Abstract: There are different types of algorithms used in eye tracking technologies. These algorithms are divided into two main categories: feature-based and model-based(Li, Winfield 2005). Feature-based technologies consist of a threshold values which are used to decide the presence or absence of a features or determinant factors. While model-based approach is an iterative search of a model parameter, which is the best fitting model that is a closest match to the image. However, these approaches have significant problems regarding computational speed and accuracy (Li et al. 2005).

Similarly, there are different types of eye – tracking technologies, which depend on different types of technologies such as infrared video cameras and other technologies, which require specific calibration and setup as well as are quite expensive. Therefore, in this paper, we propose an alternative eye – tracking technology using a new eye-tracking algorithm, which is highly portable and independent of any hardware or software systems.

# Introduction:

The history of eye tracking studies is quite old. In 1879, a French ophthalmologist named Emile Java (1839 – 1907) described the movements of the eye during the text reading process. He observed the movements of the eyes during reading of the text using a mirror and stated that eye movements are not continuous rather they are composed of many rapid movements called “saccades” along with stops called “fixations”.

“Photochronograph” was the first non-invasive and quite accurate eye-tracking device developed by Dodge and Cline in 1901 based upon corneal reflection (Dodge 1901). However, the system only tracked the horizontal movements of the eye using a photographic plate (Jacob and Karn, 2003). However, an improvement was made about four years later by an American psychologist named Charles H. Judd, who developed a photo device that could track eye movements in both directions i.e. horizontally and vertically (Shahzad and Mehmood, 2010)

Similarly, Edmund Huey developed an eye tracker device in 1908, using a small contact lens provided with a hole for pupil and an aluminum pointer was connected to lens in order to observe the gaze direction while reading (Edmund Huey, 1908).

Some studies such as the one by Miles Tinker, in 1930 tried to establish relationship between typography and reading using eye-tracking technologies (Tinker, 1963). In 1947, Paul Fitts tried to establish relationship between eye movements and the cognitive activity with the help of a video camera. He tried to record and study the ocular activities of airplane pilots while flights. His study suggested that the fixations were related to the importance of control and duration of fixation were related on how easy the information is interpreted (Russell, 2005). The first head mounted eye – tracker was developed by Hartridge and Thompson in 1948 (Hartridge, 1948).

In the ‘70s, most of the research was focused towards finding relationships between human eye movements and perceptual/cognitive processes (Jacob and Karn, 2003). The entire eye – tracking research took a great and unexpected turn in the ‘80s, with the affordability and availability of personal computers. The researchers had a great instrument for data processing and they could now use it to find out further about eye tracking interactions between humans and computers. This opened huge opportunities for different user groups starting with the people with disabilities as these eye – tracking technologies helped to create more accessible systems (Levine, 1981; Hutchinson 1989). Similarly, this new opportunity was also grabbed by various business organizations such as various marketing groups used these eye tracking technologies to understand further about the reading habits of people which could help to improve advertisements, announcements and product placements in various electronic media such as websites (Leggett, 2010).

The research discussed in this paper, is related to an eye-tracking technology, which can help in the detection of dyslexia through the reading patterns. In this paper, the authors discuss about the design and development of a prototype which can actively monitor or track the eye movements of a reader and based upon the above mentioned eye movements such as fixations, saccades, fixation durations and reading time the prototype can detect dyslexia and also automatically customize the textual content presentation to make the text more accessible for people with dyslexia.

In the first part of this paper, some relevant literate is discussed regarding dyslexia, eye- tracking technologies, eye-movements etc. In the second part, the eye- tracking algorithm, apparatus and procedures are discussed further in detail. In the third part, we discuss about the results. The fourth part consists of a discussion of results leading to conclusions and suggestions for improvements.

# Relevant Literature:

## 2.1 Eye-tracking algorithms:

There are two particular types of eye –tracking algorithms: feature – based and model – based(Li, Winfield, & Parkhurst, 2005). Feature – based eye tracking technologies detect the features of the images corresponding to the position of the eyes. They also consist of a threshold value, which is a decisive criterion for feature-based technologies to determine the presence or absence of a feature or determinant factor. While model-based approach is an iterative search of a model parameter which is a best fitting model which matches closest to the image. However, this approach can cause significant cost in terms of computational speed and accuracy(Li et al., 2005). There are various types of eye tracking technologies using infrared video cameras and other technologies, which require specific calibration and setup as well as are expensive. However, due to new webcam technologies, browser – based eye tracking technologies through simple and common webcams are gaining momentum with increased accuracy.

