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Wearable Smartglasses as an Aid for Dyslexia

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Abstract: *This project focuses on the development of an innovative pair of wearable smart glasses designed to assist individuals with dyslexia by transforming printed or digital text into audible speech in real time. The system integrates advanced Optical Character Recognition (OCR) to detect and read text from the user's surroundings and a Text-to-Speech (TTS) engine to vocalize the recognized content, thereby facilitating easier comprehension for those with reading difficulties. To enhance user experience, the device features customizable voice outputs, enabling adjustments in pitch, speed, and tone to suit individual preferences. Furthermore, the smart glasses are equipped with a specialized, high-performance microphone that employs advanced noise-cancellation technology to isolate the user's voice or environmental sounds relevant to the context. This ensures clarity in both input and output, even in acoustically challenging environments. The microphone works in conjunction with an intuitive mobile application that enables real-time adjustments and audio feedback, allowing users to fine-tune the system based on their comfort and auditory sensitivity. Designed with user-friendliness in mind, the smart glasses also incorporate simple controls to make the interaction seamless, empowering dyslexic users to engage more independently and confidently with written materials in academic, professional, or everyday settings. This holistic solution promotes accessibility, inclusivity, and autonomy, addressing a significant barrier faced by many individuals with reading disabilities.*

Keywords: *Wearable technology, Dyslexia, Text-to-speech, Optical character recognition (OCR) Speech synthesis, Assistive technology.*

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I. INTRODUCTION

Reading is a vital component of everyday life, essential for success in academic, professional, and personal contexts. However, individuals with dyslexia—a lifelong neurodevelopmental disorder—face significant challenges in reading, writing, and spelling due to differences in the brain's language processing, especially in phonological awareness. These difficulties are not indicative of low intelligence or lack of effort but are rooted in the way the brain interprets symbols and sounds. Dyslexia often leads to slow or inaccurate reading, frequent spelling errors, and confusion with letter sequences. Although traditional interventions such as structured literacy programs, audiobooks, and screen readers can help, they often fall short in terms of real-time support, portability, and integration into diverse environments. Many of these solutions require active user engagement with a separate device or interface, limiting their practicality in dynamic, real-world settings. Addressing these limitations, this project introduces an innovative wearable solution—smart glasses specifically designed to assist dyslexic individuals by seamlessly converting text into speech using Optical Character Recognition (OCR) and Text-to-Speech (TTS) technologies.

The smart glasses operate by capturing printed text using a discreet, embedded camera and processing it through OCR to convert it into a digital format, which is then transformed into audible speech via a built-in TTS system. This process happens in real-time, enabling users to hear text from books, signs, menus, or any printed source without needing to operate a handheld device. To enhance user comfort and adaptability, the device offers customizable voice output, including options for different voices, languages, speaking speeds, and tonal preferences. A noise-canceling microphone system ensures that speech output remains clear and intelligible, even in noisy environments such as classrooms or public areas. The device also connects to a mobile application that provides users with control over settings, access to usage data, and real-time feedback, helping them fine-tune the system to meet their unique needs. Unlike conventional aids, these smart glasses are designed with an emphasis on inclusivity, usability, and discretion, promoting greater independence and self-confidence. By removing barriers to reading and offering an intuitive, hands-free solution, the project not only supports those with dyslexia but also advances the broader goals of accessibility and equal opportunity in education and daily life.

