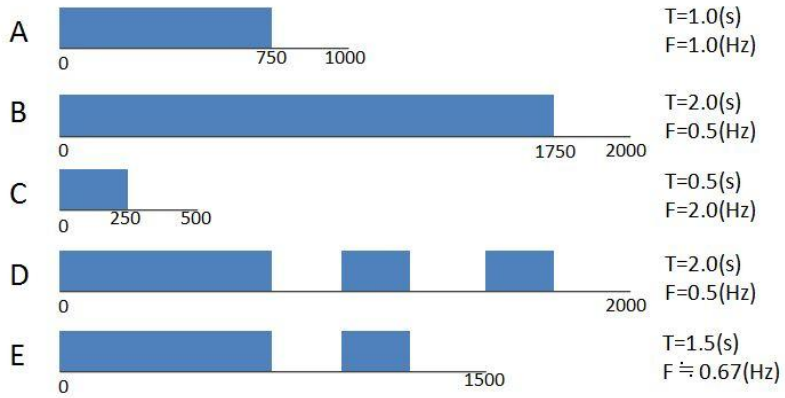


Fig.5 Vibration patterns examined by this research

4-2-3. Outline and results of this survey

In this study, we have conducted surveys twice, the preceding survey and main survey, but because the preceding survey was for setting the hypotheses used in the main survey, we now refer only to the main survey.

- Implementation period: From Nov. 26 to Dec. 14, 2012
- Implementation site: Kyoto Lighthouse, which is a general welfare facility for the visually impaired people, Tokyo Chuo Industrial Hall, etc.
- Target people: 28 visually impaired persons (Kyoto: 20, Tokyo: 8, Total: 28)
- Survey items:

(1) Can we find any consistency between the vibration patterns and the information?

(2) What information do we want to identify from the vibration patterns?

We also performed the auditory survey on the portable information terminals.

4-2-4. Hypotheses: We created the following hypotheses from the preceding survey.

We created items to discover whether there are consistencies between certain vibration patterns and certain information.

H4: There is a consistency between pattern A and “usual.”

H5-a There is a consistency between pattern B and “response-request.”

H5-b There is a consistency between pattern B and “guidance.”

H6-a There is a consistency between pattern C and “emergency.”

H6-b There is a consistency between pattern C and “urgency.”

H6-c There is a consistency between pattern C and “impatience.”

H7-a There is a consistency between pattern D and “joy.”

H7-b There is a consistency between pattern D and “pleasure.”

H8 There is no consistency between pattern E and the information.

4-2-5. Experimental results

1. There is a consistency between pattern A and “usual.” There is significance. Supported ($p<0.1$)

2-1. There is a consistency between pattern B and “response-request.” Rejected

2-2. There is a consistency between pattern B and “guidance.” Rejected

3-1. There is a consistency between pattern C and “emergency.” ($p<0.01$)

3-2. There is a consistency between pattern C and “urgency.” ($p<0.1$)

