The literature survey process was done from two perspectives. First was the medical perspective and second was the technological perspective. For the first perspective, a variety of literatures related to different types of cognitive impairments were studied. DSM-5 (Diagnostic and Statistical Manual of Mental Disorders) was considered as the benchmark for medical diagnostic procedures for mental disorders. In DSM-5, different aspects of medical conditions including symptoms, affects, treatment and interventions were explained in detail. Therefore, various cognitive impairments were studied from DSM-5.

The second perspective is related to technology-based interventions. For the second perspective, several studies regarding technology-based interventions for different types of CIs (cognitive impairments) were studied for this research. These studies reveal different types of CIs and different technologies developed to treat or control them. From these studies, it was evident that they rely heavily on medical technologies such as fMRI, EEF, Invasive surgeries and explorations, Hippocampal shape analysis, SPECT brain images, Boston Naming Test for memory etc. Another finding from the literature review was that the technologies developed are mostly targeted towards time management and memory related issues which is just one dimension of the cognitive impairment. Lastly, the medical tests such as MoCA, MMSE, CAMDEX, CERAD, Boston Naming test, Constructional Praxis, Word List Recall are all dependent on the passive inputs provided by the user. Therefore, there needs to be further research in the field of automatic detection of cognitive impairments.

In terms of technological interventions for CIs, previous studies for detection of cognitive impairment have used various methods such as ASR(Automatic Speech Recognition) (Tóth, Gosztolya, Vincze, Hoffmann, & Szatlóczki, 2015) and eye movements (Lagun, Manzanares, Zola, Buffalo, & Agichtein, 2011). However, the first study focused on the speech pattern problems and the second study focused on the memory impairments leading up to Alzheimer’s diseases. There are very few researches which are targeted for automatic detection of CIs and most of them are targeted for just a single purpose.

There were two types of CIs which we thought needed further research in terms of automatic detection systems. The first one was “Depression” as there have been some researches regarding medical interventions but no specific technology is yet developed in terms of detection or intervention. The interventions are mostly medical and detection process is heavily dependent on invasive and non-invasive medical technologies. Eyes, body posture and speech are used for detection of depression but there are issues regarding accuracy as well as the technological interventions that can be executed after detection. The interventions we came up with were related to manipulation of user interfaces to create a better working environment through automatic adjustment of brightness, color and contrast levels of user interface elements however this was not considered as a viable option as realistically, the preferences for such user interface elements are not changed frequently and probably once they are set they are not adjusted for a long period of time.

Therefore, dyslexia was considered as a viable option. There have been different types of researches for different aspects of dyslexia. However, there is a need for further research to automatically detect dyslexia through eye tracking, speech recognition or keystrokes. In this aspect, several studies regarding viability to use eye tracking for learning disability were done(Rayner, 1998). However, there needs to be a further focused research concerning dyslexia. In our literature survey, we only came across one research which has combined machine learning techniques to use eye movements to detect readers with dyslexia. They used specific equipment called Tobii 1750 which could track eye movements which consisted of a 17 inch TFT monitor. The data obtained from this device was then categorized using a classifier algorithm called LIBSVM(Rello & Ballesteros, 2015). They tested for reading time, fixations and age of participants. This study was targeted for Spanish speakers. The eye movements of people with dyslexia can be distinguished from those without dyslexia in terms of longer and more fixations, shorter saccades and more regression(Rello & Ballesteros, 2015).

Our research focuses on the development of a mobile application/ software which is independent of any hardware system. The built-in webcam of the laptops or mobile phones are used for obtaining visual information unlike the research by Luz Rello and colleagues. Previous literature also discuss about detection of dyslexia but we intend to provide intervention techniques as well. The interventions will be automatic adjustments of font face, font type, font size, colors in terms of text presentation. While in terms of text content, an alternative way to correct spelling errors will be discussed.

The practical implementation has been kicked off and by this moment it is going at the intended pace. The practical implementation consisted of two parts, first one was the detection of eye movements and second one was the intervention system. We are glad to say that we have completed the first part. The eye tracking part including signal processing and data storage of the signals received from the webcam can be easily obtained with the prototype. The second part of the project is undergoing implementation at the moment. The prototype can track the eye movements which is an important part of detection. The eyes reveal the reading patterns of dyslexics. Studies have shown that dyslexics have longer and more fixations, shorter saccades and more regressions. Saccades are continuous eye movements while reading books or watching something which have velocities of 500° per second. Between saccades, eyes remain still for a few moments which last for about 200-300ms which is known as fixation. Dyslexic readers like beginner readers make longer fixations, shorter saccades, more fixations and more regressions than normal readers. These values are being included in the new logic that is being created for the auto detection of dyslexia.

Our prototype is now capable of tracking eye movements and the position of the eye is recorded using “X” and “Y” axis values on a screen. This data is stored in the local storage and can be easily analyzed. Currently, programming is being done to write a logic which can automatically analyze the signals received from the webcam. This logic will also determine the different intervention paths which can adjust various on-screen features including content appearance and layout.

Our prototype consists of a canvas which shows a real time video of tracking of the eyes. When it is first started, it takes just a few seconds to adjust to the position and size of the eyes. Then it can continuously track the movements of the eyes and records position values and time values. A counter is established to record the number of movements as well. The values are recorded to the size of 2MB for now which roughly accounts for around 10 minutes of reading time. This threshold has been kept to minimize the risk of performance delays of the system as well as we intend to detect dyslexia within this threshold time. However, this might be subjected to change when we work further on implementation.

The eye tracking code can be implemented on any given website with a few lines of code. During the first phase of the implementation process, we have done several testing with different types of hardware and software. For example: we have tested with Apple devices, Windows devices, different types of webcams in different devices including external webcams and in-built ones. We have also done mockup tests with different websites by creating test websites and incorporating our prototype into them. The testing reveals consistency in terms of hardware and software independence.

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