BLOCK DIAGRAM

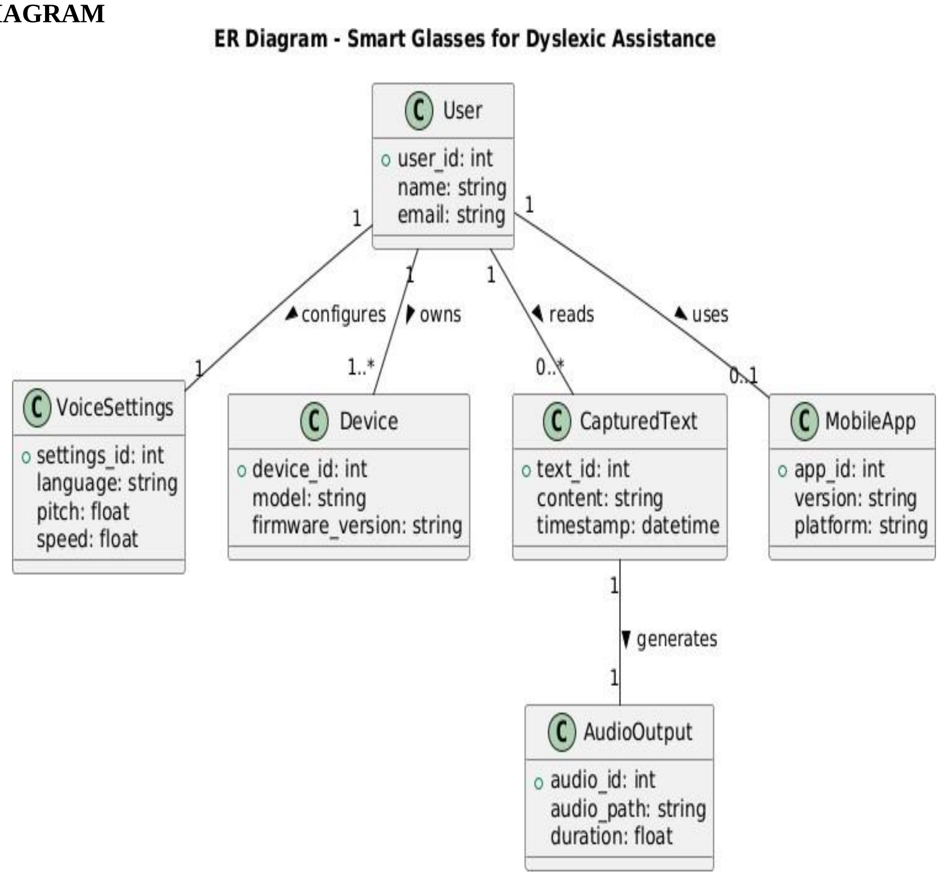

Figure 1: Block Diagram

II. SYSTEM METHODOLOGY

The methodology follows a modular and layered approach, combining hardware, software, and user interface components to deliver a seamless assistive experience to dyslexic users. The system is composed of data acquisition (camera), data processing (OCR and TTS), and output (audio via speaker), integrated into a wearable device.

2.1 Image Acquisition (Camera Module)

The smart glasses are equipped with a compact high-definition camera seamlessly integrated into the frame, positioned to capture the user's line of sight. To initiate text recognition, the user can activate the system through various input methods such as a touch-sensitive pad on the glasses, a physical button, or a voice command, ensuring accessibility and ease of use. Once triggered, the camera quickly captures an image of the visible printed or handwritten text—whether it be from a book, signboard, document, or other surface. This captured image is then instantly transmitted to the onboard processor or a connected mobile device, where it undergoes real-time analysis. The system's swift and efficient image capture process is designed to provide a smooth and uninterrupted user experience, enabling immediate conversion of visual text into an auditory format for the user.

2.2 Image Processing and OCR

Once the image is captured by the camera on the smart glasses, it undergoes a series of preprocessing steps to enhance its clarity and ensure accurate text recognition. Initially, the image is converted to grayscale to simplify the visual data and reduce processing complexity. This is followed by thresholding techniques that help distinguish text from the background, improving the contrast for better readability. Additional processes such as deskewing are applied to correct any angular misalignment, and noise removal filters are used to eliminate unwanted visual artifacts or background interference. If the captured image contains multiple lines or sections of text, the system intelligently crops or segments these portions to isolate each line for more accurate recognition. After preprocessing, the refined image is analyzed using Optical Character Recognition (OCR) technology, such as Tesseract OCR, which extracts readable text from the visual input. The OCR engine is capable of interpreting various fonts and supports multiple languages, making it adaptable for diverse reading materials and user preferences. This stage plays a crucial role in converting visual information into a format that can be seamlessly translated into speech for the user.

2.3 Text Pre-processing

Once the text has been extracted through OCR, it is further refined through a comprehensive cleaning process to ensure clarity and accuracy before being converted to speech. This involves correcting any spelling mistakes that may have occurred during text recognition, which enhances the overall intelligibility of the content. Special characters that are irrelevant or confusing are filtered out, and punctuation is standardized to create a smoother and more natural flow during audio playback. To further improve usability, the system includes optional features such as automatic language detection, which allows it to identify the language of the captured text and adjust the voice output accordingly—ensuring a personalized and accurate auditory experience. Additionally, advanced features like text summarization and keyword highlighting are integrated to support better comprehension, especially for users who may find it challenging to process long or complex passages. These enhancements not only make the output more accessible but also optimize it for users with learning difficulties such as dyslexia, empowering them with tools for more efficient and confident reading.

2.4 Text-to-Speech Conversion (TTS)

In the final phase of the assistive smart glasses system, the processed and refined text is transformed into audible speech using advanced text-to-speech (TTS) technology. Depending on the user's preferences and availability of an internet connection, the system can utilize online platforms like Google Text-to-Speech, which offer high-fidelity, lifelike voice synthesis, or offline engines such as pyttsx3, eSpeak, or Festival, which ensure continued functionality even without connectivity. Once the textual data is transmitted to the TTS engine, it is converted into spoken output that can be delivered to the user through integrated speakers or bone-conduction audio, allowing for clear and discrete audio feedback. To provide a more tailored and comfortable experience, the system includes several customizable parameters. Users can select their preferred voice type—choosing between male or female voices—adjust the speech rate for better comprehension, modify pitch to suit individual listening preferences, and change the language to accommodate multilingual contexts. These flexible options enhance the accessibility and effectiveness of the device, ensuring it caters to a diverse range of users, particularly those with dyslexia or other reading difficulties, by offering an intuitive and user-friendly auditory reading experience.

