Facial Emotion Recognition for People with Autism

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A project proposal submitted in partial fulfilment of the requirements for the MSc Computer Science

Abstract

This project proposal describes my early research in developing a mobile application to help people with autism to improve facial emotion recognition skills, which is something they tend to have difficulty with. Current methods are not as engaging for the user as they could be, and this is a problem that the application is intended to solve. It will be implemented for Android mobile devices.

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April 2016

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1. Introduction & Background

1.1 Outline of Autism

Autism is a neurodevelopmental disorder that is characterized by communication difficulties, social impairment, and a restricted pattern of interests, with some impairments becoming apparent by 1 year of age [1, p.340]. Autism varies in severity from person to person along a spectrum; people on the severe end may have no speech and extreme learning difficulties, whereas those with milder symptoms may have advanced language abilities but trouble with understanding the rules governing social behaviour. It is because of this variation in symptoms and level of impairment that autism has become known as a spectrum condition. Autism is one of the most common developmental disorders in the world, with approximately one percent of the UK population having been diagnosed with an Autism Spectrum Condition (ASC) [2].

1.2 Therapies for Autism

Since autism was first described in 1943, there have been many therapies developed from different schools of thought to address the behavioural, developmental, and educational impairments that can be found in people with ASC. Due to the variability in the needs of each individual, there is not one particular treatment that has been proven to help all those on the spectrum. However, the focal points of most treatments are improvement of social and communication skills, and minimization of problem behaviour. Other commonalities in these treatments are level of intensity, ranging from 15 - 25 hours per week, and age of commencement being as soon as possible after a child is diagnosed [3, p.75].

1.3 Autism and Facial Emotion Recognition

The human face is central in the expression and communication of emotion, and conveys much information necessary for successful social interaction. Many studies have shown that individuals with ASC experience difficulties with facial emotion recognition [4, p.1]: Neuroimaging studies have revealed that they show reduced activation in areas of the brain that process emotion, and it has been found that attention to faces at 1 year of age was the most reliable discriminator for infants who were later diagnosed with ASC [5, p.256]. Facial emotion recognition impairment is thought to be a significant factor in the social communication issues at the heart of autism [6, p.339] and it is thought that improvement of facial emotion recognition skills in people with ASC could lead to an increase in the frequency with which they engage with other people socially, and thereby have a significant effect on their quality of life [7, p.319].

Figure 1.1: Emotion recognition test for people with ASC from 1986 *[6]*

2. Currently Applied Technology

2.1 Advantages of Technology for Autism Therapy

For several decades, computer software has been developed to help people with ASC improve their strengths and weaknesses. Although the idea of learning social skills from a computer may seem contradictory, extensive research has proven the advantages and efficiency of technologies as support tools for autism therapy, some of which are given below [8, p.593]:

- They enable the creation of a predictable environment that is free from social demands which people with ASC can find stressful
- They allow the user to make choices and direct their own learning, at their own pace
- Motivation for the user to stay attentive can be achieved through specific computerized rewards

2.2 Assessment of Available Technology for Teaching Facial Emotion Recognition

Studies have found that the use of technology can help individuals with ASC to pass tests that assess emotion and there are several software applications currently available that aim to help them improve their facial emotion recognition skills [9, p.1]. Possibly the most extensively tested is *Mind Reading*, the creation of Simon Baron-Cohen, professor of developmental psychopathology at Cambridge University, and director of the Autism Research Centre. *Mind Reading* features a comprehensive set of emotional expressions, and a variety of lessons which help users to learn their meaning. Tests showed that this software application led to significant improvement in the facial emotion recognition skills of people with ASC [8, p.613].

There is little doubt that *Mind Reading* is a valuable learning tool, but there is one particular area of concern: During user-testing of the software, Professor Baron-Cohen noted, "there was a relatively high dropout rate" [8, p.613]. He hypothesized that this could relate to difficulties individuals with autism have with planning ahead and adhering to goals [8, p.614], which may well be a factor, but perhaps the dropout rate could have been lower if the software had been more engaging for the user. This also brings in to question how useful a piece of software can actually be if people do not enjoy using it.

Figure 2.1: Mind Reading *[8, p.595]*

In addition to *Mind Reading*, two other apps that aim to improve facial emotion recognition were examined: *AutismXpress* and *Emotion Select*. Unlike *Mind Reading*, neither has its own independent research basis. Both games are essentially emotion labelling tasks and reading ability is necessary for most effective use. Additionally, *AutismXpress* has a flaw of no audio to announce the selected emotion. A comment regarding *AutismXpress* on Google Play from the mother of a young boy awaiting assessment for ASC summarises why this is a problem: "If only you had a voice to tell him what the faces are as he thinks sleepy is sad".

