

Prospect: A Picture Exchange Communication System (PECS)-based Instant Messaging Application for Autism Spectrum Condition

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Abstract. Autism Spectrum Disorder (ASC) has widely gained the common attention from the public especially autistic communities. Individuals with ASC are said to have poor verbal skills and this affects them in carrying out their daily basis which they are afraid to expose themselves to the world due to their problems. ASC is diagnosed among children ranging from ages 5-12 years old and they suffer from the abnormal functioning of the brain which in turn causes lack of development activities. Thus, studies have shown that diagrammatic approaches help children with ASC to overcome their issues and improvise their visual and verbal skills. Picture Exchange Communication System or PECS consists of a series of illustrated cards and each cards has its own illustration with a caption on it. These children will understand the cards and they can compile several other cards to form sentences. This paper presents a mobile application called the Prospect, which has been developed using the agile development model for digital representation of PECS. The application is hoped to enhance the learning process and a better yielding results.

1. Introduction

Autism Spectrum Disorder (ASD) is a cognitive disorder caused due to abnormal functioning of brain impacting development activities [1]. Autism is also a neuro-developmental disorder estimated to affect up to 1 in 100 children [2]. Autism is typically diagnosed between three and four years of age [3]. The characteristics of children with autism include deficits in social interactions and speech and non-verbal communication with up to 50 per cent with autism failing to develop any useful language ability [4]. Over the time various techniques have been researched and implemented to teach and communicate with the ones suffering from ASD. A Picture Exchange Communication System (PECS) is an effectively-proven augmentative communication system commonly used for children with ASD. Specifically, it is a pictorial system that uses basic behavioral principles such as shaping, differential reinforcement and transfer of stimulus control to teach children functional communication via pictures (black-and-white or color illustrations).

Since the existence of PECS, children with autism are exposed to the option of using physical cards and the PECS board with the other partner. Prior to the PECS system, the traditional method of using physical cards slows down the learning for these children and typically a child with autism is introduced to PECS at the mere age of five and in most cases parents have no experience of the



particular system and have unable to support its use. A number of studies have found that Information Communication Technology (ICT), Computer Aided Learning (CAL) and Human Computer Interaction (HCI) based technologies can help to instigate and develop communication skills among children with ASC [5, 6, 7, 8, 9]. Since PECS is an augmentative communication system, the concept is applicable in ICT. The wide use of mobile devices such as smartphones and tablets allow people to send and receive messages instantly via the Mobile Instant Messaging (MIM) and it requires a fast Internet connection for the transmission of messages to occur [10].

To address the technological gap, this paper proposes an Instant Messaging (IM) application specifically based on the PECS system. A series of cards with certain illustrations similar to the physical cards will be the subject for the proposed application and with IM functionality, user will be able to send a simple message by combining the cards to form a sentence. The proposed application will be called Prospect which means giving hope to these ASD individuals and it will feature various cards to be used for these particular children to communicate with their peers who has the same condition via MIM, HCI and appropriate CAL elements.

The remainder of this paper is structured as follows. Section 2 presents similar applications that target on children with ASD. Section 3 describes the methodology for developing Prospect, Section 4 presents the working prototype, and finally Section 5 concludes with some indication for future research.

2. Related Work

A study was carried out to observe three examples of applications that are used to aid children with ASD. These applications use certain to achieve certain criteria in order to successfully deploy the apps. Results were obtained by comparing the proposed application with these apps. Both strength and weaknesses were tested and evaluated in order to provide a complete breakdown structure for the applications. The applications being reviewed are SoundingBoard by AbleNet Corporation, Grace by Troughton-Smith and PexPix by Baumann.

2.1. SoundingBoard

SoundingBoard is an application developed by AbleNet Corporation that make ‘boards’ of symbols. When each cards is pressed on, it will produce the sounds of corresponding phrase out from a speaker on the device. The basis of communication for this application is similar to the proposed application. This app is specially built for users with special needs to understand the fundamentals of PECS and improve their verbal skills. Hence, SoundingBoard only works offline and the application is not intended to establish conversations with people on different devices and locations. The actual depictions of the interface are shown in Figure 1.



Figure 1. Graphical user interface of SoundingBoard.

The interface is generally good and equipped with tutorials to walkthrough first time users on the usage of the particular application. However the board management interface is not very intuitive for users. It also does not let users organize cards into a logical structure which is not as helpful as the Grace application reviewed next. This is because individuals with ASD are mainly visual learners and the ability to see sentences of symbols are very beneficial to them.

