Detection of Dyslexic Children Using Machine Learning

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Abstract

From a young age, dyslexic children require specialised instruction in spelling and word analysis. It's crucial to give these kids the right technological writing assistance so they can input material and receive numerous feedback at the same time. It's unclear, nevertheless, how dyslexic kids can effectively use a gaze-based virtual keyboard (VK). In this study, we suggest using a multimodal Hindi languageeye-gaze assisted learning system based on a VK to identify dyslexic youngsters and assist in the elimination of tracking errors for people with writing and reading impairments. Eyetracker, eyetracker with softswitch, and touchscreen as a baseline modality were used to evaluate performance using a pre-established copy-typing task. 32 children participated in a series of trials to validate the system (16 dyslexic and 16 control). The outcomes demonstrate how the system's usability and
burden are significantly

Index Terms: machine learning, eye tracking (ET), dyslexia, eye-gaze-assisted learning system, multimodal interaction and interfaces, virtual keyboard (VK).

I. INTRODUCTION

The prevalence of dyslexia is at least 10% of the global population. The orthographic system, the kind and severity of dyslexia, the age at which reading is evaluated, and the sampling techniques all affect the prevalence [1]. Dyslexia affects how well a person learns the skills necessary for studying (reading), spelling, or writing (or both combined). Lower stage oculomotor skills, such as model, accommodation, and vergence, as well as higher level cognitive strategies, such as attention, memory, and language processing, must be coordinated in order to read and write. An imbalance between these elements could result in a range of learning issues, including dyslexia. A disease of this kind can lead to deficiencies in processing speed as well as problems with sense modalities, motor
skills, and

sequencing. Therefore, while creating input modalities for user interfaces that may be utilised in educational contexts, such as virtual keyboards (VKs), dyslexia should be taken in to user application accomodation

Although the precise causation of dyslexia is uncertain, one of the most widely recognised ideas holds that it is caused by a lack of phonological awareness and inadequate phonological encoding. Additionally, dyslexia has been linked to oculomotor and visual impairments [2]. It is more common in boys than in girls and affects at least 5% of school-age children [3]. It is important to remember that dyslexia is a verbal issue rather than a visual one.However, research has indicated that vision therapy may be helpful for some types of vision issues that can For example, there is a correlation between poor mental health and chronic physical illnesses. Furthermore, there is a significant chance that someone with severe mental illness will also

have long-term physical health issues. Youngsters with dyslexia struggle to recognise words correctly and fluently, and often spell poorly. Since they do not have any sensory impairments, they may not be impacted by the development of reading. The type and speed of learning are influenced by the various cognitive capacities and their strengths.Among them is processing speed, which includes thinking quickly when performing simple visual or aural activities. There have been reports that phonological impairments in children with dyslexia can be improved through testing and training related to auditory and visual processing. Moreover, a display of textual content has For example, there is a correlation between poor mental health and chronic physical illnesses. Furthermore, there is a significant chance that someone with severe mental illness will also have long-term physical health issues. Youngsters with dyslexia struggle to recognise words correctly and fluently, and often spell poorly. Since they do not have any sensory impairments, they may not be impacted by the development of reading. The type and speed of learning are influenced by the various cognitive capacities and their strengths.Among them is processing speed, which includes thinking quickly when performing simple visual or aural activities. There have been reports that phonological impairments in children with dyslexia can be improved through testing and training related to auditory and visual processing. Moreover, a display of textual content has implications for other reading tasks implications for other reading tasks.

SYSTEM OVERVIEW

Description

The following four elements make up the suggested customised assisted learning system.

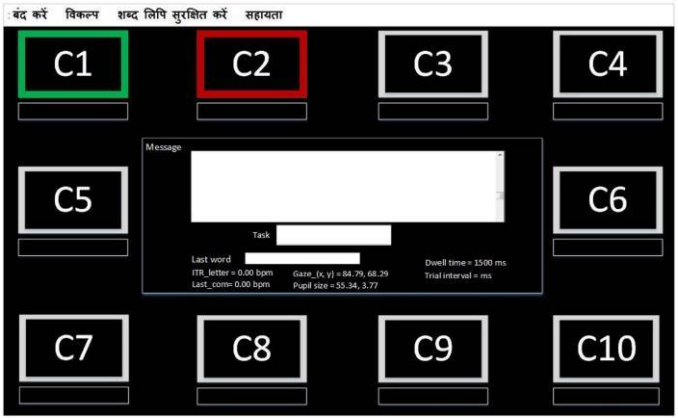
1) A Hindi language VK represented by a graphical user interface (GUI).

