■ *Research review paper*

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Merging of Artificial Intelligence Tools and Internet of Things with Assistive Technologies

Abstract. The integration of artificial intelligence (AI) with assistive technologies (AT) and Internet of Things (IoT) is a novel form of support for elderly and people with disabilities that enhances accessibility, independence, and communication, thus fostering empowerment and improved quality of life. Applications like voice assistants, special applications that translate atypical speech into understandable language or provide detailed audio navigation for the visually impaired, and other wearable devices demonstrate AI's potential to adapt dynamically to users' needs. AI and other contemporary technologies, such as machine learning, natural language processing and computer vision, can be integrated into AI-enhanced prosthetics, communication aids, automatic speech recognition and smart home systems. However, despite its transformative potential, AI adoption involves significant challenges, including ethical concerns about algorithmic bias, data privacy, and equitable access. Practical barriers such as high costs and resistance to technological adoption also pose limitations, particularly among underserved populations. Addressing these issues requires collaborative efforts, including the active involvement of individuals with disabilities in the design and implementation processes. By prioritising inclusivity and addressing limitations, AI can create meaningful advancements that promote autonomy and dignity, thus potentially paving the way for a more equitable society.

Key words: artificial intelligence; internet of things; assistive technologies; accessibility; ethical challenges.

Združevanje orodij umetne inteligence in interneta stvari s podpornimi tehnologijami

Povzetek. Vključevanje umetne inteligence (UI) in tehnologij interneta stvari v podporne tehnologije prinaša novosti na področju podpore za starejše in osebe z zmanjšanimi zmožnostmi, saj izboljšuje dostopnost, neodvisnost in komunikacijo, s čimer podpira samostojnost in boljšo kakovost življenja. Aplikacije, kot so navidezni osebni pomočniki, poseben prevajalnik netipičnega govora v razumljiv jezik in aplikacija, ki zagotavlja podrobne zvočne navigacijske smernice za slepe in slabovidne, in drugi nosljivi pripomočki dokazujejo potencial UI za dinamično prilagajanje potrebam uporabnikom. UI in druge sodobne tehnologije, kot so strojno učenje, procesiranje naravnega jezika in računalniški vid, se da povezati v inteligentne proteze, pripomočke za komunikacijo, avtomatsko prepoznavanje govora in sisteme pametnega doma. Kljub izjemnemu potencialu za preobrazbo pa je uvajanje UI povezano z izzivi, kot so etična vprašanja glede pristranskosti algoritmov, varovanja podatkov in enakopravnega dostopa. Praktične ovire, kot sta visoka cena naprav na osnovi UI in odpor do sprejemanja tehnologije, dodatno omejujejo dostopnost, zlasti pri premalo zastopanih skupinah. Reševanje teh vprašanj zahteva sodelovanje, vključno z aktivno vključitvijo oseb z zmanjšanimi zmožnostmi v procese oblikovanja in implementacije. S poudarkom na vključevanju in preseganjem omejitev lahko UI omogoči pomemben napredek, ki spodbuja avtonomijo in dostojanstvo, kar bi lahko odprlo pot do bolj pravične družbe.

Ključne besede: umetna inteligenca; internet stvari; podporne tehnologije; dostopnost; etični izzivi.

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Background

The merging of artificial intelligence (AI) tools and internet of things (IoT) with assistive technologies (AT) represents a significant evolution aimed at improving the independence and quality of life for individuals with disabilities. Assistive technology encompasses a wide array of devices and systems designed to aid people with physical, sensory, cognitive, or communication impairments, enabling them to perform tasks that may otherwise be challenging or unfeasible.[1,2] The convergence of AI with these technologies has led to more adaptable solutions with the help of advances in machine learning, natural language processing (NLP) and computer vision. These solutions include AI-enhanced prosthetics, communication aids, automatic speech recognition, and smart home systems, which facilitate daily living and promote inclusivity across various aspects of life, including education and employment.[1,3] This integration has a transformative potential to enhance user experience and accessibility. AI capabilities, particularly in machine learning and NLP, have revolutionised the functionality of assistive devices, allowing for personalised interactions that cater to the unique needs of users. For example, AI-driven tools like virtual assistants can help individuals with mobility or visual impairments perform everyday tasks through voice commands, thereby fostering greater autonomy and engagement in society.[3-5]

However, the integration of AI into assistive technologies also raises critical challenges and ethical considerations.[6,7] Privacy concerns regarding the handling of personal data, as well as the high costs associated with these technologies, can limit their accessibility for underserved populations.[6,7] Additionally, the potential for bias in AI decision-making necessitates ongoing oversight to ensure fairness and inclusivity among diverse user groups.[8] As developers and researchers continue to navigate these complexities, the ongoing evolution of AI-powered assistive technologies promises to redefine support mechanisms for individuals with disabilities, which may lead to a more inclusive and equitable society.[9,10]

The paper provides a review of the literature on how merged AI, IoT and AT tools can assist individuals with disabilities and elderly people in enhancing their independence and quality of life.