2.2. Grace

The Grace application was developed by Troughton-Smith in the year 2014. It is similar to the SoundingBoard application. Despite their similarity, Grace does not support reading out of symbols, instead providing a way to organize the cards into structured sentences. The interface of Grace is a great example of good UI design, as it is simplistic and all the colors have been chosen specifically to make it easily readable. Figure 2 shows the sample interfaces of the Grace application.

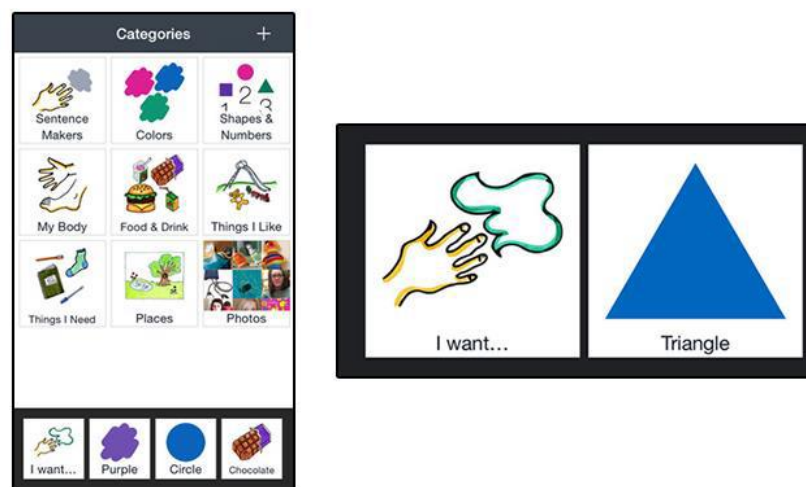


Figure 2. Graphical user interface of Grace.

From the figure, the sentences are made from symbols and are being displayed on the entire screen. This view prevents the user from getting distracted easily (which is common among autistic children). The images of the symbols themselves are really well designed, using bright colors in order to make them easier to recognize. However, it does not provide tutorials on how to use the application. Grace also does not support device to device plugin which means it is not for communication purposes with other users.

2.3. PexPix

The PexPix application was developed by Baumann in 2014. This application has one major difference as compared to the other applications which is the absence of Human Computer Interaction (HCI) concept. The interface is not quite user-friendly as the layout is not properly organized. This can be justified by the arrangement of the buttons, icons and pictures which are too crowded. Figure 3 further describes the issue based on the sample interface.

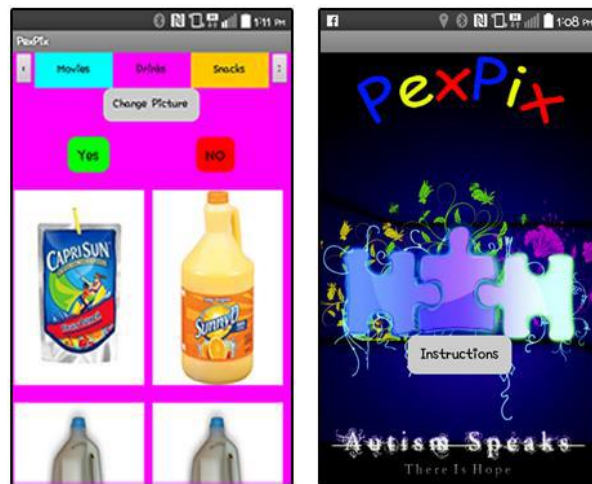


Figure 3. Graphical user interface of PexPix.

The reviews concluded that all the applications evaluated above differ in terms of interface, the fundamental concepts and other secondary elements such as reliability and the level of user-friendliness for each application. Prospect has a device-to-device plugin. In other words, it has an instant messaging functionality to enable communication between fellow users that has special needs. This is a vital part of the application as it could bring an extensive impact to the user to improve his/her verbal skills despite they are diagnosed with ASD.

3. Methodology

This project proposes an Android-based application for autistic children called the Prospect. The backbone of the application is the Picture Exchange Communication System (PECS), which serves as the core element of the application. The primary concept is to embed PECS together with Instant Messaging (IM) to enable users with Autism Spectrum Disorder (ASD) to send a message to other users. Hence, ASD individuals can use this channel as an alternate way to communicate with others.

