A Mobile Augmentative and Alternative Communication (MAAC) Application for Disabilities

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Abstract: Communication board is one of Augmentative and Alternative Communication (AAC) which provides a large amount of pictures classified under various categories. It is a useful instrument for disabled people, who are suffering from speech and language impairment, to facilitate their communication by simply selecting pictures. The traditional communication board would assist the users to communicate with the others. However, there are a number of limitations of the communication board such as large in size and difficult to carry. Because of the advanced technology, it is inexpensive to purchase a mobile device. In this paper, we present our mobile augmentative and alternative communication application, namely MAAC app, for disabled people. The MAAC app runs on the Android-based mobile devices such as smartphones or tablets. This application is suitable for disabled people who are suffered from cerebral palsy, spasm and stroke. We performed user acceptance test (UAT) with domain experts on the application and the overall comment is positive.

1 INTRODUCTION

According to the World Report on Disability (World Health Organization, 2011), there is about 15% of the world's population were estimated to be living with disability. It is a large amount of population that we should not ignore. The disabled people may face different kinds of challenges in their daily life. One of the major challenges is communication. In general, the common communication approach between disabled and normal person includes: (1) sign language, (2) lip-reading, (3) writing and (4) body language. However, those mentioned methods are not suitable for all types of disabled person, especially cerebral palsy patients, spasm patients and physical handicapped. Thus, it may introduce barrier for those patients in communication and they may encounter problem in expressing themselves.

In this paper, we illustrate how we designed a mobile augmentative and alternative communication application, namely MAAC app, for disable people. The MAAC app runs on Android-based mobile devices such as smartphones and tablets. By using this app, different degree of disabilities would utilize it in communication. To ensure the developed mobile application really assist the disabled people in communication, we collaborated with the Association for Engineering and Medical Volunteer Service (EMV 2013) to go through the whole development cycle – from user requirements collection to user acceptance testing. EMV is a non-governmental, non-profit organization in Hong Kong SAR. The goal of EMV is to enhance the independence and quality of life of people with disabilities and elderly through professional voluntary services. They provide a number of services for the disabilities and elderlies such as rehabilitation aids services, computer rehabilitation services, vocational rehabilitation services, community rehabilitation services, elderly services and social enterprise. EMV is an organization with lots of professionals from different domains such as engineering, medical and paramedical and also the EMV staffs have great experience in communicating with disable people. They understand the needs of the disabled person. Furthermore, their professional comments and advices have been valuable to us in developing a mobile application which fits the requirements of the disabled people.

The main contributions of our proposed mobile augmentative and alternative communication application (MAAC) are: (a) providing a user friendly communication tool for disabled persons, (b)

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enhancing the convenience of usage with information technology, (c) providing language localized content to target users in the Hong Kong SAR and (d) the application can be customized so that different level of disable people would use it in communication.

The rest of this paper is organized as follows: Section 2 describes the literature review. Section 3 describes the system design and implementation. Section 4 presents the results of User Acceptance Test (UAT). Section 5 offers our conclusion.

2 LITERATURE REVIEW

Augmentative and Alternative Communication (AAC) is about the communication methods for people who are suffering of speech and language impairments in substituting speaking or writing (Beukelman and Mirenda, 2005; Schlosser 2003). It is widely adopted by people who have been diagnosed in speech and language impairments such as cerebral palsy and autism. The main aim of the communication board is to "arrange language in space so individuals can, by selecting from the available options, say what they wish to say as quickly as possible, and can do so with a minimal amount of effort" (Blackstone, 1993).

Picture Exchange Communication System (PECS) or Picture Exchange (PE) is a type of AAC modes (Bondy and Frost, 2001). Using PECS, user can pick symbol cards from the card set and show his/her message to their target audience for communication. One of the PECS is communication board/book. Communication board is a picture-based tool of aided AAC, which is about using a device for exchanging messages. It lets user to express or communicate by pointing or looking at a particular word, symbol, picture or photo listed on the communication board. In general, communication board is displayed in grid form, with different words and phrases shown in the grid. The words are mainly grouped under categories, such as food, places and activities. Using communication board, the communication efficiency and effectiveness of people who is suffering with speech and language impairments could be improved. However, one of the limitations of the traditional communication board is in large size. Thus, it reduces the level of portability.

