Designing a location-aware augmented and alternative communication system to support people with language and speech disorders

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ABSTRACT

Working with those who have speech and language disorders can be a great challenge for researchers. Language difficulties can significantly affect a user's ability to communicate with others. Our aim is to design an Augmentative and Alternative Communication (AAC) system based on current location for people with language disorders in order to support communication in their everyday life. In this paper, we design a location based AAC system that provides a list of images that is able to assist in communication.

1. INTRODUCTION

Speech and language impairment is defined as a communication disorder that adversely affects not only a child's but also an adult's ability to talk, understand, read, and write. Augmentative and alternative communication (AAC) methods include all forms of communication (other than oral speech) that are used to express thoughts, needs, wants, and ideas. AAC devices can range from a simple picture board to a computer program that synthesizes speech from text. Generally, AAC systems are used when facial expressions or gestures are made to communicate with others using symbols or pictures. People with severe speech or language problems rely on AAC to supplement existing speech or to replace non-functional speech. Special augmentative aids, such as picture and symbol communication boards and electronic devices, are available to help people express themselves. These can help to increase social interaction, school performance, and feelings of self-worth. AAC users should not stop using speech if they are able to do so. The AAC aids and devices that are used are meant to enhance their communication. AAC users encounter difficulty communicating via speech due to congenital and/or acquired disabilities occurring at any time across their lifespan. These conditions include but are not limited to autism, cerebral palsy, dual sensory impairments, genetic syndromes, intellectual disability, multiple disabilities, hearing impairment, disease, stroke, and head injury like aphasia.

AAC systems may help their users to communicate by providing audio or visual prompts to support the user in speaking a word or phrase, or by speaking the word or phrase via synthesized speech (Beukelman et al. 2006). Many electronic AAC systems permit a user to pre-define words and phrases that would be difficult for the user to produce instantly.

Usually, electronic AAC systems have a high initial setup cost because of the specialized hardware or software required. However, the growing ubiquity of recent mobile devices and applications has led to widespread adoption of AAC software on typical mobile devices, tablets, and PCs (Vance et al. 2009). Typical smart phone hardware often has capabilities beyond traditional AAC hardware, such as network connectivity and embedded sensors.

The capabilities of modern mobile devices provide an opportunity to improve the usability of AAC through context-aware computing (Schilit et al. 1994). Current AAC solutions often expect the user to navigate through a hierarchical menu of speech and image options in order to speak or select an image. A networked, sensor-enabled AAC mobile device may be able to identify the user's current location, task, or conversational partner, and highlight conversational options that are most relevant to the user's context. This could take the form of ordering lunch when the user is in a restaurant or discussing tennis with a sports fan. In this paper, we describe the design and development of a location based Android application for communication.

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2. RELATED WORKS

Technology is often used to manage language disorders. Modern mobile devices such as smartphones have various types of applications that can be used to facilitate communication, allowing users to maintain their independence and avoid social exclusion, two of the primary features that identify supportive technologies (Newell et al. 2003). McGrenere et al. (2003) evaluated prototypes of aphasia-aware software for mobile devices. Participants reported that they could not read long streams of text like those found in recipes. As a result, the authors to developed a recipe book app, which replaced ingredient text with pictures, and a planner (Moffatt et al. 2004), which annotated each calendar event with photographs of the place and people associated with the event.

AphasiaWeb is in some sense an augmentative and alternative communication (AAC) system, which guides users through a conversation using audio and visual prompts (Hannah Miller and Chris Johnson 2013). A comprehensive treatment of AAC systems is given by Beukelman and Mirenda (2005). Kane et al. (2012) describe an AAC system specific to aphasia. Their TalkAbout system runs on a mobile device and provides context-aware prompting. For example, in a cafe the device's screen will automatically present the user with words related to ordering coffee. This system provides audio and visual cues that guide the user through a conversation.

Daemen et al. (2007) describe a system for telling stories through pictures, sounds, emotion icons, and written annotations. Each participant in the study responded differently to the software, revealing the difficulty intrinsic to designing a comprehensive system to manage aphasia. For example, one participant valued sound as the most important input method, while another favored pictures.

