Design and Implementation of a Four-quadrant and Voice Interaction User Interface of a Smartphone for the Visually Impaired Users

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***Abstract*—This paper presents a design of a four-quadrant and a voice interaction user interface for the visually impaired (VI) by using a smartphone. This design provides a simplified interface, big buttons, voice feedback, and some simplified functions. Moreover, it is suitable for those people who are visually impaired. This design also includes a telephone, a voice message, an emergency button, and an emergency shaking function.**

I. Introduction

Recently, as many smartphones use a touch panel instead of traditional keyboards [1], it can be hard for a visually impaired (VI) user to ascertain what button they are touching. These physically challenged individuals need a voice feedback to tell them. Although some smartphone applications are designed for VI users, they are too complex for VI users to use [2]. Therefore this design provides a friendly user interface for VI users.

At the top level of this design consists of the following four touch buttons on the four-quadrant of the smartphone [3]: 1. Telephone, 2. SMS (Short Message Service), 3. Recording, and 4. Emergency Button. In addition, this design uses voice feedback so VI users will know what button they are pressing.

II. SINGLE VIEW

It's hard for VI users to learn complex functions. Therefore this design uses a four-selection interface design which consists of four big buttons on the four-quadrant of the smartphone. In addition this design provides some friendly user functions to assist VI users to use the smartphone easily. Fig. 1 shows the VI application modules.

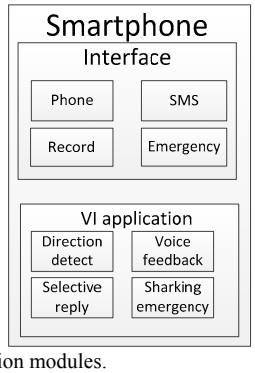


Fig. 1. VI application modules.

III. APPROACH

A. Simple Top-down Design

This design uses a simple top-down design so the user can select four main functions at each level and then, step by step, complete their desired procedure. When a user chooses the functions he wants to use, each step has no more than four options. If there are too many choices, the interface will be too complex for VI users to use. Fig. 2 shows this simple top-down design.

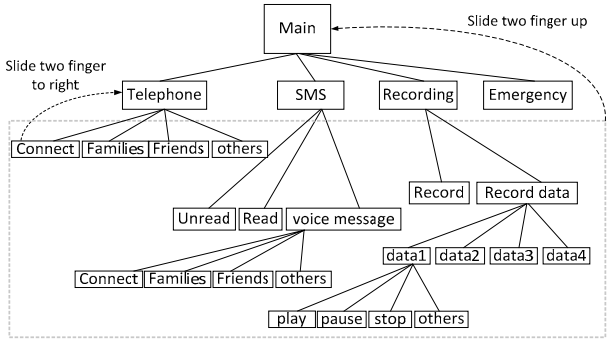
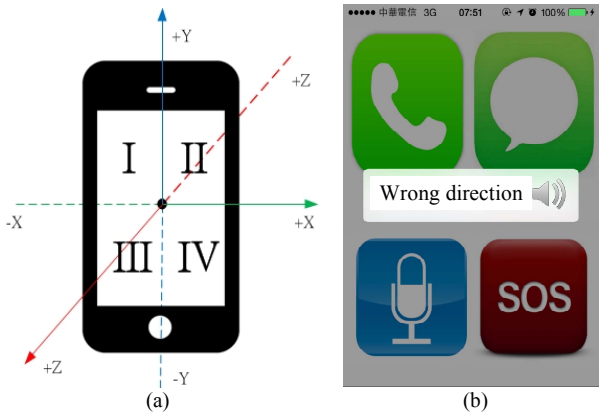


Fig. 2. Simple top-down design.

B. Smartphone Direction

This design uses the tri-axis accelerometer of the smartphone to detect the smartphone's direction as shown in Fig. 3 (a). If the smartphone is facing an incorrect direction, a warning message will pop up and a recorded voice will tell the VI user that the smartphone is facing the wrong direction. Fig. 3 (b) shows a four-quadrant interface with a warning message with a voice telling the VI user instructions.



(a) (b)

Fig. 3. (a) Smartphone direction (b) Four-quadrant interface with warning message.

Fig. 4 shows the smartphone direction detection flowchart. First, this software module initializes the accelerometer and then reads the acceleration value to detect the direction of the smartphone. Second, if the direction of the smartphone is wrong, the smartphone will tell the VI user by voice to remind the user to adjust the direction of the smartphone. Third, when the direction of the smartphone is correct, the VI user can

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operate the smartphone by touching the four touch buttons on the four-quadrant of the smartphone.

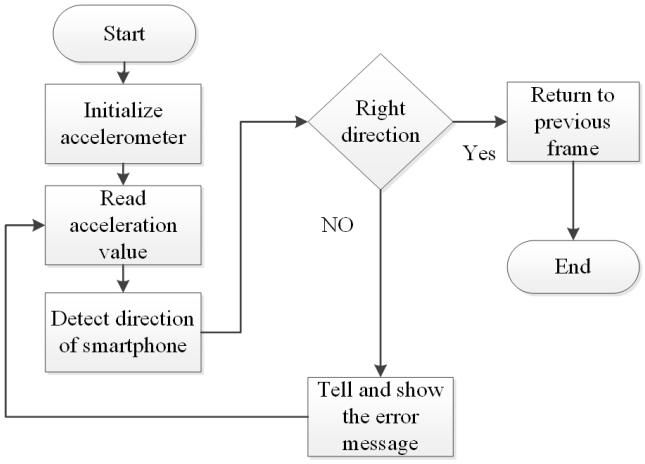

Fig. 4. Smartphone direction detection flowchart.