Prospect is developed based on the Agile Development Model, which provides a reasonably effective road map for developing this project. This methodology involves key processes that are commonly found in other process models such as planning, analysis, design, testing and implementation. In parallel to the application, the model is used as it more user-centered. This indicates that users play a crucial role and they constantly communicate with the developers to keep track of the progress of a system's development. Basically, this methodology is based on values, principles and practices. Essential to agile programming is the values and principles that create the context for collaboration among programmers and users [11]. Figure 4 shows the Agile Development Model.

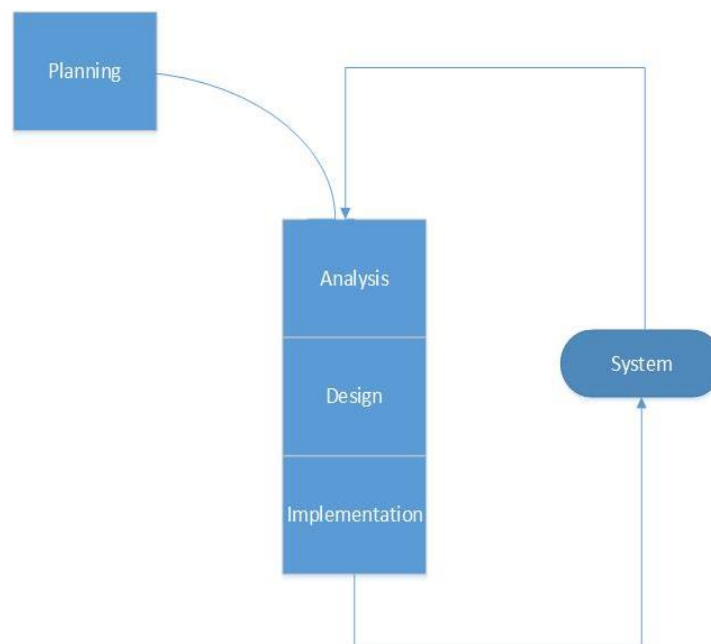


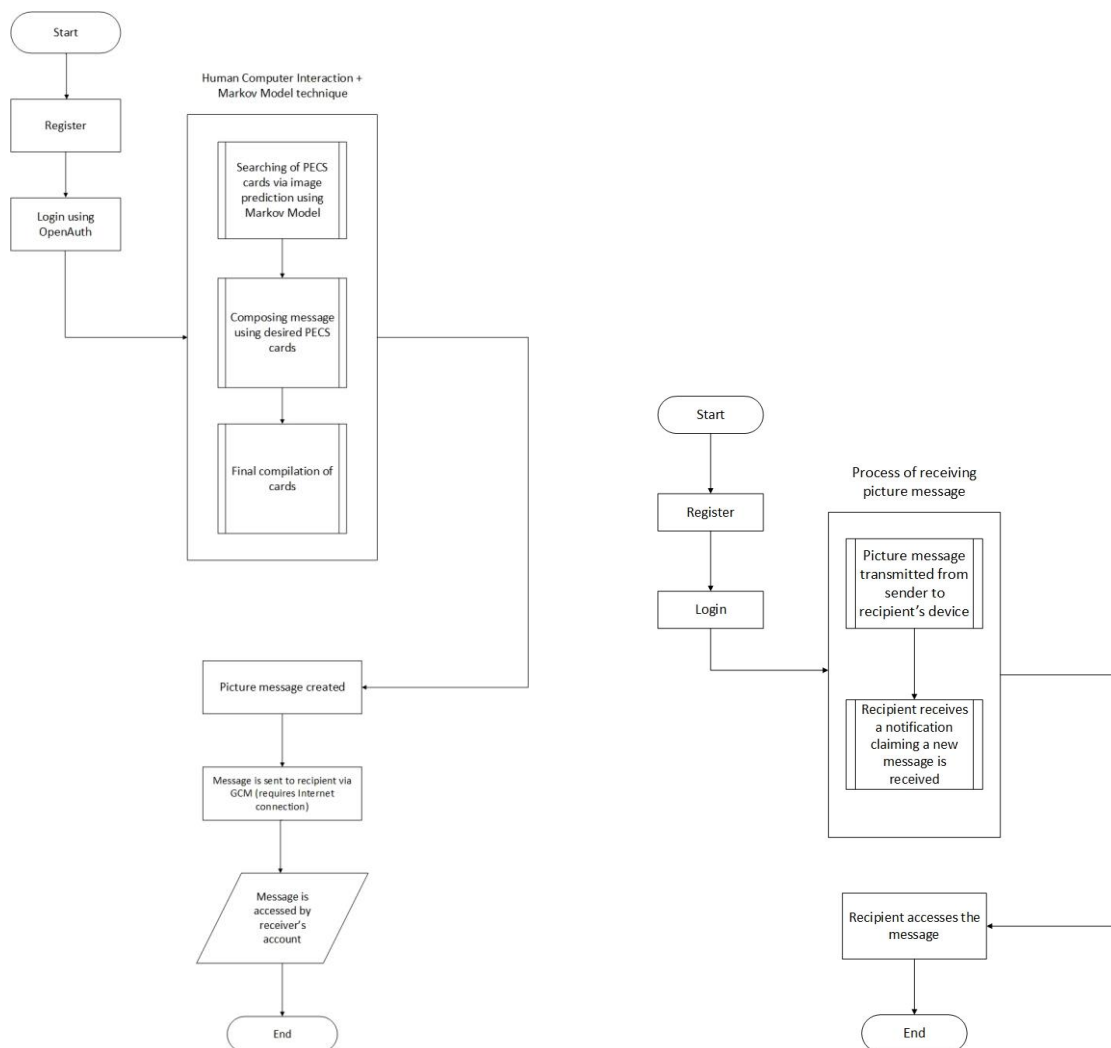
Figure 4. Agile development model.