Many other mobile AAC systems have been developed by Waller et al. (1998), Allen et al. (2007), Ahlsen et al. (1998), Van Dijk et al. (2010) and Keskinen et al. (2012). The main contribution of our research paper is to present a system that helps those with language disorders in an easy-to-use way. Our application supports various types of users, such as those dealing with aphasia or autism and children. The desired result is that participants can easily communicate with other conversational partner through our application.

3. METHODOLOGY

3.1 System architecture

In essence, our system contains various categories of images. We combine some other important services to further communication, such as Text to speech Service (TTS), a Database, Global Positioning System (GPS) and Internet access.

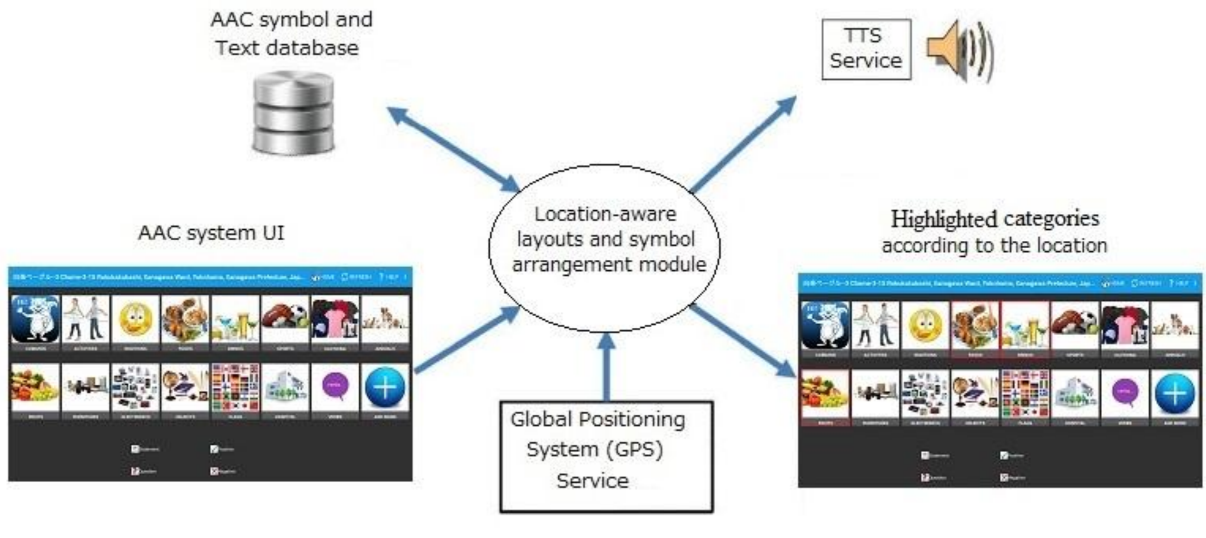

Figure 1. *Architecture of the proposed Location-aware AAC system.*

First, this system searches through the available categories based on the current location given by the GPS. Each category contains some symbols which are stored in the smartphone database. Then, the categories that are found near the current location are highlighted. A text to speech (TTS) service is an important part of any AAC system. Most current smartphones include this service. Thus, our proposed system also uses the TTS service to provide audio of the stored symbol. The overall system architecture is shown in Figure 1.

3.2 Hardware and software

The proposed system is developed on the latest Android based tablet device. However, the application can also be installed on Android based smartphone which have API level 8 or greater. Our prototype was tested on Sony z4 tablet. This Android application was developed in Eclipse IDE; the application logic was written in Java. User data such as images and phrases were stored in the smartphone memory. We used the Google Location API and Google Place API to identify the location of the user. Finally, we use the default system Gmail client to send messages to other users.

3.3 User interface design

The purpose of our system is to provide users the ability to store, organize, browse, and speak stored words and phrases in addition to sending messages based on the images. The current prototype enables users to browse items, add new items, and filter items based on the current location.

