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Navigating the Intersection of Visual Impairment & Artificial Intelligence: A Deep Dive into Empowerment, Prospects & Future Challenges

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ABSTRACT

The ongoing developments in Artificial Intelligence (AI) have created the possibility of developing new solutions to increase accessibility, autonomy, and inclusion for Visually Impaired (VI) individuals. In this paper, we have tried to visualize possible AI-assisted solutions in the fields of education, employment, and independent living.

Artificial Intelligence can provide accessible interactive learning products that would raise the overall quality of the learning experience of VI students and greatly improve their learning outcomes. In addition, these products will make it possible for VI students to pursue areas of study that are considered out-of-bounds due to a lack of accessible educational material.

AI-powered screen readers and voice-controlled interfaces in the workplace can enhance accessibility in the workplace enabling the VI employees to compete for jobs on par with their sighted counterparts and enable them to access a wider range of job opportunities.

But the development of AI is a double-edged sword and if care is not taken, the developments in Artificial Intelligence can result in further marginalization of VI individuals. In the second part of this paper, we have suggested steps or precautions to be taken to ensure that the negative effects are minimized. These precautions include taking care that the training material used to train AI tools is free of biases against persons with visual impairment, integrating inclusive development principles in the development of AI tools right from the inception stage, and ensuring that the AI tools are affordable.

Keywords: *Artificial Intelligence (AI); Education; Employment; Accessibility; Inclusivity*

INTRODUCTION

What is AI?

With the launch of Chat GPT, the term, Artificial Intelligence, entered into public use. Today, we have many AI-driven resources, including Gemini, Klaud, etc. But let us first understand the meaning of the term AI.

The Encyclopedia Brittanica defines the term Artificial Intelligence (AI) as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings" (1)

The term, AI is frequently applied to projects aimed at developing systems which have processes similar to intellectual processes in humans including the ability to reason, discover meaning, generalize or learn from experience.

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Importance of AI in supporting the blind

AI has emerged as a powerful & versatile tool for empowering the blind. AI-powered tools can improve the quality of life & opportunities for the blind in many fields, including jobs & education. Some of the benefits of AI for the blind include

a) Voice assistants that enable speech-based interaction with digital devices
b) Real-time object recognition to provide a picture of one's surroundings, people & text.
c) Navigation & mobility by providing step-by-step directions to reach one's destination & real-time obstacle detection
d) Translating text into braille using electronic braille readers for braille users & converting braille into normal text to facilitate communication with non-blind people
e) AI powered wearable devices including smart glasses to provide real-time descriptions of one's environment
f) AI powered educational tools make educational material accessible, allowing blind students to participate in classroom discussions & online courses
g) AI powered virtual assistants & chat bits provide emotional support, reducing feelings of loneliness among the blind.

In summary, AI tools provide immense help to the blind, enabling them to participate on par with their non-blind colleagues & help in the social, financial & emotional integration of blind persons into society.

BENEFITS OF AI FOR THE BLIND

In Jobs

AI powered tools that enhance job opportunities for the blind

AI powered tools have greatly increased job opportunities for the blind. These tools have increased the types of jobs that can be performed by the blind by making previously inaccessible tasks accessible & improving the effectiveness of existing accessibility solutions.

Some of the AI-powered tools that will increase job opportunities shortly include

a) Generative AI can be used for inclusive job designing, enabling employers to accommodate the unique needs of blind employees. The participation of blind employees in shaping AI solutions will lead to inclusive solutions that will enhance job prospects.
b) AI-powered software development tools (Gemini, Copilot, Chat GPT, etc.) enable faster problem-solving, a greater degree of experimentation & iterative development, resulting in faster software development with fewer coding errors.
c) Computer Vision-based Assistance (Neural Compute Stick – 2 & other Edge AI accelerators) assist blind users by providing real-time information about their surroundings, facilitating quicker navigation & task execution.

In addition to the above AI tools, the addition of AI tools to existing accessible solutions like screen readers has greatly increased their capabilities. For example, the addition of AI tools like Gemini with existing screen readers like JAWS & NVDA has increased the ability of the blind to read hard-copy documents & scanned image files independently.