Prospect is also designed and developed using object-oriented approach because the approach is able to adopt to rapid changes in a dynamic environment [11]. An object-oriented approach is aided with data flow diagrams, which this project uses the standard Unified Modified Language (UML). In UML, class diagram and use-case diagram are the diagrams used extensively to describe the system's modeling and behavior. The class diagram consists of objects and methods that will be declared in the source codes of the proposed application. Meanwhile, use-case describes the operational and step-by-step activities of the components used in the system.

3.1. Planning

The main operation of Prospect begins with the adaptation of PECS. Initially, PECS are physical cards used by individuals with ASD as a way to convey a message to the other recipient. The Prospect application will be using the PECS cards in a digital form where the illustrated set of cards will be embedded into the system. Each card will be supplied with captions describing the illustration on each card. These captions help the user to understand the illustration being displayed on the screen. Via CAL and HCI elements, user finds for the desired card which contains the desired image. Following the search for the preferred image, image prediction is enabled in the system to make it easy for users to find the image without consuming a lot of time. This makes the crafting of the text message faster and similar to the process of a normal individual crafting a message.

Then, the next process will move on to the transmission of the crafted text. The operation is aided via Google Cloud Messaging. If the process is successful, then the text will be transmitted to the recipient's device. The sending and receiving of particular information is similar to sending a regular text message but the only aspect that differs from that method is the usage of PECS digital cards as a primary subject for the whole operation of the system. Figure 5(a) and Figure 5(b) shows the flowcharts for the operation for both parties; sender and recipient.

**Figure 5(a).** Flowchart for sender's operation.**Figure 5(b).** Flowchart for recipient's operation.

3.2. Analysis

A use-case captures the functionality of the system from a user's or actor's perspective [12]. As shown in Figure 6(a), the use cases involved are Register and Login, Select Contact, Compose Message, Send Message and Create New Message. Next, Figure 6(b) shows the activity diagram for Prospect, which shows the sequence of activities in the process, this including sequential and parallel, and the decisions that are being made [11].

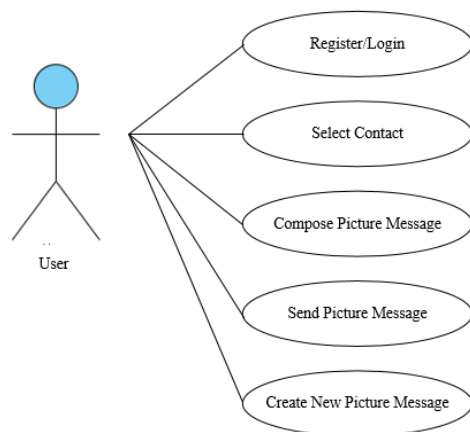


Figure 6(a). Use case diagram.