Figure 2.2: AutismXPress (Android & iOS) [10]

Figure 2.3: Emotion Select (iOS) [11]

3. Problem and Proposed Solution

3.1 Problems with Currently Available Technology

As highlighted in the previous section, a problem with the currently available software applications is that they do not appear to be as engaging to the user as they could be, which may influence how much or how often someone with ASC would choose to use such software. Furthermore, many of the available applications teach too narrow a range of emotions, and reading ability is required to make most effective use of them.

3.2 Proposed Solution

For the reasons given above, I propose to build a game application for individuals with ASC that will help them to improve their facial emotion recognition abilities in a more enjoyable and engaging way than is currently possible. It is not intended to become a replacement for currently available treatments, but to serve as a fun accompaniment. The choice of genre for the proposed game application and its requirements will be elaborated on in the following sections.

3.3 Game Genre

Having examined the various game genres, it was decided that the casual game sub-genre known as the *Matching Tile game* would be most suitable. Games of this genre require the player to manipulate tiles on a grid to make matches, with rewards given for each match. Popular examples from the genre include *Bejeweled* and *Candy Crush Saga*. Reasons for choosing the *Matching Tile game* genre are as follows:

- Simplicity and accessibility: There are few rules and no prior knowledge of video games is necessary [12, p.205].
- Frequent reward: Rewards help children to stay attentive. *Matching Tile games* give frequent rewards and do not punish mistakes [12, p.207].
- Popularity: *Candy Crush Saga* was played 151 billion times within one year of its launch [13].
- Less association with problematic video game behaviour than *Role-Playing games* and *First-Person Shooter games* [14, p.316].
- Complex motor movements not required: People with ASC often have difficulties with motor coordination [15].

Figure 3.1: Tile Matching Game: Bejeweled 2 Deluxe *[12]*

3.4 Game Concept

An 8 x 7 grid is randomly populated with faces, with each face displaying one of five possible emotions for each level of the game (see Figure 3.2). Note that they are populated in such a way so that there are no more than two consecutive horizontal/vertical faces of the same emotion. The user selects adjacent faces to swap in an attempt to create a matching line of three or more faces expressing the same emotion. When such a match occurs the consecutive faces are highlighted, the matched emotion is announced, and a reward is given. In this way the user can enjoy an engaging game whilst simultaneously improving facial emotion recognition skills. Each level of the game will feature five different facial expressions, enabling a wider variety of emotions to be taught throughout the game.

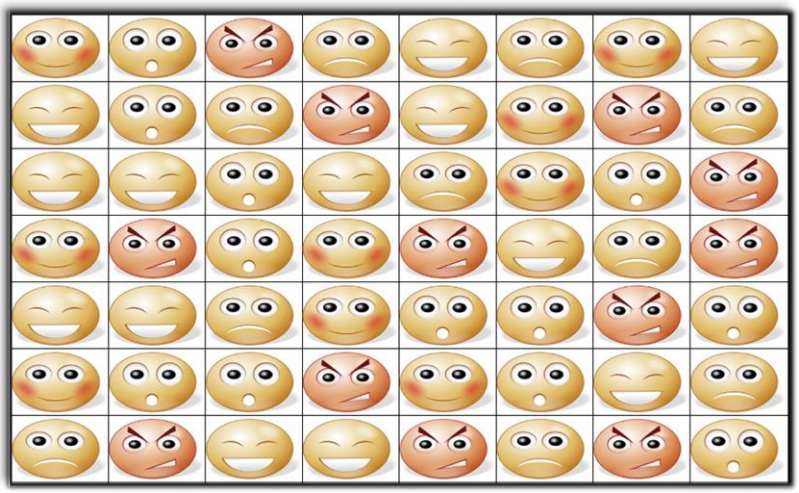

Figure 3.2: Mock-up of Level 1 grid

3.5 User Requirements

A use case flow-of-events for a single swap is given below to gain a clearer understanding of the game logic requirements:

1. Player selects two adjacent faces to swap:
    1.1. If swap results in three or more consecutive matching horizontal/vertical faces:
        1.1.1. Consecutive matching faces are highlighted
        1.1.2. Emotion represented by the matching faces is announced via audio output
        1.1.3. Reward is given
        1.1.4. Consecutive matching faces removed from the board, briefly leaving empty tiles
        1.1.5. Any faces above the empty tiles are shifted down to fill them
        1.1.6.Randomly generated faces fill the subsequent empty tiles at top of board
            1.1.6.1. If new board layout contains more matches, return to step 1.1.1
        1.1.7. Check potential consecutive matches are possible for next turn:
            1.1.7.1. If not, repopulate the board, but any earned rewards are kept
    1.2. If swap does not yield a line of consecutive faces of the same emotion:
        1.2.1.Swapped faces are returned to previous position
2. End of swap