Role of Inclusive Design in Creating Job Opportunities

The importance of inclusive design in job opportunities cannot be overemphasized. An inclusive solution helps in attracting & retaining a diverse workforce and ensures accessibility & universal solutions. Implementing accessibility features in a job design or software at the design stage also results in financial savings for the enterprise. Studies have shown that retrofitting accessibility solutions on inaccessible software can cost up to 10,000 times the original development cost.

To ensure that accessibility features are properly implemented at the design stage, the developers should follow inclusive human-centric design principles. They can take the assistance of guidelines published by the World Wide Web Consortium & Microsoft. These inclusive features should include keyboard navigation, alternative text for images, voice-enabled interfaces or speech-to-text, and text or image-to-speech.

Education

AI application that supports learning & accessibility:

AI-powered applications play an important role in enhancing the accessibility of learning materials & resources for the blind. AI-powered applications make the process of generating accessible educational content easier, cheaper & faster in comparison to traditional non-AI methods. These AI-powered tools promote equity, inclusion & independence in education & beyond.

Some of the AI powered tools used to increase access to education for the blind include

a) Assistive technology (Antara's Vembi converter, Daisy consortium, etc.) convert books, journals, test papers, etc. into accessible formats. These technologies also generate descriptions on demand for images & are also used to describe complex diagrams & charts.
b) Innovative education tools (NWEA, Braille AI tutor, etc.) enhance accessibility in areas with previously unmet accessibility needs, including enhanced math accessibility, teaching braille through gamification, provision of educational materials using audio & augmented reality, etc.
c) Inclusive design (I-STEM, etc.) enhances document accessibility, including complex layouts & scientific terminology by combining AI with human corrections.

Impact of voice assistance & text-to-speech technologies on education:

Voice Assistance & Text-to-speech technologies (TTS) have greatly increased the accessibility of educational resources & made them more engaging. Voice assistance & TTS technologies enable personalized learning and collaboration in learning, benefiting both students & educators.

Some of the benefits of these technologies to blind students are given below.

a) Voice Assistance technologies, including smart speakers (Alexa, Google Dot, etc.), allow students to learn at their speed without external pressure. Students can get help in completing their homework, have stories read to them, listen to audio books & access information online. Collaborative voice assistance solutions enable collaborative discussion among students, facilitating discussion & knowledge sharing.
b) Text-to-speech (TTS) enhances accessibility by converting text content into spoken language. Educators can leverage the use of AI TTS solutions to provide diverse auditory learning options for students. Multilingual Text-To-Speech (TTS) solutions help make educational materials available across language barriers & reach a wider audience.

How AI can provide a personalized learning experience:

AI's ability to quickly analyze vast amounts of data & draw actionable results from such analysis helps in creating learning experiences tailored to the needs, interests & tastes of each student. AI-powered tools put the student at the center of the learning journey & enhance engagement, relevance & success of the educational journey.

AI-powered educational tools create a personalized educational experience by performing the following steps

a) AI-powered tools analyze the student's needs, interests, etc. & generate personalized learning paths by adapting the educational content, instructional strategies & pace of learning to suit each student's unique needs.
b) Adaptive learning technologies use AI-based algorithms to analyze student performance data & adjust the instruction accordingly, providing personal feedback & scaffolding to promote the mastery of skills.
c) AI-driven analytics are used by educators to make informed choices about the content & method of instruction & allocate resources effectively. These analytical tools also enable the teachers to pinpoint areas where the student is struggling or excelling & optimize individualized lesson plans.

PITFALLS OF AI FOR THE BLIND:

In Jobs:

Risk of over-reliance on AI & potential job displacement:

AI is rapidly becoming an integral part of our daily lives. We are surrounded by AI-powered gadgets & solutions, from virtual assistants like Siri & Alexa to predictive text when typing messages or documents. Advances in AI hold the promise of introducing self-driving cars shortly.