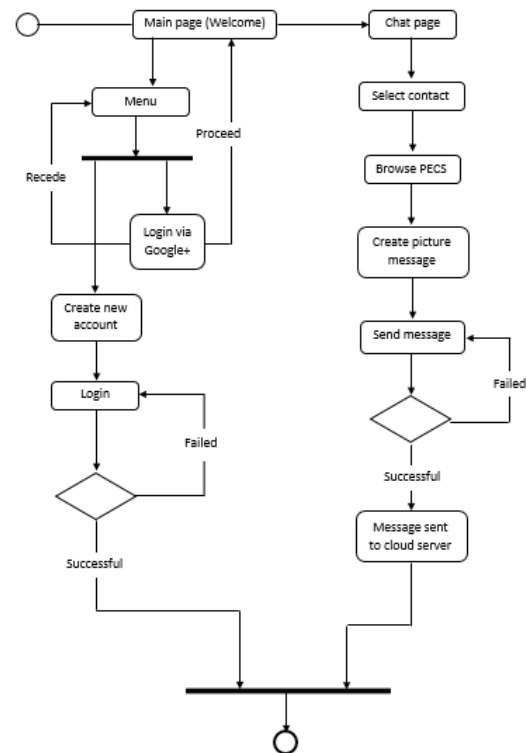


Figure 6(b). Activity diagram.

Based on the figures, it is determined during the analysis phase that an actor also known as the user will create a new account and login using the created account via certain credentials. This is prior to the first register/login use case. Next, user will select the desired contact or recipient based on the select contact use case. The next process is followed by crafting a picture message using the compose message use case and once the message is crafted, the user sends the message from the send message use case. Lastly, user repeats the process of creating a new message and can choose to send it the same recipient or a different contact.

3.3. Design

The design phase is the process of providing a complete description for the interface of an application that is being developed. All the functional features and data that have been analyzed and collected in the previous phase will be used to design a system model for the final implementation. The user interface will be designed via Android Studio IDE aided with Adobe Photoshop for some additional graphical designs. This is to make the user-experience more interactive and intuitive prior to obeying the principles of Human Computer Interaction (HCI). In addition to that, SQLite will be used as the database to store all the necessary information needed for the Prospect application. This phase also recalls all the data collected from the analysis phase and implemented into the design phase.

During this phase, the data dictionary of the Prospect application has also been developed. The schema table describes the data dictionary of a database that is used for the Prospect application. Among the fields involved in the data dictionary are the name of attributes, types of data fields, size of each data and further description for each field. Table 1 describes the data dictionary for the proposed application.

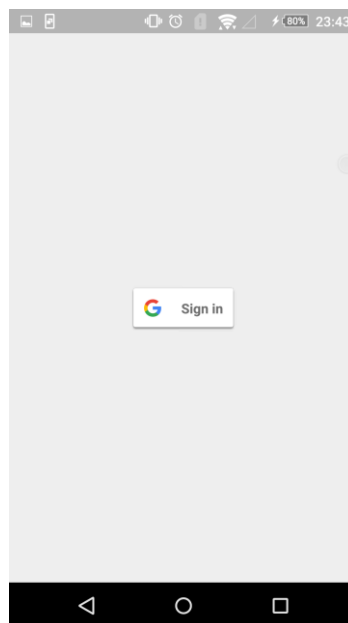
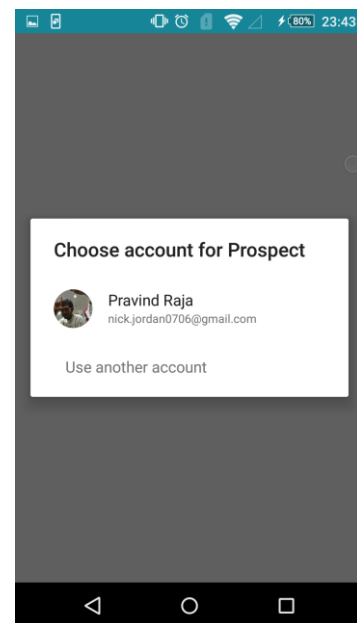
Table 1. Data dictionary for the proposed application

Name of Attributes	Types of Data	Size of Data	Descriptions
Email	varchar	50	Email for login and registration
Password	varchar	50	Password for independent account and login purposes
Firstname	varchar	50	Credentials for registering a new account
Lastname	varchar	50	Credentials for registering a new account
PictureMessage	varchar	2000	The picture message for both sender and recipient's device

4. Prototype Implementation

Android Studio IDE is used as the main Graphical User Interface platform for developing the proposed application, Prospect. It aims at providing an intuitive user experience especially for these Autism Spectrum individuals. MATLAB® software is used as the algorithm where Hidden Markov Model is used for detecting pattern recognition towards the digital PECS cards and these algorithms will be converted to C programming language to be embedded into the Android application.