Starburst is an algorithm that is a combination of feature-based and model-based technologies. The main goal of this algorithm is to find out the location of the pupil center and the corneal reflection to relate vector differences between these measures and the coordinates in the scene images. (Li et al., 2005).

Similar to our eye tracking technology, there have been a few other researches, which have used webcams for eye tracking. One of those studies was a study which used video images of mobile cameras to train neural networks (Baluja & Pomerleau, 1994). Another study with self calibrating eye tracking technology which used webcam consisted of pre-recorded gaze patterns (Alnajar, Gevers, Valenti, & Ghebreab, 2013). Another eye tracking technology called PACE could self calibrated using the user interactions (Huang, Kwok, Ngai, Chan, & Leong, 2016). Unlike these previous technologies, our prototype uses a completely browser – based, self-calibrating and real-time technology which uses gaze-interaction relationships. Another important factor is that our prototype technology can be instantly included into any website for performing gaze tracking tasks.

Pupil detection is another aspect of the eye tracking technology. However, depending on pupil detection as a sole technique could cause failure, therefore, mapping from pixels to gaze location can be used (Xu et al., 2015). However, “TurkerGaze” requires users to stare at calibration points while remaining motionless, which can be unrealistic for real time usage. Another eye movement feature, which plays an important role in the determination of specific eye movement patterns, is the detection of saccade. An algorithm called velocity-based saccade detection algorithm identifies the saccadic velocity peaks. A threshold value is determined such as 75°/s and any motion above the threshold value is considered as a saccade. However, there can be several other factors such as clear speed near the middle of the saccade (Smeets & Hooge, 2003) or the peak saccade velocity cannot be higher than certain threshold (Nyström & Holmqvist, 2010). This algorithm can thus help to distinguish between saccades and fixations. Many commercial software such as BeGaze 2.1 by SMI use this particular algorithm (Holmqvist et al., 2011).

Another commercial software algorithm is ‘Tobii fixation filter’ developed by Olsson (2007) which is used with low speed data using a double window technique(Marple-Horvat, Gilbey, & Hollands, 1996). It uses two sliding windows on opposite sides of the current velocity sample and finds the average velocity within each window. The average values are subtracted to find out if the difference value can exceed a threshold, which can be detected as a saccade. Hidden Markov Model (HMM) is another algorithm to classify data samples into saccades and fixations using probabilistic model, which is based upon velocity information. The I-HMM model (Salvucci & Goldberg, 2000) uses two states, S1 and S2 which represent the velocity distribution of either fixation samples or saccade samples. I-HMM is found to be accurate and robust however, it is very complex and requires many parameters. It needs eight parameters, which are estimated from similar sample data. Besides the two transition parameters for each state, it needs the observation probabilities in the form of velocity distributions. With the model parameters and the sequence of gaze positions, which are to be classified, Vertibi algorithm can be used to map gaze points to states such as fixations or saccades. Due to complexity of HMM it is very difficult to use them in commercial applications, as it requires various parameters that must be set beforehand of its use.

## 2.2 Eye movement studies and Medicine

There have been several researches into auto-detection systems for various purposes including monitoring of patients with Mild Cognitive Impairment (MCI). One such research is by Hayes et al. (2008), which monitored elderly individuals in their homes over a period of time. One group had mild cognitive impairment (MCI) and the control group did not have MCI. Their aim was to discover if such monitoring of activities in the home could give an indicator regarding the onset or deterioration of MCI. They found that the technique of installing wireless sensors in the home was potentially unobtrusive and led to reliable results. This research is a useful proof of concept for our proposed auto-detection system since Hayes et al. (2008) demonstrates that using technology to monitor individuals over time can give useful information about the onset or deterioration of MCI.

A similar concept was explored by Kaye et al. (2011), where the authors looked at installing unobtrusive sensors in the homes of elderly patients with the aim of assessing aging etc.

