Improving Accessibility for Dyslexic Impairments using Augmented Reality

Tushar Gupta, Mudita Sisodia, Schezeen Fazulbhoy, Mitali Raju
Department of Computer Engineering
Mukesh Patel School of Technology, Management and Engineering
Mumbai, India
t2gupta@outlook.com, muditasisodia@gmail.com, schezeenfazulbhoy@gmail.com, mitaliraju8@gmail.com

Abstract—**Dyslexia is a specific learning disability which affects a person's ability to read, spell and understand language while reading or writing. There is a need to improve accessibility for problems faced by the dyslexic. Our system employs Augmented Reality using a smartphone camera in order to overcome these obstacles by enabling user-adjustment of background-text contrast ratio and text customization in real life. After testing the application, we received positive results with a 21.03% decrease in their overall reading time for the text passages. Therefore our application proves to be a great aid in the lives of people suffering from dyslexia.**

Keywords– Accessibility, Augmented Reality, Dyslexia, Optical Character Recognition (OCR)

I. Introduction

Dyslexia, derived from the Greek words 'dys' meaning problem and 'lexia' meaning words or language. Therefore, it literally means difficulty with words. According to [1], approximately 35 million children enrolled in schools in India are dyslexic. Dyslexia cannot be categorized as a disease and it has no cure. It is extremely difficult to diagnose dyslexia due to the lack of standardized techniques. The effects of dyslexia also vary from language to language. A person struggling to read/write in English might be very comfortable with their mother tongue etc. Dyslexia is also known to occur along with other disabilities like dysgraphia, attention deficit disorder, attention deficit hyperactive disorder and visual stress syndrome, making it even more difficult to cope with day to day activities. Dyslexia is not the result of low intelligence [2]. People with dyslexia have individual strengths and weaknesses, each person is unique. Many individuals with dyslexia are creative and have unusual talents in a variety of areas. Many really successful entrepreneurs are known to have this condition. But a lot of times these intelligent kids fail at completing their basic education due to lack of awareness and accessibility to technology.

Although dyslexia is a lifelong condition, it causes the most trouble in children due to their difficulty in coping up with academics. Early diagnosis and catering to the special needs of these children will prove to be very beneficial and life-changing.

There is proof of the fact that presentation of text has a significant effect on the readability of people suffering from dyslexia. Our application is based on this evidence [3]. We will be able to provide people suffering from dyslexia–a way to absorb and consume information in the real world. Presently, there exist tools which help dyslexic people better navigate around the internet, by changing the text to sans-serif fonts, higher contrast ratio between background and the text, and increased letter spacing. We aim to translate these conventional use-cases outside the screen using Augmented Reality and real-time OCR.

Section II runs through our literature survey. In this section our paper reviews the problems faced in dyslexia and it's research, as well as discusses existing applications that help people with dyslexia. The implementation of our application, Augmenta11y, is described in section III. *Augmenta11y* scans real life textual data (for example, a street sign or a billboard) using OCR, which helps render the scanned input available for customization. Customization in terms of font style and size, dyslexia friendly yellow-black contrast and letter spacing variations are provided. A log is also maintained of previously read data for further reference. Furthermore, using Augmented Reality (AR), the computer output is superimposed on the real-life image to ensure enhanced user-interaction with the immediate environment. Section IV presents the results and observations made after testing the application on children with dyslexia. In conclusion we highlighted some gaps in existing research and how we tackled these problems. Section V gives a roadmap of our future work and the improvements we will incorporate in *Augmenta11y*.

II. Related Work

For the purpose of this project, the literature survey and review were conducted to critique, analyse and compare on the basis of the solutions they propose to counter the effects of the disability, as well as any research gaps that were present.

In [2], Luz Rello has described the main challenges of studying dyslexia for web accessibility with respect to impact and limitations. Their research states that dyslexia is impossible to measure accurately, research in this field is not progressing and there is a lot of confusion about the disability. It is also suggested that customized typeface and font size would benefit people with dyslexia.

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Lukes, D states in [4], parameters affecting dyslexia are fonts, colour schemes, text formatting, text size to the amount of text displayed ratio.

In [3], Rello and Baeza-Yates talked mainly about which fonts have been preferred and proven to be more useful to people with dyslexia. Their research suggests that sans serif, monospaced and Roman font styles significantly improved the reading performance over serif, proportional and italic fonts. Their experiment was only based on reading speed and accuracy. As part of their future work, the effect of font types on the comprehension and in different contexts and devices will be studied, on both people with and without dyslexia.

Rello, L., Saggion, H., & Baeza-Yates, R carried out a test in [5], an eye-tracking study with 62 people (31 with dyslexia). They tested whether highlighting keywords in a passage has an impact on readability and comprehensibility. Their results were positive as it was observed that this method improved the comprehension of participants with dyslexia.