Sono Flex (Sono Flex, 2013) is a commercial mobile application developed by Tobii Technology. This application serves as an AAC vocabulary tool with English user interface only. They developed the application which supports Apple iOS, Android OS, Amazon Kindle Fire and Tobii Communicator. Sono Flex displays many words, phrases or short sentences on the screen. Also, the application allows user to categorize types of words. For each word/phrase, the application would also show the related image in the button. Once the user forms a sentence, the application can pronounce it to the others. However, Sono Flex does not allow user to add any new word. This reduces the flexibility in updating its word/phrase library. Furthermore, Sono Flex provides English user interface only which makes it difficult for local users in the Hong Kong SAR to adopt it for communication.

Com Aid (Com Aid, 2013) is a free Android OS mobile application which serves as a communication board. The application, which was developed by Tung Wah Group of Hospitals Kwan Fong Kai Chi School in the Hong Kong SAR, provides Traditional Chinese interface and it supports text-to-speech conversion. It assists the users with speech disorder to communicate and hence to encourage the users to communicate with others. Com Aid offers a colourful user interface. Similar to Sono Flex, it displays the word with related image. This application lets users to add new word/phrase with the picture and pronounce the sentence. However, sometimes it is difficult to handle drag and drop the word/phrase to form a sentence when using Com Aid. Also, if the user selects a different word/phrase category, the application does not update the screen to reflect the change. Thus, user cannot select the word/phrase properly and it may introduce barrier for the disabled user to use it for communication.

3 SYSTEM DESIGN AND IMPLEMENTATION

3.1 Limitations in Existing AAC Mobile Applications

The traditional communication board is typically large in size and limited in portability. Currently, because of the advanced development in technology, it is inexpensive to purchase mobile devices such as smartphone or tablet. At the moment, there are quite a number of AAC applications for mobile devices in the market. Nonetheless, we cannot find an AAC application that the content and user interface of the application could be localized, e.g. Traditional Chinese for Hong Kong SAR users. If the mobile application only provides user interface in English, it

would limit the Hong Kong disabled users to use those AAC applications in their daily communication. Furthermore, we discovered that the existing AAC mobile applications are not flexible enough to allow user, his/her friends, family members, caregivers or the therapists to do any customization. Due to these aforementioned limitations in the existing AAC mobile applications, we proposed to develop a new mobile augmentative and alternative communication application, namely MAAC app. The MAAC app aims to:

(1) Provide an accessibility and localized tool for assisting disabled users, in Hong Kong SAR, to communicate with the others,
(2) Be easy to use by different degree of disabilities,
(3) Be able to customize, by the user or his/her friends, family members, caregivers or the therapists, so as to match with the degree of the disabilities of the user.

3.2 Requirements

We held more than 10 meetings with EMV staff to collect the user requirements. We collected not only the functional requirements but also non-functional requirements. Furthermore, during the meetings, we discussed a number of user interface design issues that need to be handled during the development. Since the application is mainly designed for disabled users, some of the requirements on the user interface design, such as high contrast text, resizable text and large buttons, and functions, such as assisted auto-scan mode, are tailor made for disabled users. The functional and non-functional requirements are presented in Section 3.2.1 and 3.2.2 respectively. Section 3.3 presents the System architecture of the MAAC app. Section 3.4 presents the design issues of the MAAC app.

3.2.1 Functional Requirements

There are two types of major users in using the MAAC app: (a) the disabled people and (b) the normal people such as the users' family members, friends, caregivers or therapists. The functions of the MAAC app would be divided into two aspects: (1) general usage and (2) customizable settings. The general usage is to use the MAAC app to compose phrase/sentence by pressing the buttons in the main page interface. Once the user composed a phrase/sentence, the play button can be pressed to pronounce the phrase/sentence using pre-recorded sound clip or online speech synthesizer. With this feature equipped, the user can be more effective in communicating with others. The customizable settings let the disabled user to have control in a number of items of the application such as the font size and words sorting mode. The detail of the customizable settings is given in Section 3.4.4. If the disabled user is not able to change the settings by himself/herself, he/she can ask a normal person (e.g. his/her friends, family members, caregivers or therapists) for help in changing the settings of the MAAC app. However, if the degree of disabilities of the users allows them to control the user interface properly, they can also change the customizable settings by themselves. Figure 1 shows the use-case diagram of the MAAC app.