- *Browsing items*: Each item in our system contains a picture and an associated word or phrase. The application is also capable of playing audio associated with the text using the built-in speech synthesizer. The context bar displays the current user location. Like other AAC systems, words and phrases may be assigned to hierarchical groups, which enable users to organize words and phrases by the location that they are spoken in or by the partner that they are most often discussed with.
- *Adding new items*: This process is similar to how users add content to existing AAC systems. Users may add new words or phrases to the system catalogue themselves. Adding a new item requires the user to: 1) input the text to be spoken; and 2) add an associated image. Words and phrases may be entered using the smart phone keyboard. The associated image may be captured by the user via the phone camera, selected from a set of previously captured images, or chosen automatically.
- *Filtering and updating items*: The image categories are highlighted depending on the current location. The user is capable of updating the previously stored words or phrases.

This system provides the ability to detect the user's current location via GPS. It detects the user's location using the Google Location API, which relies upon GPS and Wi-Fi localization.

3.4 Flow diagram of the system

The basic flow diagram of our system is shown in Figure 2. The system algorithm is shown in Algorithm 1 and Algorithm 2. Algorithm 1 contains the main method locationAwareAAC() and Algorithm 2 contains the supporting method getCurrentLocation() for the main method. The method locationAwareAAC() calls the method getCurrentLocation() to get the current location information using the Google Location API and Google Place API.

Algorithm 1:

locationAwareAAC()

1. Get current location using getCurrentLocation()
2. resultCategories = Query the database and get the category list using the current location.
3. If (resultCategories !=NULL) then load and highlight the categories. Otherwise no need to highlight and load categories.
4. Select any category.
5. Select any item to hear a full sentence using TTS.
6. If the user wants to send an email then send the text associated with the image to the partner. When the user sends the image it will automatically attach the current address.

Algorithm 2:

getCurrentLocation ()

1. Check the internet connection
2. Find the current location using the Google Location API and Google Place API.
3. Return location.

3.5 Detecting location

One of the unique features of mobile applications is location awareness. Mobile users take their devices with them everywhere; adding location awareness to our app offers users a more contextual experience. The location

APIs available from Google Play services facilitate the addition of location awareness to our application with automated location tracking. To detect the current location we use the Google Location API. First, we need to check if internet is available to the device. If internet connection is available then we find the current location using the Google Place API. The Google Place API works with a specific category of word, such as food, bank, restaurant, school etc. We then apply a database query to match the current location with the stored image database. After results are found, categories that match with the current location are highlighted. Our current system checks categories within a 500m radius from the current device position.

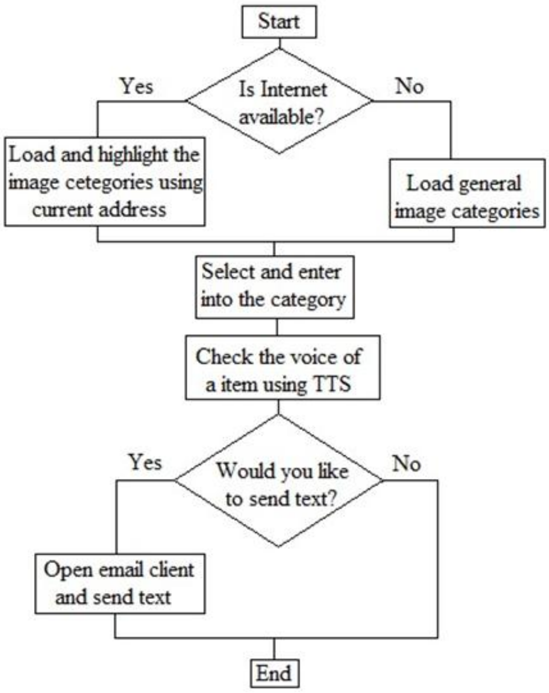

Figure 2. *Flow diagram of the proposed system.*

3.5 Text to Speech service

Our system was developed on an Android OS (Version 6.0 Marshmallow) and allows us to convert text into voice. It allows us not only to convert image into text but also to speak the text in a variety of different languages. Java provides the TextToSpeech class for this purpose. After choosing specific category, we can choose an image, at which point the application gives the word or full sentence that is stored in the image database.

3.6 Sending email

To send an email from our application, we are able to use the existing default email client provided by the smartphone OS such as Gmail, Outlook, K-9 Mail etc. To do this, it was necessary to write an Activity that launches an email client, using an implicit Intent with the correct action and data. After choosing an image from a category, the system sends the text associated with those images using our device's default email client. When a healthy user receives email, they are unaware if the sender has a disability or not. In this way, our system can improve empathy for the affected people.

