UPDATE ARTICLE

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Emerging technologies based on artificial intelligence and augmented reality

Tecnologias emergentes baseadas em inteligência artificial e realidade aumentada

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KEYWORDS:

Artificial intelligence; Augmented reality; visual impairment; Assistive technology; Visual rehabilitation.

ABSTRACT

Artificial intelligence and augmented reality have had a profound impact on the field of assistive technology. Intelligent image-processing systems enable visually impaired individuals to access visual information in unprecedented ways. This article highlights the role of assistive technology in promoting autonomy, social inclusion, and quality of life through resources such as screen readers, smart canes, and navigation applications. Artificial intelligence enables the interpretation of the surrounding environment, recognition of objects, and real-time scene description, while augmented reality enhances residual visual performance through mobile and wearable devices. The article discusses applications of these technologies in daily activities, education, and mobility, as well as the ethical and economic challenges associated with ensuring their equitable and safe use.

PALAVRAS-CHAVE:

Inteligência artificial; Realidade aumentada; Deficiência visual; tecnologia assistiva; Reabilitação visual.

RESUMO

A inteligência artificial e a realidade aumentada (RA) trouxeram um impacto profundo na disciplina de tecnologias assistivas. Sistemas inteligentes de processamento de imagens possibilitaram às pessoas com deficiência visual o acesso a informações visuais de uma forma inédita. Este artigo destaca o papel da tecnologia assistiva na promoção da autonomia, inclusão social e qualidade de vida, por meio de recursos como leitores de tela, bengalas inteligentes e aplicativos de navegação. A inteligência artificial permite a interpretação do ambiente, reconhecimento de objetos e descrição de cenas em tempo real, enquanto a realidade aumentada potencializa o desempenho visual residual com dispositivos móveis e vestíveis. Nesse artigo discutimos aplicações dessas tecnologias em atividades diárias, educação e mobilidade, além dos desafios éticos e econômicos para garantir o uso equitativo e seguro dessas tecnologias.

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INTRODUCTION

It is estimated that approximately 285 million people worldwide live with visual impairment[1]. According to data from the 2022 census, Brazil has approximately 7.9 million people who experience visual impairment even when using corrective glasses or contact lenses. Despite advances in ophthalmologic treatments and the early detection of many eye diseases, a substantial portion of the population continues to live with reduced functional vision.

Technology is playing an increasingly important role in enabling the effective participation of people with disabilities in society. Assistive technology promotes greater functional independence among individuals with disabilities and addresses needs related to mobility and navigation, reading, and audio description[2].

Despite these advances, many of these technologies remain costly, creating a barrier to their large-scale adoption, particularly in developing countries such as Brazil. Furthermore, technologies developed exclusively for people with disabilities may carry social stigma associated with minority groups, which can constitute an additional barrier to their acceptance and use[3].

In this context, artificial intelligence (AI) and augmented reality (AR) systems may help overcome some of the obstacles to the development and dissemination of assistive technologies. Advances in image processing, enhanced by deep learning techniques, now enable the delivery of information in real time through mobile device interfaces, such as smartphones.

The aim of this review is to describe the applications of AI and AR systems in assistive technologies for individuals with visual impairment.

Assistive technology

Assistive technology for individuals with visual impairment comprises a range of resources, devices, systems, and services designed to enhance, maintain, or improve functional vision and autonomy among individuals who are blind or have low vision. Its primary objective is to reduce barriers imposed by the physical, social, and informational environment, thereby promoting independence, social participation, and quality of life. Unlike medical or surgical interventions, assistive technology is non-invasive and mediates the interaction between the user and the surrounding environment by adapting or transforming information.

In everyday life, assistive technology plays a central role in activities of daily living, including reading, mobility, communication, and access to information. Beyond functional benefits, assistive technology also has a significant impact on the social inclusion and psychological well-being of individuals with visual impairment. By reducing dependence on others, these resources may strengthen self-esteem, self-confidence, and the sense of autonomy[4]. In educational and professional contexts, assistive tools facilitate access to digital content, educational materials, and work environments, thereby contributing to greater social equity. In urban environments, the integration of assistive technologies with intelligent infrastructure further expands opportunities for full participation in social life.