2) An eye tracker, a soft switch, and a TS are three unique input modalities combined into a multimodal textual content entry input.

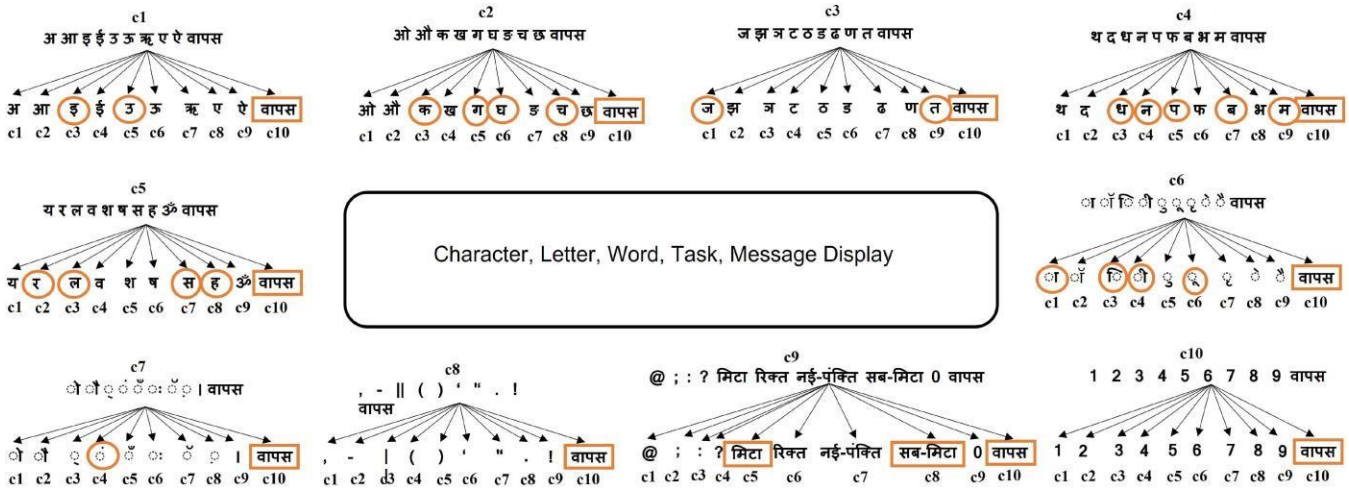
3) A novel multimodal feedback system that processes audio and visual stimuli [8]. Specifically, there are two kinds of visual sensory processing feedbacks with GUI: positive feedbacks for purposeful item selection and negative feedbacks for inadvertent item selection. Depending on whether the gaze is maintained, the button border's colour changes from silver to green (positive feedback) or red (negative feedback).

4) An original typing exercise and children's inherent motivation.

The VK consisting of commands can be Selected by user



The primary level of the GUI incorporates ten orders. Each order is made out of a bunch of ten characters. Character determination requires the client to enter two orders by following two stages. During the initial step, the client needs to pick an order box (at the essential level of the GUI) wherein the ideal person is found. The effective determination of an order box changes the substance of the buttons of the GUI to the subsequent level, where the ten orders at the presentation are relegated to the ten characters, character in a special order box, and at last select it to compose it in the result message show. After the determination of a person at the subsequent level, the GUI returns to the fundamental level (i.e., first level) to work with the following person choice. The framework is intended to compose all the Hindi language letters including half-letter scripts and required punctuation marks. designing a VK application Figure 1: Hierarchical structure illustrating the letter selection command sequence (c1)–(c10). An oval shape is used to highlight the selected characters or letters, and a rectangle shape is used to highlight the commands that are



utilised for correction. The inputted words, tasks, and characters/letters are displayed in the centre box. To help engage the participants, the system displayed feedback comments such as "well-done" or "well-tried" at the end of each assignment based on the typing performance of the children.