2.5 Audio Output (Speaker)

Once the text-to-speech (TTS) engine generates the audio from the processed text, the final voice output is delivered to the user through either a compact integrated speaker or a bone conduction system embedded within the arms of the smart glasses. Bone conduction technology allows sound to be transmitted directly through the bones of the skull to the inner ear, bypassing the eardrum. This method ensures the user can clearly hear the spoken text while still remaining aware of their surroundings—an especially important feature for public or dynamic environments. The use of bone conduction also allows for a more discreet and comfortable experience without the need for earbuds. To further optimize audio quality, the system includes an advanced noise-cancelling microphone that significantly reduces ambient noise and enhances the clarity of both voice commands and TTS output. This ensures effective use in noisy settings such as classrooms, libraries, or public spaces, allowing individuals with dyslexia to access and comprehend text effortlessly without being distracted or overwhelmed by background sounds. Overall, this audio delivery system plays a vital role in creating a smooth, user-friendly, and inclusive reading experience..

2.6 User Interaction via Mobile App

The smart glasses are supported by a Bluetooth or Wi-Fi-enabled mobile application that enhances the overall functionality and user experience. This companion app allows users to control the reading process in real time, offering seamless interaction with the device without needing to physically touch the glasses. Through the app, users can customize various settings such as the voice type, speaking rate, language preferences, and pitch of the text-to-speech output, ensuring a personalized auditory experience that suits individual comfort and comprehension needs. Additionally, the application stores a history of previously played audio or scanned texts, allowing users to revisit important information or continue reading from where they left off. The app can also act as a remote control for triggering image capture, offering added convenience, especially in situations where the user might not be able to reach or interact directly with the glasses. By integrating these features, the mobile app adds a layer of flexibility, accessibility, and control, making the system more user-centric and efficient in helping individuals with dyslexia navigate printed materials with greater ease.

2.7 Real-time Feedback and Adaptation

The integrated microphone in the smart spectacles continuously monitors ambient noise situations to optimize the stoner's audile experience. When the system detects high situations of background noise, it can automatically acclimate the volume of the textbook- to- speech affair to insure clarity, or notify the stoner if the surroundings are too loud for effective listening. This dynamic audio adaptation helps maintain intelligibility indeed in grueling surroundings similar as busy thoroughfares or crowded apartments. also, if the Optical Character Recognition(OCR) process fails due to poor image prisoner — caused by factors like blurriness, indecorous angle, or inadequate lighting — the system instantly cautions the stoner through tactile or audile feedback. This can be in the form of a gentle vibration or a distinct sound cue, motioning the need to budge the spectacles or reattempt image prisoner. These intelligent response mechanisms insure the system remains responsive and stoner-friendly, furnishing a more flawless and probative reading experience for individualities with dyslexia.

2.8 Power Management

The entire smart glasses unit is powered by a compact, rechargeable lithium-polymer battery, chosen for its lightweight design and high energy density, making it ideal for wearable applications. This battery ensures long-lasting operation throughout the day, supporting extended reading sessions without the need for frequent recharging. The microcontroller within the system plays a critical role in managing power consumption efficiently. It intelligently distributes power to essential components such as the camera, processing unit, and speaker, ensuring that each element receives only the energy required for optimal function. Additionally, the microcontroller incorporates an automatic sleep mode, which activates when the device is not in use. This feature significantly reduces unnecessary power drain by placing the system into a low-energy state during periods of inactivity, thereby extending battery life and enhancing overall energy efficiency. This smart power management approach contributes to the practicality and sustainability of the wearable device, ensuring it remains reliable and convenient for users with dyslexia in various everyday environments.