C. Voice Feedback

VI users can't see what button they are touching. This design provides a voice feedback to let them know what button they are touching. When the VI user touches the button, the smartphone will read the specific button's name and give a voice feedback to the user who can then easily know the function of the particular button.

D. Telephone

After selecting a telephone function, the user can select from the options of regular communication, families, friends, or others. This design groups telephone numbers in order that the user will take less time to find the number he or she wants to call. The VI user can slide two fingers to either the left or right to change to the next page of the user interface.

E. SMS

The majority of people usually send a message by typing words, but it's hard for VI users to type words by using a touch panel. As some VI users even don't know how to type a specific word, this design provides a simple selection for a VI user to reply to a message. When the VI user receives a message, the smartphone can read the message and give some suggested words for a user to select to reply to that message, such as "Ok", "No, thanks", "Yes, please", "I understand". This design can also send a voice answer as a reply to a message.

F. Recording

When people have something important to remember, they will take notes. But, as VI users can't take either pictures or notes, they usually use their hearing to receive a message. This design provides a recording function to record important things.

G. Emergency Button

Most VI users don't use too many of the functions available on a smartphone. The "Emergency button" is often the most important button. When the user needs help, such as if he either is wounded or is lost, by pressing the emergency button the user will be able to directly contact relatives, family or SOS units. When calling relatives, this function will also send a SMS simultaneously. The SMS will contain the user's current location. Moreover, some emergencies often occur suddenly and unexpectedly. It may not convenient for a VI user to press the emergency button. This design provides another way to use the emergency function by shaking the smartphone up and down more than 10 times in order to call for help. Fig. 5 shows the acceleration value when the user shakes the smartphone. This design sets a threshold to detect whether or not a user is shaking the smartphone. Fig. 6 shows the emergency message that will be sent out by shaking the smartphone when the acceleration values are more than 1.5g when accumulated ten times within an interval of 9 seconds.

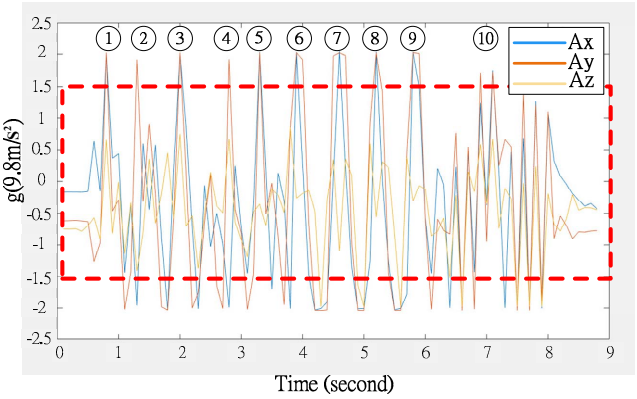

Fig. 5 The acceleration value when a VI user shakes the smartphone more than 10 times.

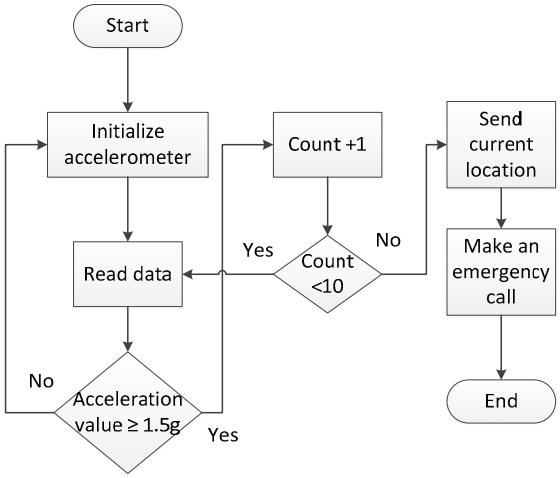

Fig. 6 The flowchart of the emergency function activated by shaking the smartphone.

IV. Experimental Results and Comparison

This design presents a friendly smartphone interface for VI users, with a four-quadrant button which is simple and friendly for elderly VI individuals to use. Table I shows a comparison of this design with others. Some designs also have voice feedback, but the voice feedback user interface is too complex for VI users, especially for older people. Table II shows the lines of the program code of this design.

TABLE I
A COMPARISON OF THIS DESIGN WITH OTHERS

Major function	A smartphone system with accessible mode [1]	Design A [2]	This design
Voice feedback	Yes	Yes	Yes
Simple user interface	No	No	Yes
Voice message	No	No	Yes
Emergency button	No	No	Yes
Emergency function by shaking the smartphone	No	No	Yes

TABLE II
THE LINES OF THE PROGRAM CODE OF THIS DESIGN

Module	The lines of the program code
Phone	150
SMS	171
Record	75
Emergency	33
Direction detection	25

V. CONCLUSIONS

This paper presents a friendly smartphone interface with both four-quadrant buttons and a voice interaction to provide VI users with an easy way to use a smartphone. In addition, this design also provides an easy way both to record important things and to type words. This design also has a selective way to reply to messages. In addition to a one button emergency function, this design also provides another emergency function which is activated by shaking the smartphone ten times.

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