Figure 2: Ten instructions (c1)–(c10) in the Hindi language VK are located. Commands C1 and C2 respectively display two sorts of visual feedback: positive for intended item selection and negative for unintentional

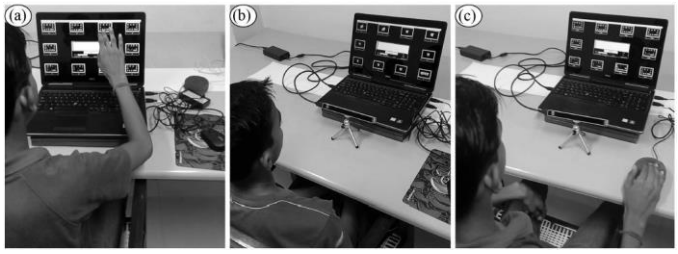
items selection by the user to detect

There are ten commands in the GUI's initial level. Each command consists of a group of 10 When ten words are typed using a modified VK, machine learning can identify youngsters who are dyslexic, and the modality with ET yields the greatest results. The findings imply that typical input modalities like TS and mouse are not the best choices for children with dyslexia and that an ETSS offers an efficient input modality for writing help. The application of both positive and negative feedback should be improved even more to help children with dyslexia overcome their oculomotor deficiencies and high error rate. technological writing assistance so they can input material and receive numerous feedback at the same time. It's unclear, nevertheless, how dyslexic kids can effectively use a gaze-based virtual keyboard (VK). In this work, we suggest using the multimodal Hindi language eye-gaze-assisted learning system based on a VK to identify dyslexic youngsters and assist in the elimination of tracking errors for individuals with writing and reading impairments. Eyetracker, eyetracker with softswitch, and touchscreen as a baseline modality were used to evaluate performance using a pre-established copytyping task.

Each order is made out of a bunch of ten characters. Character choice requires the client to enter two orders by following two stages. During the initial step, the client needs to pick an order box (at the essential level of the GUI) where the ideal person is found. The effective determination of an order box changes the substance of the buttons of the GUI to the subsequent level, where the ten orders at the showcase are relegated

Group	Age	Gender	Handed	Vision Correction
Dyslexic (n=16)	11.05 (1.09)	9 M, 7 F	13 R, 3 L	15 N, 1 Y
Control (n=16)	12.43 (1.03)	12 M, 4 F	14 R, 2 L	13 N, 3 Y

n = sample size; Age = mean (standard deviation); M = Male, F = Female; R = right handed, L = left handed; N = no vision correction, Y = vision correction (wear eyeglasses).



experimental conditions where participants complete the typing task: (a) with the TS modality condition; (b) with the ET modality condition; and (c) with the ETSS modality condition.

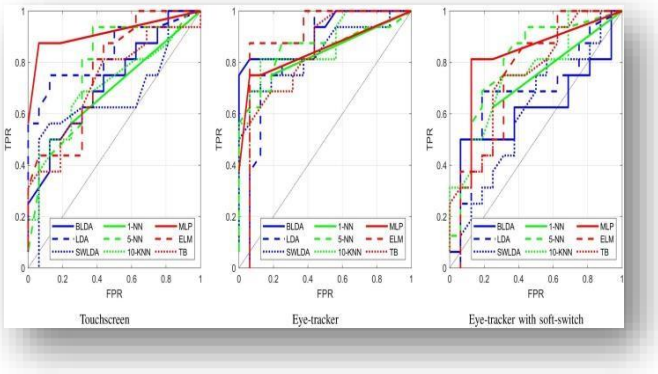
The experimental group was limited to those with a diagnosis of dyslexia and no other medical conditions. The inclusion criteria for the control group included agematched, normally healthy, school-going students without significant learning disabilities. The existence of any user.

The exclusion criterion served as an additional requirement. Two individuals in each group finished the tests with vision correction. Every participant had never used the VK application's input modalities before. Participants were informed about the nature of the task, the technique, and the goal of the study prior to it. The participants in the study did not get any financial assistance. The Helsinki Declaration of 2000 was adhered to in this study's experimentation. Devices for

Multimodal Input

Two input devices are used in this study: a soft-switch device that serves as a single input tool and a portable eye tracker that measures eye gazing

Information Gathering Using an eye-tracker equipment, the eye-gaze signals were recorded at 30 Hz. It uses binocular infrared illumination with a spatial resolution of [0.1 roots mean square (rms)] to capture the pupil diameter (in millimetres) for both eyes as well as the (x,y) coordinates of gaze. A command was selected as a single input using the soft-switch device.During the experiment, subjects were asked to take a seat in a comfortable chair in front of the Dell 15.6-inch PC display panel with a 60 Hz refresh rate and an optimal resolution of 1920 x 1080 pixels (TS). The participant and the PC display screen were around 80 centimetres apart. The observed values of the horizontal and vertical The experimental group was limited to those with a diagnosis of dyslexia and no other medical conditions. matched in age The inclusion criteria for the control group was normal, healthy school attendance without a specific learning problem. The exclusion criterion was the existence of any other condition. Two individuals in each group finished the tests with vision correction. Every participant had never used the VK application's input modalities before. Participants were informed about the nature of the task, the technique, and the goal of the study prior to it. The participants in the study did not get any financial assistance. The Helsinki Declaration of 2000 was adhered to in this study's experimentation.