Methods

This scoping review followed the methodological framework adhered to the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines. The objective was to systematically map the existing literature at the intersection of assistive technologies, artificial intelligence, and the Internet of Things, and to identify research gaps, key concepts, and technological trends in this multidisciplinary domain.

Results

AI, IoT and AT

The quality of life for people with disabilities can be challenging even for the most basic daily activities, because their ability to communicate effectively and live independently is often limited. AI, IoT and AT cover various areas (Figure 1) and their intersections provide new subareas (Figure 2).[14] The integration of these areas has the potential to alleviate many of the barriers that people with disabilities face in their everyday lives.[11] AI also offers opportunities for education and employment that maintain dignity and inclusivity.[12] In this regard, several software companies are actively engaged in the research and development of tools designed to improve the lives of people with disabilities. The variety of AI-driven support systems, including speech recognition, computer vision, mobility help and cognitive aids, which are reviewed in more detail below, indicate that AI holds a promising future for enhancing the well-being of people with disabilities.

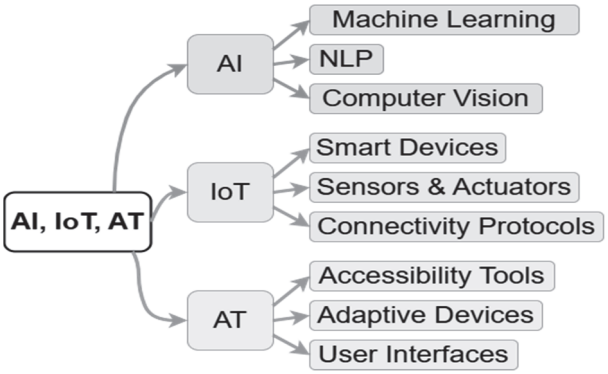

Figure 1 Areas of Artificial Intelligence (AI), Internet of Things (IoT) and Assistive Technologies (AT).

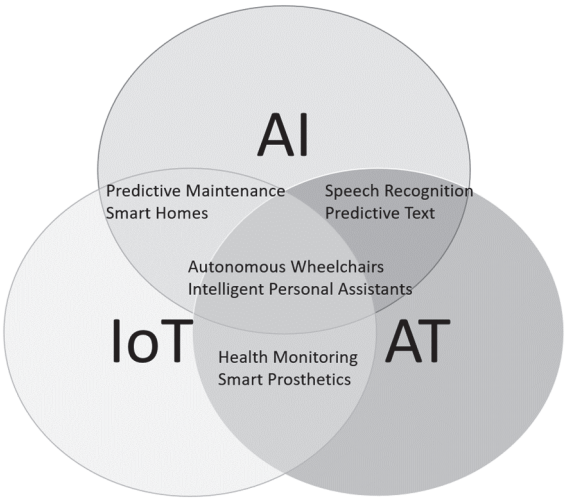

Figure 2 Intersections of Artificial Intelligence (AI), Internet of Things (IoT) and Assistive Technologies (AT) and the associated subareas.

Visual impairment

There are several innovative assistive technologies aimed at enhancing navigation for individuals with visual impairments. One notable system is Visisense,[13] which provides comprehensive IoT-based navigation support designed specifically for the visually impaired. Personal stories highlight how AI and IoT are improving assistive technologies, demonstrating significant life-changing impacts for users.[14] Among the emerging technologies, Smart Shoes utilises IoT capabilities to address everyday challenges faced by individuals with vision deficiencies.[15] Additionally, a system that incorporates a smart stick along with a mobile application helps users identify various objects such as walls and vehicles, thereby enhancing their spatial awareness.[16] This system employs multiple laser sensors to assist in object recognition, delivering audio messages to alert users about their surroundings.[17] Moreover, mobile applications have been developed to facilitate navigation for visually impaired persons in public transportation systems, proving to be a valuable resource in urban environments.[18]