4. RESULT AND DISCUSSION

4.1 User community

This application is designed as a single user system to be used in everyday life for an individual with limited or no speech capabilities. We constructed the application with four distinct user communities in mind.

- *Aphasia user*: This community can understand everything but have lost their ability to speak and possibly read. Therefore, they will need icons to identify words and a high-level vocabulary.
- *Autism user*: These users are characterized by a difficulty in communicating and forming relationships with other people and in using language and abstract concepts.

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- *Children*: If children wish to communicate with others when they are incapable of writing a sentence, this system can help them use images and voice to create a sentence.
- *Foreign language speakers*: This system not only supports the English but also other languages. Thus, users are able to easily operate, generate, and use the local language with this system.

4.2 Usability testing

Usability testing is a method of testing a product while considering the target users in order to find usability problems existing in the product. A usability study aids in the removal of design issues, which should improve the end user experience with the product. In usability testing, users are given tasks to perform using the product and observed to see if they have any problems performing the tasks. While the user is performing the task, the usability team will observe how the user is navigating the application as well as the user facial expression to observe how they are reacting to the application. Depending on the observations, the usability team will suggest design solutions. Real users should be utilized in usability testing because they don't know the internal details of the system. Thus, we test our system on Japanese students in an English environment. After using our system they rated it on a 5 point scale (1=low, 5=high). The result of their rating is shown in Table 1.

Table 1. *Usability testing result.*

Participant	Age	Liked application	Better than current	Would use
P1	23	5	5	5
P2	23	4	5	5
P3	24	3	4	4
P4	23	5	5	4
P5	25	4	5	5

4.3 Discussion of result

The operation of our system is very simple, as shown in Figure 3. Figure 3 (a) and (b) show the general categories and highlighted categories. If a restaurant, café or supermarket is near the current location then the system will automatically highlight the food, drink and fruit categories. The last two images (c) and (d) of Figure 3 show the application after selecting the food category. Figure 3 (d) shows the message in the message box after confirming an item in the category. Finally, it is possible to send a message via email with the current location by pressing the send button.

This paper demonstrates some communication methods that help individuals who struggle to produce or comprehend spoken or written language. The developed system provides mobile based language therapy that can lead to positive changes in the language and functional communication skills of individuals with speech and language disorders. This system can easily capture and manage photographs using a mobile device, which is useful to people with such a disability. Users may find different applications for the system that are influenced not only by the nature of their diseases but also by their personal circumstances and communicative goals. For example, individuals with autism think in a visual way and recall visual images and memories easily. They can understand and benefit from concrete and visual information regarding daily events. Our system can present language in a consistent and visual manner. Children with autism, cerebral palsy, developmental disabilities, or rare genetic syndromes can receive communication and learning support through our system. We also believe our system can assist those who cannot speak foreign languages but start to live in a foreign country. This system provides support for different types of users who have Android based smartphones. AphasiaWeb is a web application that provides only visual and audio prompts for an aphasia user. It is a social networking web application where users can share their thoughts and feelings. Similarly, TalkAbout and PhotoTalk support only people with aphasia. However our system is able to assist multiple user communities. It also supports multiple languages. It can help users send their generated messages to other users similar to an instant messaging system. The proposed system uses mobile device GPS that can give the application the current user location. This system has a rich image library that can properly support the user. Moreover, actual AAC systems are expensive and specialized. However, our system is implemented on an Android operating system, which is popular all over the world. When reading the email messages, it is not possible to notice that the users have language impairment. Thus, they are treated as a normal user. As a result, our system automatically increases empathy towards the user. Table 2 shows a comparison to other systems.