3.6 User Interface Design Considerations

Neurological impairments raise important issues for the design of appropriate user interfaces. Results have shown that people with ASC can be sensitive to some stimuli and that they do not perform as well on rich interfaces [16, p.7775]. It has been shown that children with ASC have a clear preference for colours in the blue and green hue sectors [17]. In addition, an interface that is designed for children should not have any interactive elements around the screen as they can accidentally be tapped upon, interrupting game flow and causing frustration to the user [18]. These considerations will be applied to the game's user interface design.

3.7 Technical Requirements

The below survey from 2013 (see figures 3.3 and 3.4) indicated that the most commonly used devices by children with ASC are tablets and computers, with the most common interface being touchscreen and mouse. A survey taken in 2015 revealed that a third of pre-school children in the UK have their own tablet [19].

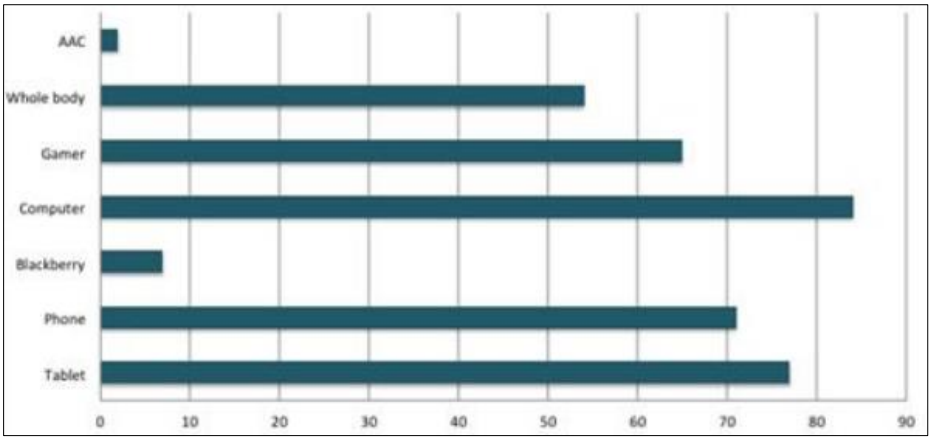

Figure 3.3: What kinds of devices do autistic children use? *[20]*

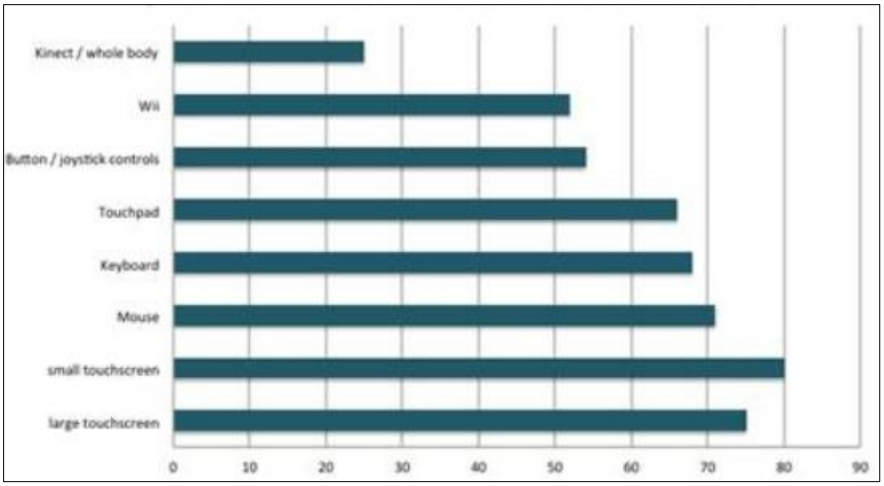

Figure 3.4: What kinds of interfaces can autistic children use? *[20]*

Due to the accessibility of tablets, it was decided that the game should be built as an app for mobile devices. The technical requirements for the game are as follows:

- It shall handle the following media types:
    - .png files for the face images
    - .ogg files for music and the audio stating the matched emotion
- It shall be able to adapt to a variety of screen sizes and pixel densities
- It will save high scores and levels automatically on a server that will be retrievable even if the device is temporarily switched off
- There will be no other buttons or settings reachable from the main game screen
- Any vacant space around the edge of the screen that is not part of the game area will not respond to touch

4. Plan for Developing the Solution

4.1 Early Prototypes

To best inform the decision of whether to make the game available as a native app or a web app, early prototypes have already been implemented in both Android and HTML5. This led to the decision that Android would present less risk than HTML5 as Android applications are written in Java, which is familiar from the Programming in Java module that was taken as part of this MSc. The Android prototype was briefly demonstrated to Dr Gutierrez-Santos during a supervision meeting. A web app may still become part of the project to increase accessibility to the game, and this will be elaborated on in the next section.