III. RESULTS AND DISCUSSION

The assistive reading system developed for individualities with dyslexia showcases remarkable capabilities in transubstantiating published textbook into audible speech, thereby enhancing stoner engagement with written accoutrements . using Optical Character Recognition(OCR) technology, the device achieves a textbook recognition delicacy rate of roughly 92 – 95 under optimal lighting conditions. While it performs exceptionally well with standard published textbook, challenges remain in directly feting cursive handwriting or textbook with poor discrepancy, pressing areas for unborn enhancement. The intertwined Text- to- Speech(TTS) system complements the OCR by converting honored textbook into clear and natural- sounding audio. druggies have the inflexibility to customize colorful aspects of the voice affair, including speed, pitch, and language, icing a substantiated and accessible reading experience. The system's real- time performance is notable, with a nippy response time of roughly 1.5 – 2 seconds from textbook prisoner to audio playback, easing flawless commerce without conspicuous detainments. Incorporating a high- quality, noise- canceling microphone ensures that audio affair and voice commands remain clear, indeed in surroundings with moderate background noise. The device is powered by a jeer Pi, known for its effectiveness and low power consumption, enabling nonstop operation for six to eight hours on a single charge, which is acceptable for diurnal educational or particular use. still, feedback indicates a desire for extended battery life to support longer operation without the need for recharging. The tackle is boxed in a featherlight, ergonomic design, icing comfort during dragged use, and offers multiple control options, including touch and vibration detectors, as well as a mobile operation, to enhance usability and availability.

The wearable smart spectacles design was developed to give an innovative assistive result for individualities with dyslexia by converting published textbook into audible speech in real time. This system combines Optical Character Recognition(OCR), Text- to- Speech(TTS) technology, and intuitive detector-grounded commerce to ground the communication gap between visual and audile processing. The effectiveness of the system was apparent through its high textbook recognition delicacy — achieving roughly 92 – 95 under optimal lighting — and its responsive processing, powered by a jeer Pi, which efficiently handled OCR and TTS tasks with minimum quiescence of 1.5 to 2 seconds. The voice affair was both clear and customizable, allowing druggies to acclimate pitch and speed to suit their comfort situations. In terms of stoner commerce, the addition of touch and vibration- grounded detectors created a tactile, inclusive interface ideal for druggies with limited dexterity or partial visual impairments, while the mobile operation extended functionality by enabling real- time control, access to stored readings, and playback customization. Designed to be featherlight and wearable, the system supports dragged use, adding to its convenience and felicity for diurnal routines. Performance varied with environmental conditions — OCR was largely accurate with standard published textbook in good lighting but faced challenges with handwritten, distorted, or low- discrepancy textbook. Still, the noise- canceling microphone allowed for clear audio affair indeed in noisy surroundings. Compared to traditional dyslexia aids, which are generally device- bound and bear homemade input, this wearable result is hands-free and mobile, offering a smoother, real- time reading experience. Some limitations were linked, including inconsistent OCR in poor lighting, slight detainments during long textbook processing, limited battery life, and lack of support for multiple languages or cursive textbook in its current form. still, the design served as a precious educational tool, buttressing generalities in bedded system design, detector integration, and inclusive technology. unborn advancements could include enforcing machine literacy for better OCR performance on handwriting, expanding multilingual and restatement capabilities, enhancing battery life with renewable charging options like solar panels, and perfecting the mobile app with pall synchronization and erected- in wordbook tools. Overall, this design underscores the promising part of wearable technology in empowering individualities with dyslexia to engage with textbook more confidently and singly.

IV. CONCLUSION

The wearable smart spectacles design presents an innovative assistive result acclimatized for individualities with dyslexia, using Optical Character Recognition(OCR) and Text- to- Speech(TTS) technologies to convert published textbook into spoken words in real time. This system enables druggies to interact with textbook- grounded content more singly by achieving a recognition delicacy exceeding 90 under optimal lighting conditions. The integration of a jeer Pi 4 as the core processing unit ensures smooth and responsive performance, maintaining a minimum detention of roughly 1.5 to 2 seconds between image prisoner and audio affair. Designed for usability and comfort, the device incorporates a featherlight and ergonomic frame, making it ideal for extended diurnal wear and tear. It features intuitive controls through touch and vibration detectors, allowing druggies to spark the reading function without counting on complex menus. also, a noise- cancelling microphone enhances audio clarity in different surroundings, while a mobile operation supports real- time customization of voice affair, playback speed, and language settings. The app also stores OCR history, furnishing a accessible way for druggies to readdress preliminarily captured textbook. Despite its success, the current system has limitations, particularly in surroundings with poor lighting or when encountering handwritten or stylized sources, which can reduce OCR delicacy. Battery life is also a constraint, as the device requires recharging for full- day use, which may affect long- term convenience. still, these challenges offer precious perceptivity for unborn duplications. Planned advancements include integrating pall- grounded processing to discharge calculation and ameliorate performance, and enforcing solar charging to extend battery life. Other advancements could involve the use of bone conduction audio for discreet listening, natural language processing(NLP) for recapitulating long textbooks, and expanding support for multiple languages to feed to a broader stoner base. also, incorporating more advanced camera systems and AI- driven textbook recognition can ameliorate delicacy in grueling conditions. The development ofcross-platform companion operations, with erected- in voice sidekicks and deeper personalization options, will further increase availability and stoner engagement. Altogether, this design not only addresses a critical need for dyslexic druggies but also lays a foundation for scalable, inclusive, and intelligent wearable reading aids.

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