A paper published by BrightStarLearning, [4], outlines some of the current scientific theories of the dyslexia disorder and introduces a reading technique, Reader™. Reader™ is a computer-based technological remediation developed by BrightStar Learning that is designed to improve literacy skills by targeting the key magnocellular and cerebellar deficits found in many dyslexics. It is a non-invasive, non-language based technology. A similar ideology is followed in our application as well.

The main inferences drawn from these papers state that dyslexia is a complicated disability in the sense that no two people suffering from this condition would be affected in the same variation. There are a large number of trivial everyday activities that may pass off as normal for a non-dyslexic person but serve as hindrances for those suffering. In [4], these activities have been stated such as :

1. Learning sequenced activities (inconsistent/ unpredictable)
2. Unfamiliar/unusual fonts that are not comfortable on websites
3. Distractions caused by audio/video noises in the scene
4. Reading large blocks of text without any white spaces
5. Difficulty in reading words that appear to swirl together or blur when text-web page contrast is too bright.

We have tried resolving these issues using augmented reality techniques.

III. Implementation

The designed system was built on React Native, a cross-platform mobile application development solution which is maintained by Facebook. It helps developers focus on high level application logic and converts this code into native Android and iOS components. What separates React from other similar frameworks and made it our top choice was it's vibrant open source community, working tirelessly to develop extremely useful third-party packages, without which developing this app would have been much more challenging.

Based on the research and literature review performed in Section II, the application was developed to focus on improving reading comprehension performance for individuals suffering from dyslexia. The main features of the proposed application include:

1. **Real time text detection**: Using asynchronous functions and event listeners, the application provides a seamless experience through *real-time and offline Optical Character Recognition (OCR).*
2. **Customizable font styles**: Our research showed that there's no universal solution in terms of fonts used, sizes, spacing, and contrast. Thus, the app supports a number of options for the user to adjust their experience based on their preferences.
3. **Reader Mode:** Our initial tests showed that reading paragraphs through the application was a pain point, so we added an additional feature which makes the real-time bounding boxes clickable, and opening it in a new screen with clear and bigger text options. This screen also has the option to read the text aloud for the user.

A. Algorithms Implemented

1) Dynamic font sizing

In order to ensure that the rendered font is proportional to the original font, i.e. to fit the bounding box, we had to dynamically set the font size. In the case of a single line of text,

$$fontSize = boxHeight \tag{1}$$

In case of multiple lines of text, to expand to fit the entire box, the height of the bounding box is divided by the number of lines. Out of the quotient, 50% is to be occupied by text and the other 50% will be the vertical spacing between the lines (line height).

$$fontSize = boxHeight/(noOfLines*2) \tag{2}$$

$$lineHeight = x*fontSize \tag{3}$$

Where, x is a multiplication factor set by the user to adjust *lineHeight*. By default, it is set to 1.

Since the bounding box has not been given a hard set height and width, it may expand and contract according to the line height, all while maintaining its proportion.

2) Major Object Detection

This algorithm helps us understand what the emphasis of the current scene is, after which the major objects detected can be localised. It detects all objects present in the scene along with their characteristics like area and density. This response is then stored in descending order. Assuming, the biggest object is the most predominant one and also the region of interest, we display that as the sole major object.

There are cases where objects detected in the scene could be of similar sizes. This is dealt with by looping through the response and checking whether the area of any of the objects scanned is greater than the threshold i.e. 45% of maximum area. If it is greater than the threshold, it is at par with the major object of the scene and is thus treated so itself. However, if its calculated area is lesser than the threshold, it is eliminated in case of major object view. This algorithm helps eliminate small noisy outliers.

3) Stabilization Algorithm

This algorithm was devised to detect similarities between the previous and current scanned input data, so as to determine when re-rendering can be avoided. This helps save processing power. The algorithm works as follows:

1. Store all currently displayed textual data in the *textArray[]*
2. Every time a new response is recorded, Compare the string similarity to existing contents of *textArray[]*
3. If result is less than threshold value (0.6-0.9), go to step 4
4. RE-RENDER next input, update *textArray[]*
5. Else, use current data values of *textArray[]*

B. User Interface

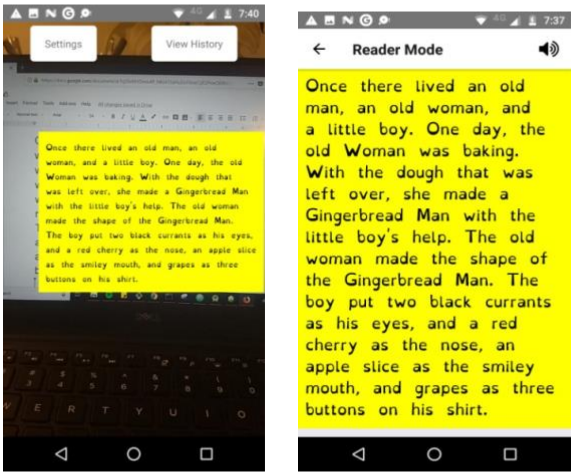

Figure 1. (a) Camera View with Major Object Detection (b) Reader Mode

The user interface of the app was kept to be as minimal and non-intrusive as possible. Every text box is clickable and leads to the Reader Mode. The Settings button on the top opens a modal which allows the user to tweak the styling of the text according to their needs. The History button navigates them to a page that stores a log of all the major text detected and clicked on text.