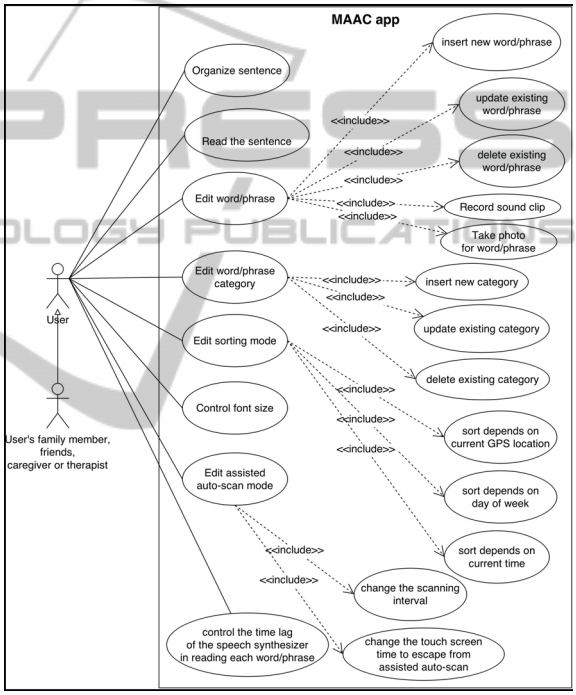

Figure 1: Use case diagram of the MAAC app.

One of the objectives in developing MAAC app is to provide a well-designed user interface for the users so that they can compose phrases/sentences conveying their message and to be read out to the message recipients easily. The following is a list of functionalities that MAAC app provides:

- Manage word/phrase (with corresponding picture and sound clip) database – MAAC app allows user to add in new word/phrase with optionally the desired corresponding picture and sound clip for pronouncing the word/phrase or changing the existing entries in the word/phrase database. Thus, it lets the user able to create his/her own personal AAC.

- Capture/Select a photo for a word/phrase – MAAC app allows user to take a photo with the built-in camera as one source of providing the desired picture for a word/phrase, which is shown as the background image of the button for select that word/phrase. Alternatively, a photo in the photo library of the device can be selected serving the same purpose. With this feature, it provides an alternative, possibly easier, way to remember or recognize the (writing of) word/phrase and therapist can use the image to train the user how to effectively communicate with the others (Bondy and Frost, 2001). This would further enhance the disabled user's motivation in communication.
- Read out a phrase/sentence – after the user has composed a phrase/sentence, he/she can press the "Play" button to pronounce the sentence using the online speech synthesizer or a pre-recorded sound clip.
- Record/Select a sound clip for a word/phrase – MAAC app allows users using their own voice in recording a sound clip for each word with the device's voice recording function, i.e. MAAC app can use the user's own voice recorded sound clip to pronounce the word/phrase. Alternatively, a sound clip can be selected from the device's media library.

3.2.2 Non-functional Requirements

There are some non-functional requirements for the MAAC app.

- Accessibility: the application should be easy to use on Android-based mobile devices. The design of the interface should be able to fit and run in different screen resolution of different devices.
- Usability: the application and its user interface should be easy to use and understand. The provided word/phrase is localized which related to the daily life in Hong Kong SAR.
- Interface: the application should provide consistent user interface, be user-friendly and simple so as to prevent any difficulty imposed on disabled users, e.g. the button should be easily pressed; the user interface should be in Traditional Chinese for local Hong Kong SAR users.

3.3 System Architecture

The MAAC app was developed using Java and the application package file was 786k. Since the design of the application is flexible that user can add/delete words in the application, if the user want to add more words, it needs more disk space from the device. For each new word, it needs around 80KB from the disc memory.Users are able to install and run the MAAC app on Android-based mobile device with Android OS version 4.0 or above. The application is a standalone application that would run without connection to the Internet. However, if the user want to download a sound clip for a word/phrase from an online source, it is necessary to connect to the Internet via wireless or mobile network access point. As mentioned in the previous section, the user can also record the sound clip using his/her voice. In case the user is not able to speak, the user can also seek help from a normal person (such as therapists and caregivers) to record the pronunciation of the word/phrase. Thus, the user still can use the pronounce sentence function even there is no Internet connection.