4.2 Development Methodology

One of the hallmarks of an Agile methodology is Iterative Planning; the idea that continuing to plan throughout a project is just as important as the plan itself [21]. Iterative planning shall play a strong role in this project. As previously mentioned, first iterations of the game have already been built in both Android and HTML5. The web app may yet feature in the end result of the project, but in consideration of the time constraints, attempting to implement a native app and web app simultaneously is thought to be too high risk. The creation of a web app will therefore only be decided upon after the implementation of an acceptable Android prototype. Frequent iterations shall be delivered throughout as this will allow the most flexibility to the schedule and minimize risk.

4.3 Technology

A SQLite database shall be used for local data storage such as high scores and game state. As SQLite is embedded within the Android operating system a setup procedure is not required which will help to keep things simple [22]. Use of Backend as a Service (BaaS) was considered to connect to backend cloud storage, but the added complexity this would introduce is too high risk.

If the schedule will allow for creation of a web app version of the game, Android's WebView class will be used to display web pages in the native app and to bind JavaScript from a web page to the Android client-side code (see figure 4.1) [23].

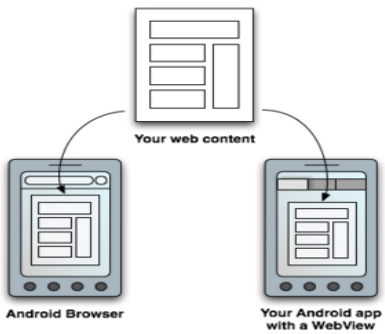

Figure 4.1: Android app displaying web pages with a WebView

Other tools that shall be used are Android Studio, JUnit 4, and Git for version control. HTML5 may also be used, schedule permitting.

4.4 Project Break-down

As the writing of the report is likely to take several months, this will be done as the project progresses, with particular attention being given to it in the last month.

The Java code for the game logic has already been written to fulfil the requirements listed in sections 3.4 and 3.5. An Object-oriented programming approach was used and care was taken to avoid code repetition, keep classes loosely coupled, and to adhere to SOLID principles of good design. However, this is something that has since been studied in further detail with the Software Design and Programming module of this MSc, so it is likely that the code would benefit from refactoring. The Model View Controller pattern shall be used to keep the data (the Model) separate from the view and game logic. This will be of particular benefit if an accompanying web app is built.

For the images used in the game, a graphic designer has given written permission to use her 'Very Emotional Emoticons' for the app [24]. For the audio recordings to announce the matches in the game, my 6-year-old niece allowed me to record some lively audio of her saying each emotion. These have been converted into .ogg files for the game.

Work on the backend of the application will be an early priority, with the aim of producing a working Android app that can store data with SQLite. If this is accomplished with at least five weeks to spare before the deadline, work will begin on a web app that will be used together with Android's WebView and bound with JavaScript.

4.5 Testing

A test-driven approach will be adopted throughout. Regarding User Testing, a request will be made to do this at the Puzzle Centre, which specialises in the treatment of people with ASC.

4.6 Risk Assessment

The development methodology described in section 4.2 will help to minimize risk, but there is still no shortage of things that could go wrong. The backend technologies are unfamiliar and this is something that will require attention early in the project. Furthermore, technology moves fast and technologies that are being relied upon can become no longer supported. There are a range of other things that could set back the schedule, such as myself, family or supervisor becoming sick, or an increase in work commitments.

4.7 Fallback Plans

In the event of something going wrong, the first thing will be to sacrifice some of the app's functionality. In the event of larger problems, the web app idea will be completely abandoned and the focus will be just on the Android app.

5. Concluding Statement

I have proposed to build an application to help people with ASC to learn to recognize emotions in a fun and interactive way. This will be done primarily as an Android application that uses SQLite to store game state on the back end. If a working prototype is completed early enough in the schedule, the plan for the project will be reassessed and construction of a web app will begin. This will be executed with Android's WebView class that allows web pages to be added to a native device and manipulated with JavaScript.

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