Augmenta11y was showcased at the Dutch Design Week 2018 held at Eindhoven, Netherlands as a part of Oswald Labs' presentation. Over 300,000 people attend this exhibition every year, and it served as the alpha testing of our app. Based on the preliminary feedback, we were able to better understand our target users – and implement additional features such as the Reader mode, which proved to be a must-have feature in later experiments.

C. Performance Evaluation Metrics

The main parameters that we wanted to test was the change in the reading speed and the students' preferences with respect to the fonts, size, text-to-background contrast ratio and line height.

Two paragraphs were provided for each age group, modeled according to the recommended normal verbal and comprehensive skill levels. Both paragraphs varied from each other based on characters, words and information they contain, for the sake of testing. These paragraphs were be presented to the subjects either in softcopy (on a computer screen, tablet, etc.) or a hardcopy (printed) format.

The first passage was presented to the subjects as it is and the time taken to read it was measured. The second paragraph was then presented to the same subject along with the application to aid the reading. They could interact with the bounding boxes presented and access the read aloud mode as well for better understandability. Again, the time taken to read the passage was recorded

Conducting these tests helped us gain insight on improvements the application brings about in terms of accuracy and time taken. It also helped us better understand which preferences for customization were more useful than the others.

IV. Results And Discussion

The test subjects were a group of students of the ages 12-14 years, with 9 females and 5 males. 11 of the students had a reading disability dyslexia and 3 had dyslexia of miscalculia.

In Figure 2, a two-dimensional bar chart was plotted of the testing results. In most of the cases, the time taken for reading the second passage was found to be lesser than the time taken to read the first passage. For instance, subject 14 took 180 seconds to read the first passage, and 140 seconds to read the second passage. This was made possible through the app and its customized font styling, coupled with a reader mode making the passage much more readable.

On an average, *a decrease of 21.03% in reading time was observed across all the students*. The average difference between a normal reading and one done through the application was 15 seconds.

Moreover, subjects were asked to answer a few questions about their experience using the app, and it was observed that 93% of the subjects agreed that a change in contrast between the background and the text helped improve readability, and

86% of students preferred the yellow background and black text combination over the white background and black text combination.

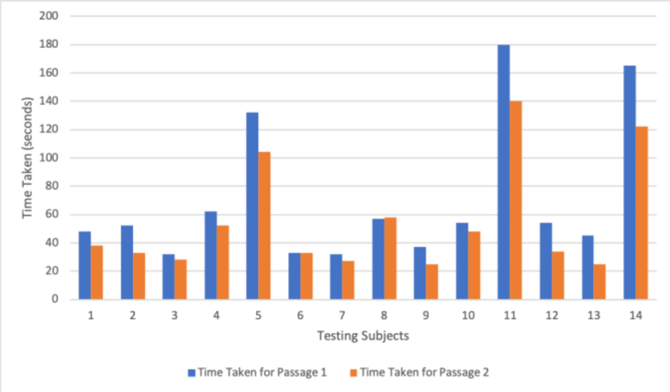

Figure 2. Comparison in Reading Times

Minor glitches in the current prototype, such as overlapping of close-proximity text boxes and overseeing grammatical errors at block-level have been given utmost priority.

V. Conclusion

There are no clear statistics for people with dyslexia as diagnosing it is not trivial. Research says that children with dyslexia seem to benefit from coloured overlays, incurring a stark improvement of 15 seconds in reading time. Small fonts and tweaks like colour contrasts and use of specific fonts have proven to beneficial to them. Thus, there is a pressing need for further testing and research to be conducted with different font styles and settings.

Having shown an astonishing improvement of 21.03% in reading time, this prototype application serves as a tool that not only eases these hindrances presented to individuals with dyslexia, but also makes way for a healthier and richer experience.

The impact created by this application on the targeted community would be immense. There is a dire need for a technologically sound tool, such as *Augmenta11y* that drives improvement, inclusivity as well as ease of accessibility in the lives of the disabled.

VI. Future Work

Testing and building confidence in the essence of this project is an important aspect. Our immediate future plans include conduction more ground research on the finer aspects of the application, with reference to context of what not only theoretically works, but also does so practically. Having completed the initial module, our focus now lies on testing this module in great detail and implementing the intelligence received from the feedback.

Augmenta11y is currently live in beta and is on track for a public release by the end of 2018.

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