Figure 2 and 3 show the entity-relationship (ER) diagram of the word/phrase database and the system architecture of the MAAC app respectively.

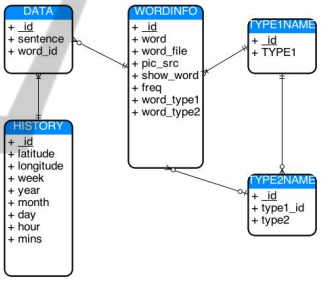

Figure 2: Entity-relationship diagram of the MAAC app.

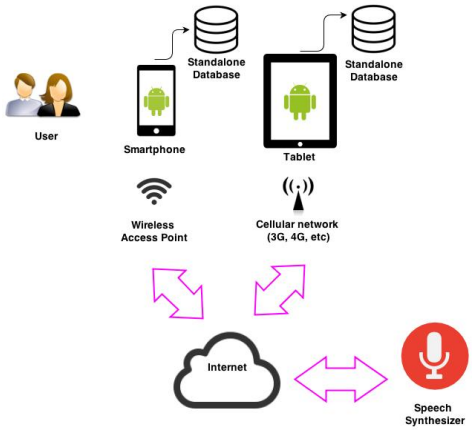

Figure 3: System architecture of the MAAC app.

3.4 Design Issues

3.4.1 User Interface

According to the non-functional requirements, the application should be easy to use and could be run in different type of the Android-based mobile devices. One of the requirements is the user's Android device should run Android OS version 4.0 or above. The user interface of the application can adjust to fit different resolution. After discussed with the EMV professionals, we designed an interface (see Figure 4) with serious considerations in the accessibility. The words/phrases are grouped into six categories: Noun (名詞), Verb (動詞), Adjective (形容詞), Adverb (副詞), Quantifier (量詞), Time (時間). The button of each word/phrase category has different colored background and border for easier differentiation. Each word/phrase is shown as a round-cornered button, with the same border color as their corresponding word/phrase category, in a 4x6 grid. The text shown in button is designed with high contrast such that the user can easily distinguish the category and the word/phrase. Furthermore, the font size within the button is customizable in settings (設定). The detail of customizable settings is given in Section 3.4.4.

Figure 4: The main user interface of the MAAC app. First row provides six word/phrase categories (indicated by 'a'; from left to right): Noun, Verb, Adjective, Adverb, Quantifier and Time.

When the user presses a specific category button, the 4x6 grid will update immediately and show the words/phrases in the selected category. Figure 5 shows the interface when the user pressed the Time category.

3.4.2 Normal Mode

According to the requirements, the application should offer different input methods to serve different disability degree of the disabled user. Thus,

Figure 5: The interface after the user pressed Time category button.

Figure 6: (a) The text field for displaying the phrase/sentence composed; (b) Play button for pronouncing the phrase/sentence.

we designed two approaches to let the user to make the selection: (1) normal mode and (2) assisted auto-scan mode.

We designed normal mode for users who can perform multi-touch gesture. When the user presses a word/phrase button, the word/phrase will be displayed in the text field (see Figure 6 – region (a)). For example, if the user wants to compose a sentence "I (我) want to (想) sleep (訓覺)", he/she presses the buttons of "I (我)", "want to (想)" and "sleep (訓覺)" respectively to compose the sentence displayed in the text field. Once finished, the user can press the "Play" button to read out the sentence.

3.4.3 Assisted Auto-scan Mode

For the assisted auto-scan mode, we target this mode for the user with higher degree of disabilities that the user cannot provide multi-touch gesture as input, but he/she can touch or tap the touch screen. There are many ways to implement the assisted auto-scan mode. EMV professionals suggested the main screen would be divided like a pyramid: the first level: left and right (Figure 7 – label 1 border); once the user make the choice by tapping the screen, the second

level: top and down (Figure 7 – label 2 border); once the user make the choice by tapping the screen, the third level: column by column (Figure 7 –label 3 border). For each level, the group of buttons is highlighted and the user can tap the screen to go into the sub-level. However, we did not adopt this design as this approach is not user friendly and efficient enough. For example, if the user would like to press the button at top row and leftmost column, the user taps the screen 4 times.