3-3. There is a consistency between pattern C and “impatience.” Rejected

4-1. There is a consistency between pattern D and “joy.” Rejected

4-2. There is a consistency between pattern D and “pleasure.” Rejected

5. There is no consistency between the pattern E and the information. Rejected

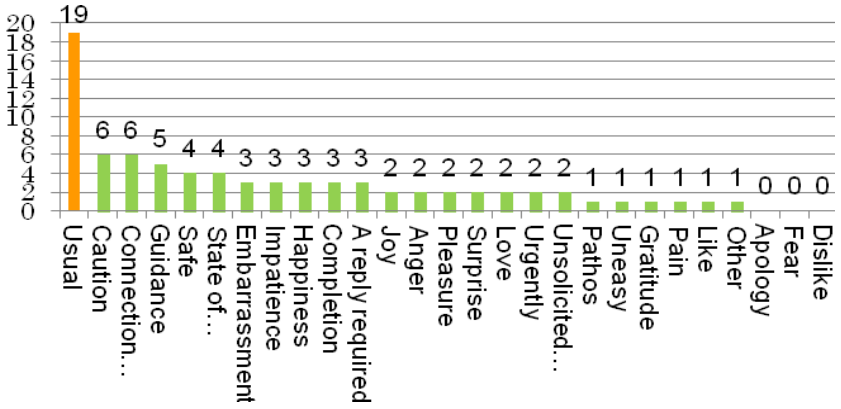


Fig.6 Image of the pattern A

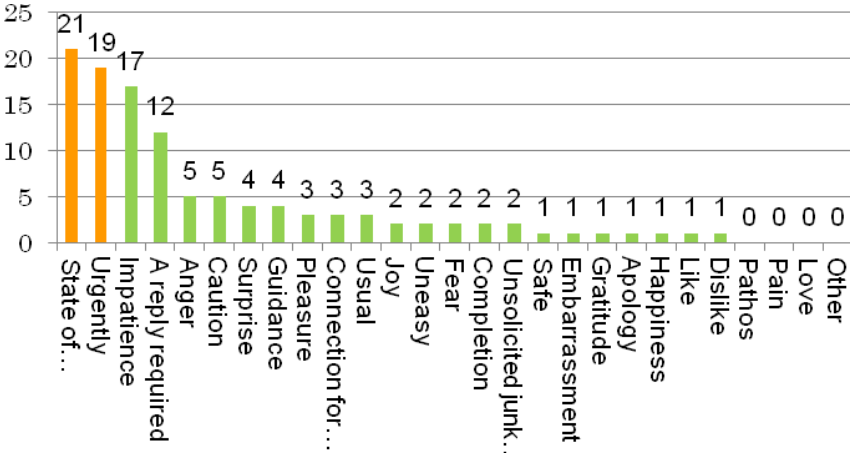


Fig.7 Image of the pattern C

We obtained the following three results regarding the information we wanted to identify based on vibration patterns.

- Users significantly desired to identify emergency information. Supported. (100%)
- User significantly desired to identify function information. Supported. (100%)
- User significantly desired to identify feeling information. Supported. ($p<0.1$)
- Facts revealed from the audio survey:

Because it is difficult to hear the sound of a cell-phone when it is stored in a pocket or a bag, visually impaired people want a mode for increasing the vibration.

When using a navigational guidance application, visually impaired people want a function that changes the vibration as they approach the destination or other similar functions.

4-2-6. Conclusion

From the results of this study, we found that there is a consistency between pattern A and “usual,” as well as between pattern C and “emergency/urgency.” In addition, no consistency was found between the information and the pattern in which multiple types of vibrations were combined; however, this might have been caused by the fact that the images were split.

In addition, for the items that we want to identify from the vibration, there was significance in the fact that many people want to identify emergency-alert, urgency, and response-request information.

It is important to adequately identify these types of information. We have revealed that a consistency can be found between the information and urgency/emergency; therefore, we believe we can use these patterns.

4-2-7. Future prospects

Regarding the future prospects of this study, although we have already investigated the consistency between five types of patterns and 26 items of information at this time, we need to investigate the consistency between other patterns and the information. In addition, as we targeted only visually impaired people in this study, we should also perform similar surveys of sighted people.

What visually impaired people want in terms of portable information terminals includes something that can be realized immediately and responding to such a need will lead to being able to use portable information terminals more conveniently.

In addition, vibration can become a communication tool not only for visually impaired people but also for everyone, including blind-sighted people, deaf people, and even sighted people. We believe that if such a form of communication is realized, it will lead to making the lives of people more rich.

5. Final statement

In this study, in order to improve the touch panel and other operations of smartphones for the use of visually impaired people and expand their use of the smartphones, we

- developed a braille entry method on the touch panel and
- considered the usability of a new communication method using vibration.

As a result, we have proven the efficacy of three-point braille entry and the effectiveness of vibration communication in both normal and emergency-alert/urgency communication. From these incidents, we have been able to find contact points for visually impaired people, who have hardly been involved with smartphones. By using these contact points as starting points, we can also promote their affinity with smartphones and their use of applications that they may presently use on a personal computer. This study has a large prospect and even a small beachhead. By attempting to modify smartphones for visually impaired people, which is a subject often ignored, and by initiating their active approach, we hope to stimulate various further developments in order to reduce and overcome the difficulty before us.

6.References

[1] *braille text display devices ;The electric mechanical device which displays Braille.*

[2]*heuristic survey ;The method that an expert solves a problem for experience intellect.*

[3]*iPhone4 ; made by Apple Inc.*

[4]*Xperia acro ; made by Sony Ericsson mobile communications Co., Ltd.*

[5]*GallaxySII ; made by Samsung Electronics Co., Ltd.*

[6]*iPhone4S ; made by Apple Inc.*

[7]*iPhone5 ; made by Apple Inc.*

[8]*Double hand-tap method ; It is a Japanese character input method as iPhone application by Apple Inc.*

[9]*Three-point braille entry method ; Panasonic mobile communications Co., Ltd and collaborative investigation of Kyoto Institute of Technology.*

[10]*One-line entry method;[Ippitsu]was devised by welfare member of Japanese Android.*

[11]Takayuki KOUNO, Mikio UCHIYAMA, Toshio KISHIMOTO, Masaoki KAWATA, Hiroshi NAKAMOTO and Shigeru OHTA(2009*)A Study on Tactile Vibration Signals to Convey Text Information –A New Means of Communication by Morse Code for the Deaf and Blind-*

[12]Yasutaka TORAYA and Ryo HIRAYAMA(2011*)Impression evaluation of the face mark in a mobile phone*.