Furthermore in another study by Dwolatzky et al. (2003) an evaluation of a computer based test system for detecting cognitive impairments was conducted. The authors concluded, based on empirical research, that the software was able to provide quite accurate results. However, the main issue with this kind of software is that it requires users to submit to a series of tests, where the results of these are aggregated to reach a conclusion about cognitive impairment of the user. This kind of testing, while useful in a ‘medical’ context, would not be useful or appropriate for interactive systems used in consumer-oriented technologies.

In a more recent body of work, researchers have begun to explore computerized assessment of cognitive and mental health related conditions. For example, Gutman, Moskovic, and Jeret (2016), investigated the use of computerized testing of cognitive decline in persons with Down’s syndrome and Alzheimer’s disease. According to the authors, the test can be used to reliably quantify cognitive function over time. In a behavioral study of persons with depression, Saeb et al. (2015) explored whether and to what extent mobile phone sensors could be used to detect behaviors linked to depressive symptoms. The authors argue that phone sensors offer the opportunity to monitor mental health conditions such as depression. In another study by Sikka et al. (2015), the authors developed a prototype for automatically detecting and assessing pain in children. The authors argue that through “computer vision” and machine learning, software programs can assess and measure pain using facial recognition. Finally, Rello (2014) , investigated the use of computer based systems as a means for suggesting synonyms for difficult words. This was based on the knowledge that those with dyslexia will have an easier time reading a body of text that uses simpler words and other aids, e.g. certain fonts are known to be better for dyslexic readers etc. The authors tested a type of e-reader with some of these concepts allowing a user to select certain dyslexic-friendly options. However, this work did not examine the option of automatic detection of impairments and then subsequent automatic adaptation of the user’s interaction.

There have also been efforts at detecting dyslexia automatically. One example is a US patent for automatic detection of dyslexia filed by (G. Pavlidis, 1989). This used bespoke equipment to ‘read’ eye movements etc. However, while the ideas were good, the requirement of special equipment would not be suitable for an everyday type of interactive system, which would be potentially used by anyone. Therefore, UNSAID uses research from medicine and rehabilitation science as a basis for examining the feasibility and prospective benefits of an auto-detection and –personalization system for removing barriers to using ICT for persons with cognitive disabilities. UNSAID research focuses on the unobtrusive assessment of dyslexia leading to automatic detection and subsequent auto-adjustments are performed to create an easily accessible and personalized environment.

The use of eye tracking technologies to the fullest extent started with the study of human visual attention during the reading and information processing experiments (Duchowski, 2002). There remains a long history behind the current eye tracking technologies, which dates back to the late 19th century. The first phase of eye tracking studies were conducted between 1879 and 1920 which cemented the foundation of eye movement through discovery of various eye movement patterns such as saccadic suppression, saccade latency, size of perceptual span etc (Duchowski, 2002). The second phase of the development of eye tracking technologies lies between 1930 and 1958 which was a more hands on research period combining the behaviorist movement in experimental psychology (Duchowski, 2002). The third phase remained between 1970 and 1998, which showed improvements in eye movement technologies in terms of accuracy and also became useful as diagnostic and interactive technologies. The diagnostic role consisted of gaining evidence of user’s visual and attentional processes by recording eye movements over some stimulus (Duchowski, 2002). With the advent of new and improved graphical displays, interactive patterns and stronger computational power, eye trackers are also now serving as a powerful means of interaction in an array of devices and applications.

There have been two major focus areas in terms of eye detection technologies: one is eye localization in the image and other is the gaze estimation (Hansen & Ji, 2010). There are three major aspects of eye detection: first is to find out the existence of eyes, second is to determine the location and position of eyes using center of pupil or iris and the third is to track the eyes throughout the video images from frame to frame. Thus detected eyes are used to estimate and track the direct visual scope of a person or the line of sight.

## 2.3 Eye movement studies and Dyslexia

Almost all the eye movement studies are dependent on six major eye movement patterns. These six eye movements are measured in order to determine various conditions:

1. Fixation: the time taken for processing image by Fovea;
2. Saccade: the time taken by fovea to focus its attention from one image to another or the time interval between two fixations
3. Gaze Duration: It includes several fixations and also relatively small amount of time for short saccades between fixations. Therefore, it is the cumulative duration and average spatial location of a series of consecutive fixations inside an area of interest. (Lupu, R. G., and Ungureanu, F. (2013))
4. Area of interest: The area defined by a research team as per their needs such as area of a display device.
5. Scan Path: Spatial arrangement of a sequence of fixations (Lupu, R. G., and Ungureanu, F. (2013))
6. Regressions are right to left movements or movements back to the previously read lines of text(Rayner, 1998).