Table 2. *Comparison with other systems.*

Name	Platform	Type	Users
AphasiaWeb	Web	AAC for Social Networking	Aphasia
TalkAbout	iOS	AAC only	Aphasia
PhotoTalk	iPAQ pocket pc (windows)	AAC Only	Aphasia
Proposed system	Android	Instant messaging with AAC	Aphasia, autism, children, people with other languages

a) General categories

b) Highlighted categories

c) Category of Foods

d) Message box with message after selecting the item pizza

Figure 3. *Screenshot of the proposed system.*

5. CONCLUSION

We have implemented an AAC system for people with speech disabilities. Most people with speech disabilities currently use AAC devices and mobile applications. At this time, available applications are more cost effective but less user-friendly and have limited vocabularies which are geared toward users with limited cognitive abilities and only available in English. In contrast, our system is user-friendly, contains a large vocabulary, target users with higher cognitive abilities, supports multi-language use and location-awareness, and is extremely inexpensive. Finally, the first prototype was built on the latest Android OS because it has the largest user community all over the world. In addition, we have checked our system with occupational therapists. During the testing session, we received some suggestions. In the future, we intend to include theirs suggestions in our system so that we can better support the individuals with language and speech related disabilities.

6. REFERENCES

Ahlsen E. and Geroimenko V. (1998), Virtual reality as a communication aid for persons with aphasia. In Proc. of Intl. Conf. on Disability, Virtual Reality and Associated Technologies, ICDVRAT'98, pp. 229–235.

Alan F. Newell, Alex Carmichael, Peter Gregor, and Norman Alm (2003), The human-computer interaction handbook. Chapter Information technology for cognitive support, L. Erlbaum Associates Inc., pp. 464–481.

Allen M., McGrenere J., and Purves B. (2007), The design and field evaluation of PhotoTalk: a digital image communication application for people. In Proc. of the 9th Intl. ACM SIGACCESS Conf. on Computers and Accessibility, Assets'07, ACM, pp. 187–194.

Beukelman, D.R. and Mirenda, P. (2006), Augmentative & Alternative Communication: Supporting Children & Adults with Complex Communication Needs. Paul H. Brookes Publishing Company.

Beukelman D. and P. Mirenda (2005), Augmentative and Alternative Communication. Paul H. Brookes Publishing Company.

Daemen E., Dadlani P., Du J., Li Y., Erik-Paker P., Martens J.-B., and Ruyter B. De (2007), Designing a free style, indirect, and interactive storytelling application for people with aphasia. In Proc. of the 11th IFIP TC 13 Intl. Conf. on Human-computer interaction, INTERACT'07, pp. 221–234.

Kane S. K., Linam-Church B., Althoff K. and McCall D. (2012), What we talk about: designing a context-aware communication tool for people with aphasia. In Proc. of the 14th Intl. ACM SIGACCESS Conf. on Computers and accessibility, ASSETS'12, ACM, pp. 49–56.

Keskinen T., Heimonen T., Turunen M., Rajaniemi J.-P., and Kauppinen S., Symbolchat (2012), A flexible picture-based communication platform for users with intellectual disabilities. Interacting with Computers, **24,** 5, pp. 374–386.

McGrenere J., Davies R., Findlater L., Graf P., Klawe M., Moffatt K., Purves B., and Yang S. (2003), Insights from the aphasia project: designing technology for and with people who have aphasia. In Proceedings of the 2003 conference on Universal usability, CUU'03, ACM, pp. 112–118.

Miller Hannah and Johnson Chris (2013), AphasiaWeb: A Social Network for Individuals with Aphasia. In Proc. of the 15th Intl. ACM SIGACCESS Conf. on Computers and Accessibility, Article No. 4 ACM.

Moffatt K., McGrenere J., Purves B., and Klawe M. (2004), The participatory design of a sound and image enhanced daily planner for people with aphasia. In Proc. of the SIGCHI Conf. on Human Factors in Computing Systems, CHI'04, ACM, pp. 407–414.

Schilit, B., Adams, N., and Want, R. (1994), Context-aware computing applications. WMCSA'94 Proc. of the 1994 First Workshop on Mobile Computing Systems and Applications, IEEE, pp. 85-90.

Vance, A. (2009) Insurers fight speech-impairment remedy. The New York Times.

Van Dijk B., Dadlani P., Van Halteren Aart, Biemans M. (2010), Life changes, connection stays: photo sharing and social connectedness for people with special needs. In Proc. of the 28th Annual European Conf. on Cognitive Ergonomics, ECCE'10, ACM, pp. 135–142.

Waller A., Dennis F., Brodie J., and Cairns A. Y. (1998), Evaluating the use of TalksBac, a predictive communication device for nonfluent adults with aphasia. International Journal of Language and Communication Disorders, **33,** 1, pp. 45–70.