Artificial intelligence

AI has emerged as an important tool for enhancing the autonomy, safety, and quality of life of individuals with visual impairment. Through advanced computer vision and machine learning techniques, AI-based assistive systems can interpret the environment in real time, identify obstacles, recognize objects, and provide spatial orientation. These capabilities enable users to better understand their surroundings, anticipate potential risks, and navigate more safely in both indoor and outdoor environments. Algorithms such as convolutional neural networks enable the extraction of complex visual information from standard cameras, while simultaneous localization and mapping methods allow the construction of environmental maps and support navigation in locations where Global Positioning System (GPS) signals are unavailable[5].

In addition to navigation, AI contributes significantly to the interpretative perception of the environment by transforming images into understandable descriptions delivered through audio output or sonification[6]. This capability supports the creation of mental representations of space and helps users understand the position of objects, people, and architectural structures. Another important benefit is the possibility of personalizing assistive systems. Techniques such as incremental learning allow users to train the system to recognize personal objects, familiar environments, or individuals. At the same time, transfer learning reduces the need for large task-specific datasets, thereby accelerating the development of practical and accessible solutions[7].

Advances in the optimization and compression of AI models have made it feasible to run these systems directly on smartphones and wearable devices, reducing dependence on remote connectivity and improving system reliability. As a result, AI is no longer only an experimental technology but also an active mediator between the user and the environment, supporting greater independence, social inclusion, and participation in everyday activities among individuals with visual impairment.

Augmented reality systems

AR is defined as a technology that enhances real-world environments by superimposing computer-generated information in real time while maintaining the user's interaction with the physical world. Unlike virtual reality, which completely replaces the real environment with a digital space, AR functions as an interface between the user and the surrounding environment, adding, modifying, or processing perceptual elements—primarily visual, but also auditory and tactile—in a contextualized manner. This characteristic is particularly relevant in ophthalmology because most AR systems are vision-based and can be integrated directly into the user's perceptual process.

In the visual rehabilitation of individuals with low vision, AR can be applied as a non-invasive strategy and functional aid to enhance residual visual performance and facilitate everyday activities. AR systems typically use cameras, processing units, and displays, such as smartphones and smart glasses, to capture the environment, process visual information, and present it in an optimized format to the user. For individuals with low vision, these applications include selective image magnification, edge enhancement, contrast enhancement, text extraction using optical character recognition, and object recognition using AI algorithms[8]. These techniques do not restore lost vision; rather, they reorganize and emphasize relevant environmental information, making it more accessible within existing visual limitations.

Product accessibility

In addition to advances in assistive technology based on sophisticated systems, there is an increasing trend toward incorporating accessibility features for people with disabilities into devices designed for the general public, in accordance with the principles of universal design. In this approach, individuals with disabilities can access product functionalities without the need for specialized adaptations, even when these features were not originally developed specifically to compensate for functional limitations.

In this context, examples include voice assistants such as Amazon Alexa, which provide users with access to device functions through audio interaction. More recently, smart glasses incorporating Meta Platforms AI technologies can convert visual information into spoken descriptions by combining computer vision systems with large language models. These products have broad appeal among the general public while simultaneously expanding usability for individuals with disabilities.

Application of assistive technologies based on AI and AR

Activities of daily living

Various applications and wearable devices currently available on the market offer advanced AI and computer vision functionalities to users. From earlier optical character recognition systems to platforms integrated with large language models, such as the Be My Eyes application, the range of everyday applications continues to expand.

Seiple et al.[9] analyzed the use of four AI-based assistive systems—two smartphone applications, Seeing AI and Google Lookout, and two wearable devices, OrCam MyEye and Envision Glasses—applied to common daily tasks such as reading printed text, identifying objects, recognizing people, describing scenes, and indoor orientation. The use of AI significantly increased the likelihood that participants were able to perform these tasks and reduced the time required to complete them.

Other new-generation wearable devices, such as NuEyes Pro and eSight Go, incorporate AR features, including customizable image magnification and contrast enhancement, with an appearance similar to that of conventional eyeglasses. As a result, these devices can be integrated efficiently and discreetly into daily activities.