There have been several studies focusing on cognitive activities and eye movements (Hyönä & Olson, 1995). These studies suggest that the reading patterns of people with and without dyslexia differ in various ways and can be inferred through their eye movement patterns(Hutzler & Wimmer, 2004; Hyönä & Olson, 1995; Rayner, 1998). In one study by Rayner, it is suggested that different aspects of eye movements such as shorter fixations are related to better ability to read whereas longer fixations infer problems with ability to read caused by overload of cognitive processing. Therefore, eye movement differs in dyslexic and non-dyslexic individuals. Many studies have suggested that these eye movements are representative of reading disabilities. However, studies by Tinker (1946, 1958)and (Rayner, 1985, 1998)have shown that eye movements are related to reading disability and are reflections of underlying problems, which may be related to cognition.

In several non-reading tasks it has been shown that people with dyslexia have different patterns of eye movements than those without dyslexia(Eden, Stein, Wood, & Wood, 1995; Pavlidis, 1978). Research by Eden et al. (1995)showed that the eye – movement stability during fixation – was worse in children with dyslexia in comparison to those without dyslexia. However, replication studies have been inconclusive. In reading studies conducted by several researchers it is shown that readers with dyslexia tend to process less parafoveal information during each fixation in comparison to the other readers(Rayner, Murphy, Henderson, & Pollatsek, 1989; Underwood & Zola, 1986).The visual field is categorized into three areas depending on the visual acuity limitations: fovea, parafovea and periphery. Parafoveal region is the 2-5orange, which extends beyond the foveal region to about 15-20 characters. These studies, which include reading and non-reading tasks, suggest that there is an obvious difference in the eye movement patterns of dyslexic and non-dyslexic people. There are different eye movement patterns such as saccades, fixation and regression. Saccades are the continuous eye movements made when reading or looking at objects. Within these saccades, our eyes have momentary fixation moments where they remain still for 200 – 300ms, which are called fixations. Regressions are right to left movements or movements back to the previously read lines of text(Rayner, 1998).

Eye movement patterns of dyslexic readers tend to be different than those without dyslexia in terms of more frequency of fixations with longer durations, shorter saccades and more regressions(Adler-grinberg & Stark, 1978; Borsting, 2002; Eden et al., 1995; Lefton, Nagle, Johnson, & Fisher, 1979; Rello, 2014). The higher number of fixations are representative of dyslexia as people with dyslexia have relative more fixations than non-people with dyslexia(De Luca, Di Pace, Judica, Spinelli, & Zoccolotti, 1999; Hutzler & Wimmer, 2004). Research on reading disabilities has employed eye-tracking technologies, and the data have been employed in various studies regarding reading and information processing tasks(Rayner, 1998).

The literature reviewed in this section suggests that dyslexia is not just a reading disability but that reading disability represents broader and more complex physiological phenomena. In addition, the literature suggests that a cognitive disability may lead to reduction in language processing capabilities, which is seen on the surface as difficulty to read and understand text or language.

Our prototype consisted of two different aspects combined into one technology. The first part was the eye tracking technology and the second one was the automatic adjustment system. Our main objective was to understand the usage of eye tracking technology to distinguish between people with dyslexia from those without dyslexia. Besides this goal, we also needed to focus on some parameters to achieve this objective such as the application had to be simple in design to be accessible for everyone, it had to be non-invasive in nature, it needed to be secure and safe to use and the data that was collected must also be stored securely.

The prototype was based upon the findings from the previous studies, which suggested that the eye movement patterns of people with dyslexia were very different from those without dyslexia. These studies suggested that the reading patterns varied between dyslexic and non-dyslexic individuals.

The same was also true for non-reading tasks as well. These differences of eye movement patterns were displayed by various factors such as regressions, fixations durations, number of fixations and saccades. Although there were some studies conducted prior to our study regarding the effects of these factors on eye movement patterns of dyslexic readers, there was a research gap when it came to technologies which could automatically detect these changes in patterns of eye movements.