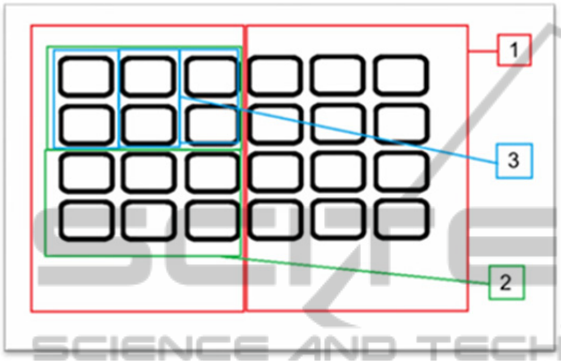

Figure 7: Initial design of assisted auto-scan mode.

To further improve the user experience and reduce the number of tap, we design another approach for the assisted auto-scan mode. This approach is illustrated in Figure 8. The group of buttons is highlighted in column-based in a round-robin approach (along horizontal direction; see Figure 8 – arrow 1). The user can tap on touch screen if he/she chooses a specific column and then the highlight will move in row-based, again, in round-robin approach (along vertical direction); until the user tap the touch screen to select a specific button (see Figure 8 – arrow 2). If the target word/phrase does not exist in the current page, this design also supports scanning the "Previous page" and "Next page" buttons. When the highlight goes to the "Next page" button, the user can tap the screen, the word/phrase on next page will be shown. If the user wants to select the button in the first column and the first row, by using this approach, he/she only needs to touch the screen 2 times. Compared with the initial design, it reduced the number of taps which is usually difficult for this type of target users.

However, refer to the final design, user may spend more time in locating a specific button if the button is located at the rightmost column and bottom row in the grid. Since there is a time elapse in moving from one column/row to the next column/row, for the experienced user, he/she may feel annoying if the scanning time between

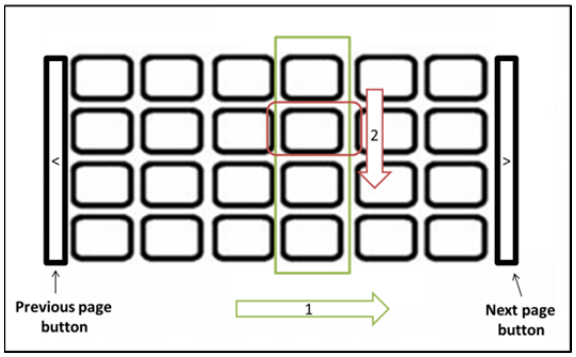

Figure 8: Final design of assisted auto-scan mode.

columns/rows is too long. To further enhance the user experience, it is better to provide a mechanism to increase/decrease the scanning time interval.

3.4.4 Customizable Settings

During the design of the application, we considered that MAAC app should be customizable to provide personalized experience that fits the needs of different users. After the discussion with EMV professionals, we decided to provide the followings in customizable settings:

a) Sorting control – the user can customize the sorting of frequently used words/phases based on (1) current GPS location, (2) Day-of-the-week and (3) current time;
b) Font size control – the user can adjust the button font size;
c) Scanning control – the user can adjust (1) the idle time before escaping the assisted auto-scan mode and (2) auto-scanning speed;
d) Time lag control for speech synthesis – the user can edit the time lag of the speech synthesizer in reading each word/phrase

Figure 9 shows the customizable settings page of the MAAC app.

3.4.5 Insert New Word/Phrase and Category

As mentioned in Section 3.2, one of the requirements is letting the user to insert new word/phrase to the word/phrase database. If the user is not able to control the application easily, he/she can seek help from his/her friends, family members, caregiver or therapists to insert the word/phrase. First, the user go to the Insert new word/phrase page (see Figure 10). At the beginning of the insert, the buttons related to sound are disabled since a new word/phrase does not exist at that moment.