The integration of AI solutions in the workplace has the potential to revolutionise industries by boosting efficiency & unleashing creativity. AI-powered automation will streamline repetitive tasks, allowing employees to focus on higher-value work that requires critical thinking & problem-solving skills. This shift in job roles enables employees to tap into their full potential & contributes to overall workforce transformation.

But this rosy picture also holds several dangers, especially for blind employees. The dangers to blind employees for the implementation of AI solutions are given below.

a) The spread of AI will lead to the replacement of employees by AI solutions in traditional jobs in sectors including manufacturing, healthcare, finance, etc. The implementation of AI solutions is likely to affect the jobs generally held by blind individuals disproportionately.
b) the replacement of human workers by AI solutions will lead to a larger pool of prospective employees chasing a shrinking pool of jobs, which may result in further marginalisation of blind individuals.
c) The loss of employment will result in lower economic power, leading to a reduction in spending, which may further disadvantage blind individuals.
d) Blind employees who have lost their jobs & are unable to find new ones will be forced to depend on family members or charities to meet their daily needs. This dependence can lead to disagreements among family members, substance abuse & mental problems.

Challenges in ensuring AI inclusivity & workplace integration:

The integration of AI solutions in the workplace presents both opportunities & challenges about diversity, equality & inclusion strategies. Some of the challenges posed by AI-powered solutions to inclusivity, diversity & equity activities are given below.

a) AI-based tools can unintentionally perpetuate existing inequalities by continuing the marginalization of historically marginalized groups & reducing the effectiveness of inclusion strategies. This behaviour might be due to biased historical data or flawed algorithms. AI tools trained on biased historical data would perpetuate systematic inequalities.
b) The use of AI tools in business processes, including recruitment, performance evaluation, decision-making, etc., can raise ethical questions. It is necessary to ensure transparency, accountability, & responsible deployment of AI tools to ensure that ethical questions are effectively answered & the tools follow diversity, equality, & inclusivity principles.
c) Ethically designed AI solutions can enhance inclusivity efforts. These tools can assist in diversity & inclusivity audits, workforce analysis, etc., leading to equitable outcomes.

Need for continuous learning & adaptation to new AI tools:

The rapidly evolving landscape of AI-powered tools will necessitate continuous learning & adaptation. Learning will become a lifelong activity in the new AI-dominated workplace to maintain one's edge & skill set.

Some of the reasons for continuous learning in the coming AI-dominated workplace are given below.

a) AI tools & techniques will evolve constantly & rapidly. Continuous learning will ensure that we are ready to take advantage of the latest technological developments.
b) Learning new AI tools will help in keeping our skills relevant in the workplace. All employees, including software developers, data scientists, business professionals, etc., will have to keep their skills updated or risk job loss.
c) AI tools can analyze large amounts of data & present multiple solutions to the user. Continuous learning will keep our problem-solving skills agile & enable us to select the right tool for the specific problem & select the appropriate solution from those presented by the AI tool.
d) Employers prefer professionals who keep their skills & knowledge updated. Continuous learning will help in career growth.

In Education:

Digital divide & access to educational resources:

The Digital Divide is the gap between those countries, cities, or individuals with access to information & communication technologies & those countries, cities, or individuals without such access. Due to the rapid growth & deployment of AI-powered tools & solutions, the digital divide is increasingly referred to as the AI divide. The AI divide arises due to the differences in AI access, skill sets, economic growth, ownership of training data used to train AI tools, development levels, etc.

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Addressing the AI divide & ensuring equal access to AI resources are essential for an inclusive & innovative society. Some of the steps that may be taken to bridge the AI divide are given below.

a) Digital literacy is essential for bridging the AI gap. Educators can deploy AI solutions to close or minimize the AI gap.
b) Policy makers must give priority to deploying technologies to close the AI gap.

Ensuring data security & privacy for users:

In the book The Godfather, written by Mario Puzo, the Godfather, Don Corleone, remarks, "A lawyer with a briefcase can steal more than a hundred men with guns.". In today's digital age, a hacker who gains access to an organisation's or individual's critical data can steal a thousand times more. The misuse of a person's critical data, including name, address, medical information, financial information, etc., can lead to many crimes. In the field of education, the theft of test papers or answer keys can make or break careers. The damage caused by such thefts is borne disproportionately by the marginalised sections of society, including the blind.