# Methods

## 3.1 Participants:

4 dyslexic participants who are all university students were selected. They had different levels of dyslexia, which varied, from simple hindrances while reading to severe hindrances. All participants were Norwegian speakers. Although there are different forms of dyslexia, all of our participants were visual dyslexics.

## 3.2 Apparatus and Procedure

Our prototype is a client-side eye tracking technology, which is completely written in JavaScript and uses various regression models, which match pupil positions, and various other eye features with respect to screen locations during a user interaction session. With the addition of very few lines of JavaScript code, our prototype can be integrated into any other website, software or secondary usage platform and our prototype will be activated to screen and detect dyslexia and provide customizations and suggestions according to the needs of the users.

It is simple in design and this simplicity makes it capable of running in real time in any JavaScript enabled browser. Unlike many other eye tracking solutions, it does not require a calibration model or preliminary calibration sessions, because it is enabled with an automatic learning capability which can learn and map new pupil positions, different eye features in correspondence to the screen coordinates. As mentioned above, our prototype is independent of hardware or software platforms. In terms of hardware, it uses a built-in webcam in any laptop or any other normal webcam to track the eyes. In terms of software, it is written in simple JavaScript, which can be easily used in almost all web platforms. It is easy to use as well as it has been proven to be quite reliable and accurate. The algorithm used for our prototype uses similar underlying factors as the prototype discussed by Papoutsaki et al. (2016). The algorithm uses a new method of storing and analyzing the eye tracking data. As a result of this process, a user can be distinguished as someone who has or has not dyslexia. Similarly, based upon this result, the appearance of textual contents is changed.

### 3.2.1 Pupil Detection:

Our prototype uses three different facial and eye detection libraries namely clmtrackr(Mathias, 2015), js-objectdetect(Garaizar & Guenaga, 2014) and tracking.js(Lundgren, Rocha, Rocha, Carvalho, & Bello, 2015). It detects the eye regions and focuses on the pupil location. For accurate detection of pupil location, a comparative search of the entire regions is done to compare it for the highest contrast. This is done on the basis of the assumption that the iris is circular, darker and pupil is located at its center.

### 3.2.3 Mapping Pupil position on Screen:

To map the pupil on the screen, we use the X and Y coordinates. Here, we need to combine the X and Y coordinates to create a gaze point on the screen. Thus, we can obtain *n=(n1……nN)* pupil locations for which X=(x1…xN) and Y=(y1…yN), where (n1….nN) = (x1 + y1)…..(xN + yN)).

Ridge regression model maps the eye pixels to gaze point locations (Hoerl & Kennard, 1970). As described above in section 2.3, there are various types of eye movements. Among them, the two major eye movements are saccades and visual fixations, which lasts for 200-500ms when eyes focus on a specific area (Rayner, 1998). During this period of fixation, the information is retained for further cognitive processing. Therefore, this period of fixation is used in our ridge regression model.