METHODS

Metrics for Typing Performance

Using techniques from earlier research projects, performance was evaluated by computing the information transfer rate (ITR) and text entry rate (the number of letters spelt out in a minute without any errors in the input text) [22], [28]. ITRcom and ITRletter, respectively, were used to measure the ITR at the command and letter levels. The total number of commands the user has produced to type Nletter characters is represented by the number Ncom. T is the total time needed to type every letter or make a Ncom. There are 88 commands at the letter level (Mletter = 88); there are 10 commands overall (Mcom = 10). The B. Classification and Feature Selection Seven cutting-edge classifiers are used to evaluate how children with and without dyslexia are classified. It is carried out using stepwise LDA (SLDA) [31] and Bayesian LDA (BLDA) [30], two variants of linear discriminant analysis (LDA). base model is used by SLDA, and iterative procedures are then taken to add and remove features from the model. An F-statistic's p-value is calculated at each stage to evaluate

models with and without a prospective feature. We also took into consideration the weighted k-nearest neighbour (k-NN) technique, in which the probability of belonging to one of the two classes based on the k neighbours determines the confidence value for the binary classification. For class 1, the k-NN confidence value is set to negative, whereas for class it is set to positive. We buttons labelled "delete," "clear-all," and "go-back" were utilised as custom commands to fix the mistakes. The ITR presumes

Dyslexia Behavioural Tool and Screening Test The children underwent a dyslexia screening exam to determine whether they had the disorder, and the researchers had access to the test results. The verbal comprehension index (VCI) (similarities, vocabulary, comprehension, information, and word reasoning) and perceptual reasoning index (PRI) (block design, picture concept, matrix reasoning, and picture completion) were measured using the Wechsler Intelligence Scale (WISC-I for Children Personal Assessment The participant's performance on the system usability level is determined using the results of the System Usability Scale (SUS) [36]. The account when evaluating the effort put forth by the participants in the experimental tasks. The user's workload when interacting with the VK application is determined by the mental and physical demands.

RESULTS

Based on the information obtained from the typing experiment, an evaluation of the general overall performance of machine learning techniques, the multimodal VK interface, and feedback was conducted. The special commands were not taken into account while calculating the adjusted error rate for each condition. Although the user made the typing errors, they were fixed at some point during the text entering

The false discovery rate (FDR) correction method was used to conduct a Wilcoxon signed rank test for multiple comparisons on various performance measurements across In this paper, a multimodal virtual keyboard (VK) is proposed as an assisted learning system that can help children with dyslexia with their writing. Numerous factors, including schooling, employment, finances, physical health, social and community ties, and psychological and emotional well-being, can be impacted by dyslexia and its effects on mental health. All of this suggests that long-term physical and mental disorders are closely related, and this should be considered when creating multimodal virtual reality environments. Two sets of kids of comparable ages were used to compare the system. range (about eleven years old). Although the Latin script is the subject of most studies, the Hindi script has unique characteristics: Hindi features a long list of intricate graphemes together with a consistent symbolsound mapping. This study employs a visual keyboard (VK) with an eye tracker for direct communication purposes, such as command selection and the identification of dyslexic youngsters based on typing performance analysis. On the other hand, VKs with ET can offer severely disabled individuals, such as stroke patients undergoing rehabilitation, an other mode of communication [28]. It is also possible to evaluate oculomotor and visual problems with VKs employing ET. Various assessment measures, including typing execution, ease of use, and responsibility, are recommended to assess the varieties inside and between modalities.

CONCLUSION

When ten words are typed using a modified VK, machine learning can identify youngsters who are dyslexic, and the modality with ET yields the greatest results. The findings imply that typical input modalities like TS and mouse are not the best choices for children with dyslexia and that an ETSS offers an efficient input modality for writing help.The

application of both positive and negative feedback should be improved even more to help children with dyslexia overcome their oculomotor deficiencies and high error rate.

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