When user starts the application for the first time, a welcome page will be displayed and user will be redirected to the login page. The login method is accessed via the user's Google Play account. Once the login processes are successful then the application displays the chat page where all similar users who has the application appears on the screen. The interfaces for Prospect are shown in Figure 7.

**Figure 7(a).** Welcome page.**Figure 7(b).** Login page.**Figure 7(c).** Login via Google.

To start composing a message, user simply tap on the space at the bottom of the screen to display the QWERTY keyboard layout and user can craft out their text messages or tap the emoji icon to browse through a selection of emoji. The PECS cards will be embedded into the emoji library and user can choose between a selections of digital cards in order to compose their message. Once the message is crafted, then user will send the message and the process is shown in Figure 8.

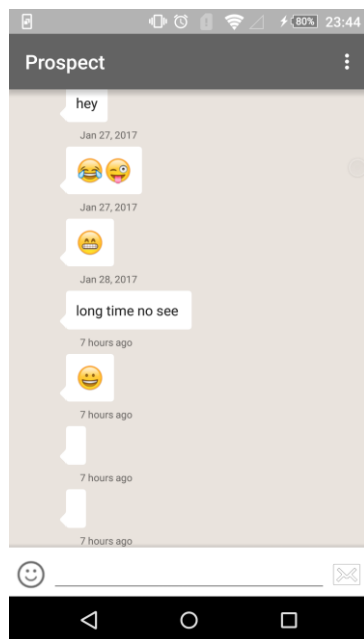


Figure 8(a). Chat page.

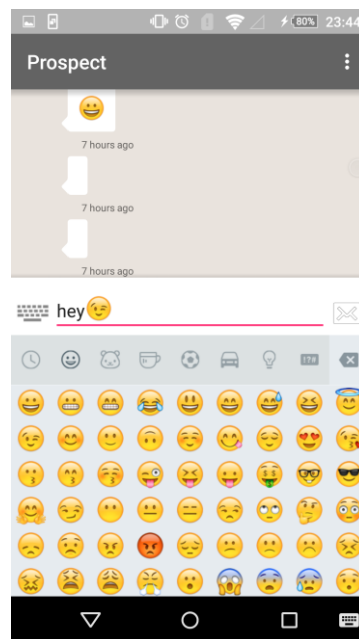


Figure 8(b). Chat menu.

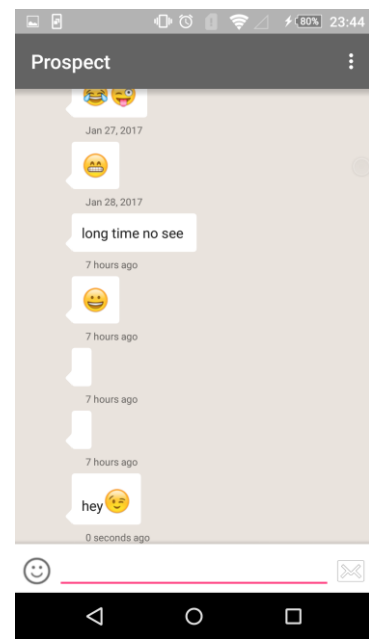


Figure 8(c). Sending message.

5. Conclusions and Future Works

This paper proposed an application called Prospect that is able to establish a communication via Instant Messaging (IM) and send a message to the other partner via the Picture Exchange Communication System (PECS) using a series of pictorial cards. The application was designed in line with the advancement of Human Computer Interaction (HCI) and Computer-Aided Learning (CAL). CAL and HCI play important roles in ensuring the system operates according to the user's desires. Both these elements create a relationship in which a two-way communication between human and machine is established with an expectation of producing a positive outcome.

The benefit of Prospect is three-fold. First, the application allows children diagnosed with ASD to communicate using Instant Messaging (MIM) and at the same time providing a fun yet interactive learning experience. Second, Prospect is hoped to give a positive exposure to technology and networking to the children thus allowing them to improve their communication and language skills in the process. Third and finally, by introducing mobile computing as a new medium for PECS, this application has potential to revolutionize the traditional PECS methods into digital and interactive experience. In the near future, Prospect will be evaluated by a targeted group of end users, which are children between ages 5-12 with ASD and have difficulties in engaging verbal communication.

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