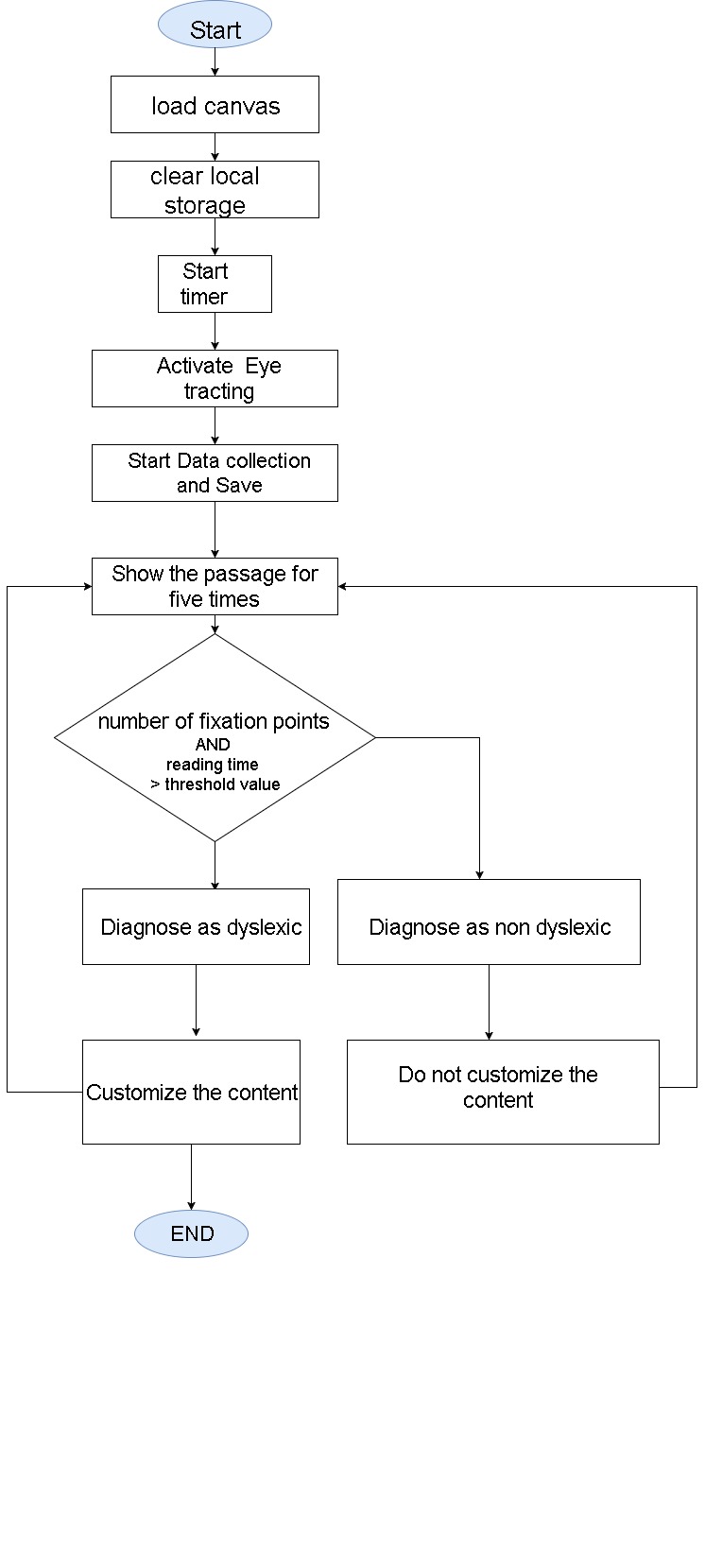
A normal built-in webcam of a laptop was used for the purpose of the user testing. The participants were shown a simple page containing a single passage of text containing 77 words on the screen. Five consecutive passages were shown to each participant.

When the user first initiates the testing, an alert is generated, which informs the user that the webcam is going to be activated and their eye tracking data is going to be stored. Once the user agrees, the user is presented with the first passage and simultaneously the eye tracking data is continuously analyzed. After the user completes reading the passage and triggers an event to move on to the next passage, the eye tracking information from the first passage reading task is analyzed. For every “*n*” pupil location, there is a combination of (x1+y1) coordinates. These coordinate values are stored in the local-storage. This “n” pupil location can give us the number of fixations. If the number of fixations “*n*” is found to be greater than the threshold value, and the reading time is found to be more than the respective threshold then the user is detected to be dyslexic. On the other hand, if the number of fixations and the reading time are found to be less than the threshold values, then the user is not detected as dyslexic. An alert will be generated at the end of the analysis, which will inform the user that he/she is dyslexic, or not. If the user is found to be dyslexic the user will be notified that the appearance of the textual contents will be changed. Once the user agrees, the appearance of the textual contents will be changed in terms of font-size, font-type, line-spacing etc. If the user is not found to be dyslexic the appearance of the text will remain the same.

**Structure of our prototype:**

Our prototype consists of three major parts:

1. Input and storage
2. Processing
3. Output
4. Input and storage: - This part of the prototype is responsible for detecting the eyes and the various movement patterns within the eyes. The eye movement information in terms of number of fixations and the duration of reading time is stored.
5. Processing: The data stored was then analyzed. From various literature and previous experiments logic was derived for the prototype in terms of two particular logic statements for number of fixations and the reading time. In order to obtain better accuracy the two values were interlinked and if both conditions matched then the result would be positive otherwise it would be negative.
6. Output: Once the processing is completed, the output is shown which consists of two things. The first one is the detection of dyslexia, which can be positive or negative. The second thing is the automatic customization of textual contents; if the user is found to have dyslexia then the appearance of the textual contents change otherwise there are no changes. The automatic customizations are set according to the standards set forth by various previous literatures, researches and dyslexia organizations.