Some of the steps that an organisation should follow to maintain data security & protect user information are given below.

a) Obtain user consent before collecting personal data & communicate transparently how such data will be used & the period for which it will be retained.
b) Strictly follow relevant privacy regulations (European GDPR, etc.)
c) Encrypt & anonymise personally identifiable information & use strong encryption methods when datAIs being transferred or at rest.
d) Implement access control measures so that access is limited to authorised persons only.
e) Conduct regular security audits & monitor implementation of security practices
f) Have well-defined protocols for handling data breaches
g) Educate users about privacy risks & best practices
h) Establish granular controls on data sharing
i) Provide users with an option to opt out of data collection.

BALANCING THE EQUATION:

Strategies for Maximising Benefits While Minimising Risks:

In the foregoing sections, we have looked at the benefits to the blind from the use of AI-powered tools in the fields of jobs & education. We have also looked at the pitfalls in the same fields due to the use of AI-powered tools. Now, let us look at some strategies through which we can try to maximise the benefits of AI for the blind while at the same time minimising the risks.

a) Ensure that blind individuals are involved in all steps of the development of the AI solutions, including design, testing & feedback to ensure their accessibility
b) Prioritise understanding of user needs & goals by adopting a user-centered design method
c) Ensure that the AI judgment is combined with appropriate human oversight
d) Leverage crowd sourcing for data labelling & validation
e) Ensure that the training data used to train the AI solutions is free from bias
f) Promote fairness in AI decision-making
g) Ensure privacy & data security

User-centered design & stakeholder involvement in AI development:

Adopting user-centered design & involving all stakeholders in the development of AI solutions will result in solutions that are well-suited for their tasks & will not face resistance from users. We will now list some steps that should be taken to ensure the AI solutions have user-centered design & stakeholder involvement.

User-centered design –

a) Understand user needs, goals & pain points
b) Prioritise on solving the user's pain points & meeting user needs when designing & developing solutions
c) Involve the end-users in testing of each iterative design, testing & refinement
d) Prototypes should be tested with real users in real-life settings
e) Ensure accessibility to make the solutions inclusive for diverse users

Stakeholder Involvement –

a) Collaborate with all types of stakeholders, including end-users, developers, domain experts, etc.
b) Ensure that the collaboration is an ongoing activity throughout the design & implementation process rather than a one-off event
c) Involve all stakeholders in discussions on ethical issues including elimination of conscious & unconscious bias, fairness, privacy etc.
d) Ensure that there is alignment between user needs & business requirements.

Future prospects & ongoing AI research for the blind:

In this section, we are going to gaze into our crystal balls & see what new devices & solutions ongoing AI research is likely to provide for the blind shortly.

a) AI powered wearable smart glasses which use object detection, text recognition, etc. to identify things in the user's surroundings in real-time & convey it to the blind user using voice assistants
b) Smartphone-based solutions for identifying objects, detecting obstacles, providing real-time guidance including walking directions, etc.
c) Convolutional neural networks will play a vital role in solving image classification challenges for the blind
d) Expected advances in AI & robotics may lead to personal assistive robots for the blind, which would enhance their safety & independence.

CONCLUSION

In the previous pages, we have considered the benefits of AI for the blind in the areas of jobs & education. We have also looked at the pitfalls of AI in the same fields. Finally, we have used our crystal ball to gaze into the future benefits of ongoing AI research.

AI has the potential to boost inclusion & open previously unthought-of opportunities for the blind if developed with adequate safeguards. If AI development is done with inclusion being an afterthought, the same AI developments can turn into a curse instead of a boon.

As we move ahead to integrate AI more & more into our lives, we should ensure that it is developed with adequate guardrails. By thoughtfully harnessing AI's potential, we can build a future that is inclusive, just & empowering for all.

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