Access to information and education

Screen readers such as JAWS and NVDA for computer operating systems, as well as VoiceOver and TalkBack available on mobile devices, enable audio access to a wide range of digital content, including books, academic articles, news portals, and social media platforms. These tools support multiple languages and are compatible with a variety of operating systems and digital formats.

Braille displays have also undergone significant technological advances, increasing the availability and usability of the tactile writing system. These devices are particularly valuable in fields such as mathematics and computer programming, where visual elements such as graphs and diagrams are difficult to convert into audio formats. Braille displays enable access to complex content, thereby facilitating learning and participation in specialized educational activities[10].

The evolution of intelligent voice assistants also allows users to perform various tasks in digital environments, such as participating in remote meetings and preparing documents or spreadsheets. These technologies increase user autonomy and facilitate access to information, as well as interaction with productivity and communication tools in educational and professional settings[11].

Navigation and mobility

Mobility and navigation across different environments represent major challenges for individuals with visual impairment. Difficulties in crossing streets, navigating unfamiliar routes, using public transportation, or detecting physical obstacles are common. Assistive technologies are increasingly addressing these challenges through the integration of GPS technologies, AI, and AR. These systems enable real-time environmental information, geolocation services, and route planning in urban environments that incorporate different modes of transportation, thereby enhancing independence and safety for individuals with disabilities[12].

Emerging devices also extend the functionality of the traditional long cane. By incorporating sensors that provide tactile feedback, these systems help overcome limitations of conventional canes by enabling the detection of obstacles at different heights. Examples include the WeWalk Smart Cane, which integrates with smartphones, and wearable devices such as the SunuBand, which provide haptic notifications to assist with mobility and navigation.

Navigation applications such as Google Maps, DotWalker, and Lazarillo enable route planning to a desired destination while providing audible guidance throughout the journey. These applications also allow users to search for nearby points of interest based on their current location.

Systems incorporating AR may also provide audio guidance through headphones, enabling users to receive environmental information without the need to hold a device. The Microsoft Soundscape application uses spatial audio cues to help users construct a mental representation of their surroundings and provides contextual information about intersections and landmarks along the route.

Prospects and challenges

The continuous evolution of AI and AR systems, together with advances in connectivity and data-processing speed, is expected to provide individuals with visual impairment with increasing autonomy and greater opportunities for social and economic participation. The integration of different modalities, such as computer vision and natural language processing, into mobile and wearable devices enables multimodal interaction systems with broad applicability, rather than tools designed for a single specific task.

Despite these advances, several structural and ethical challenges remain. Affordability represents one of the main barriers, as many AI-based devices are costly or available only on proprietary platforms, limiting their accessibility for users in low-income contexts or developing countries. In addition, reliance on internet connectivity remains a constraint, particularly in regions with limited infrastructure. From an ethical perspective, concerns have been raised regarding data privacy[13], especially in systems that rely on facial recognition or process sensitive personal information[14]. AI-generated image descriptions may also reflect algorithmic biases present in training datasets, potentially reinforcing prejudice or stereotypes rooted in particular cultural or social contexts[15], sometimes even affecting individuals with disabilities. Finally, usability remains an important challenge, as complex or unintuitive interfaces may hinder the adoption and practical benefits of these technologies.

The development of digital infrastructure, funding for research and development, improved access to technologies, investment in digital education, and responsible regulation are essential to ensure the equitable, safe, and ethical use of emerging assistive technologies. Achieving these goals requires coordinated action among governments, regulatory bodies, developers, and the active participation of users.

In summary, progress in assistive technologies has been fundamental in promoting autonomy, social inclusion, and quality of life for individuals with visual impairment. Tools such as screen readers, Braille displays, smart canes, navigation applications, and voice assistants contribute significantly to overcoming barriers and expanding educational, professional, and social opportunities. Despite notable advances in AI, AR, and innovative assistive devices, challenges related to accessibility, usability, privacy, and equity remain. Addressing these barriers requires a combination of technological innovation, supportive public policies, ethical regulation, and the active participation of users to ensure that the benefits of these solutions reach all who need them in an equitable and sustainable manner.

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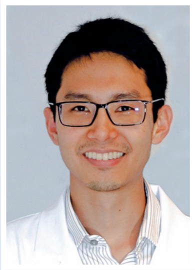

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