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# 4. Results:

From the user – testing with the four participants, 3 out of 4 participants were found to be dyslexic. One participant was not found to be dyslexic since the participant was very slightly affected by dyslexia….. Similarly, we can search for other technologies, which are affordable and can provide the same level of hardware or software independence. Since, most of the eye-tracking technologies are quite expensive, a technology such as our prototype can be an affordable solution to many. One of our participants suggested that incorporation of our prototype in various online news outlets or websites can help the businesses gain more customers, which can be beneficial for the businesses as well as customers. In reality this is quite possible as our prototype can be inserted into any website and it will instantly start working because it is independent of any hardware or software systems.

# 5. Discussion and Conclusion:

There are different medical tests, which are used to detect dyslexia. This process is both time and resource consuming since these tests take a long time. Therefore, many people remain undetected as dyslexics and they have to suffer from various reading disabilities throughout their lives. The Swedish Council on Technology Assessment in Health Care (SBU) has recently presented a systematic review of the scientific evidence for screening and diagnostic tests for children and adolescents with dyslexia(Benfatto et al., 2016). According to this report, most of the tests that are used today lack scientific support. One of the key concerns raised in the report is that the existing test are insufficiently evaluated with respect to their predictive validity, which leads to difficulties to conclude the usefulness of the tests that are in current practice (Benfatto et al., 2016).

Here, we have presented an eye-tracking algorithm, which can detect dyslexia and other similar reading disabilities. The two specific parameters regarding reading such as reading time and number of fixations are extracted and further processed. Each parameter is compared against their respective threshold value and if they are found to exceed the threshold value then the participant is considered to be dyslexic. For the purpose of increasing accuracy, both the parameters must have exceeded the threshold values in order to determine the participant to be dyslexic.

Our prototype is different from other eye-tracking technologies in terms of the innovative concept of detection of eye movements using simple webcams located in a normal laptop. It is also independent of any hardware or software platforms. Most of the previous applications or eye detection technologies, which we came across in our research, were dependent on hardware platforms or software technologies. They also had further issues related to portability and interchange of data due to various data formats. The technologies, which have been developed for detection of dyslexia, are quite new and they still have a long way to go to become completely reliable and accurate as well. The data format used in our prototype is also highly interchangeable.

While we do believe that our prototype is a novel approach towards detection of dyslexia, it is important to state that dyslexia is a multi-faceted disability. There are various types of dyslexia, which vary in terms of phonological deficit, visual and spatial perceptions and cognitive impairments. Many prior researches have debated over the source of dyslexia and its effects. However, in recent years, most of the researches have concluded that dyslexia is a language-based disorder associated with a phonological deficit and it can affect the ability to read, process and comprehend written text(Vellutino, Fletcher, Snowling, & Scanlon, 2004). With the support of these previous research findings, we make an assumption, that the language processing has a direct influence on the eye movements during reading. This assumption has been supported by various researches in the fields of cognitive psychology and psycholinguistics(Rayner, Pollatsek, Ashby, & Clifton Jr, 2012). Therefore, atypical eye movements are although a secondary consequence of dyslexia, eye tracking is an effective means for assessment of the processing demands that subjects experience while reading which creates a sound basis for developing predictive and automated models useful for screening(Benfatto et al., 2016). Similarly, eye tracking during free viewing of natural images and videos have been implemented to differentiate subjects with Parkinson’s disease, schizophrenia and autism spectrum disorders from control subjects(Tseng et al., 2013; Wang et al., 2015).

We believe that this is a novel approach towards detection of dyslexia and further improvements are necessary to refine the detection algorithm. In future, the algorithm can contain multiple parameters related to reading patterns as described above in section 2.3. The user testing can be carried out with higher number of participants to increase validity. Similarly, the user testing should also contain people with different types of dyslexia or other reading disabilities of similar kind. Another approach can be a comparative study between two different types of participants; those who have dyslexia and those who have not.

This study shows that the two parameters: reading time and number of fixations can be used to detect dyslexia. However, further incorporation of several other parameters can increase accuracy. It has also shown that a simple webcam technology can be used for detection of dyslexia. It shows that eye tracking technologies can be made economically viable in the future.

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