The left-bottom area is “photo taking” area. User can take photo which matches the word/phrase using

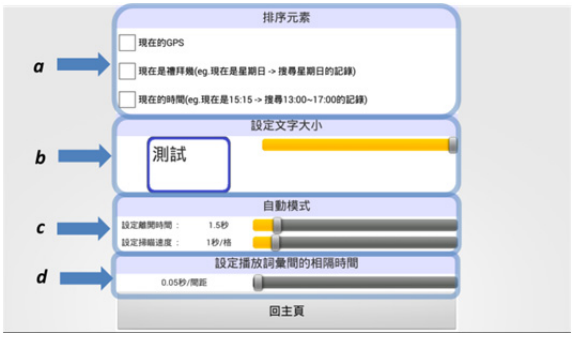

Figure 9: Customizable settings page in MAAC app. (a) Sorting control; (b) Font size control; (c) Scanning control; (d) Time lag control for speech synthesis.

the device's camera. If the user does that, captured photo will be underlay in the word/phrase button as the background. After the user finished the input, the record button and the speech synthesizer button are then enabled. User can select which category of the word/phrase belongs and control whether showing the text and the photo in the button of a word/phrase. To finish the insertion, user can press "Save" button and then the application would check the correctness of the input data. If there is an error, an error message will be shown; otherwise, the application would store all input data into the database. If the user wants to insert a new word/phrase category, user should have input the name of this category first (see Figure 10 – area (a)); otherwise, when user presses "Add" button, the application could not insert the word/phrase category to database, and display an error message in the screen. After input the name, user can select the target category in the pop up list, and user could press "Add" button to complete the process.

Figure 10: Insert new word/phrase interface. (a) Insert new category.

4 RESULTS OF USER ACCEPTANCE TEST (UAT)

After finished the development, we have arranged a User Acceptance Test (UAT) with the EMV staff which was held on 08 May 2013 in the Jockey Club Digital Inclusion Center (JCDIC, 2013). The participants included occupational therapists, engineers and professional workers of AAC. The testing cases included: (a) layout and accessibility, (b) basic functions and (c) customizable settings functions.

For the layout accessibility, the EMV staff commented that the design of application layout is good and simple for the target users. The adopted color scheme is easy for the target users to distinguish the word/phrase categories. The EMV staff provided a positive feedback on the basic functions in MAAC app.

In UAT, the EMV staff provided a number of feedbacks on the current user interface design. Firstly, when the user presses the "Play" button, the application will pronounce each word/phrase, in the sentence, one by one. In the current design, the pronounced word/phrase will be removed immediately from the text field after the application pronounced it. The EMV staff commented that all the wordings of the sentence should keep in the text field since the other listeners can read the sentence from the screen and listen at the same time. In addition, the user can re-play the same sentence.

Secondly, in the current design of the assisted auto-scan mode, the "Play" button is scanned in the main page only. If the user selects to browse a specific word/phrase category, the "Play" button will be not scanned. To be more consistent, the EMV staff suggested the "Play" button should be scanned in any page.

In summary, the comments from the professional the EMV staff are positive. The application is easy to use, fulfills the needs of the disabled people and the content is localized and relevant to the Hong Kong SAR.

Figure 11: User acceptance test with EMV staff.

5 CONCLUSIONS

In this paper, we presented the details of a mobile augmented and alternative communication application – MAAC app. The application can be run on Android-based mobile device such as mobile phone or tablet. MAAC app provides a better user experience for the disabled people. The application was verified and evaluated by professionals such as occupational therapists and engineers. The application is now under final revision and EMV has planned to release this application in Google Play Store at the end of 2013. Users can download this application for free.

In summary, we developed a mobile augmented and alternative communication application for disabled people. We fulfilled the application requirements and finished the application with a number of features such as customizable settings. Nevertheless, there are still rooms for further improvements. In the current design, the user interface can only provide Traditional Chinese. To let more users adopt and utilize this mobile application, in the future, we would like to enhance the application with a multi-lingual interface, such as English and Simplified Chinese. Thus, the community of the disabilities can enjoy this tool for communication. We hope this application would help the disabled people in communication, enhance the digital inclusion and establish an information society without discrimination.

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