AI is playing a transformative role in enhancing the lives of visually impaired individuals through various applications that improve object recognition and interaction with their environment. Advanced machine learning algorithms, particularly those based on deep learning, have shown significant promise in enhancing object recognition capabilities, allowing visually impaired users to identify and interact with objects in real-time.[19] Wearable assistive devices, such as AI-powered smart glasses, take advantage of these advancements to help users better navigate their surroundings by recognising obstacles and providing audio descriptions of their environment.[20,21] Innovative tools like "Be My AI" and the WeWalk cane are drastically changing daily routines for visually impaired individuals by integrating AI capabilities that facilitate safer navigation and enhanced interaction with the world.[22] These technologies leverage the IoT to create smart environments that enhance accessibility, such as smart roads that provide safer crossing points.[23]

There is a suite of web standards, Web Accessibility Initiative – Accessible Rich Internet Applications (WAI-ARIA),[24] which enhances the accessibility of web content and applications for people with visual impairments.

Screen readers, such as VoiceOver on iOS and TalkBack on Android OS have already been integrated into smartphones.[9] In addition to their primary function of reading out emails and text messages, they now use AI to describe app icons, battery levels and other user-interface elements.

Virtual Assistants like Siri and Google Assistant are also embedded into smartphones. These tools assist users in navigating various functions and communicating with others. Applications such as Lookout by Google and Seeing AI by Microsoft utilise the smartphone camera to identify and announce currency notes, objects, labels and signs.

However, there exists a significant disparity between state-of-the-art computer vision algorithms and the systems created to assist individuals who are blind or visually impaired. In addition, there is a notable absence of benchmark datasets specifically tailored to the recognition of various objects in both indoor and outdoor settings from the perspective of those with visual impairments. Hence, a more comprehensive approach is needed in the design of innovative interfaces capable of conveying system outputs in ways aligned with the unique requirements of visually impaired individuals.[25] Nevertheless, current literature demonstrates the effective synergy of IoT for data collection and connectivity, AI for processing and decision-making, and assistive technologies for practical application in improving the lives of visually impaired individuals.

Hearing impairment

Merging IoT, AI and AT makes the world more accessible for individuals who are deaf and hard of hearing through services like captioning and speech recognition. This positively impacts how they

consume media, learn and communicate in person and over the phone or internet. Automatic speech recognition (ASR) allows for audio input to be converted into easy-to-read captions. In order to generate accurate captions, ASR relies on AI and machine learning to decipher what is being said and attribute context. ASR is used in a variety of situations to translate speech to text, both for in-person conversations as well as phone conversations and video calls. Research indicates that AI hearing aids can enhance hearing ability in challenging environments, such as noisy social situations, by up to 55 %.[26,27] In educational settings, AI can automatically generate captions for video content, making lectures and materials more accessible to students with hearing impairments.[28] However, medical device manufacturers increasingly embed algorithmic data surveillance in smart wearables like hearing aids, often using patient data for profit with minimal transparency and lack of clear disclosures.[29] Overall, though, AI and IoT technologies are paving the way for enhanced quality of life and increased independence for those with hearing disabilities.

Mobility impairment

As AI, IoT and AT converge, they offer transformative solutions that extend beyond traditional assistive devices and can significantly benefit individuals with diverse mobility impairments.[30] This integration facilitates the development of smart environments and intelligent systems that can dynamically adapt to individual needs, thereby enhancing autonomy, safety, and overall quality of life. In the domain of mobility and navigation, AI-enabled smart wheelchairs are capable of autonomously navigating complex environments, avoiding obstacles, and adjusting to variable terrain through real-time sensor data.[31] These systems may incorporate voice and gesture control, eye-tracking navigation, GPS, and indoor mapping technologies, alongside adaptive speed and safety mechanisms. Smart prosthetics represent another major advancement, employing embedded sensors and machine learning algorithms to analyse user movement patterns in real time, resulting in improved gait stability, responsiveness, and user comfort.[32]

In parallel, IoT-enabled smart home technologies enable users to control lighting, temperature, appliances, and access points through accessible interfaces.[33] AI further augments these systems by learning individual routines and predicting user needs, thus reducing cognitive load. Wearable devices can monitor vital signs, posture, physical activity, and fall events, and when integrated with AI, they enable early detection of anomalies, automated alerts to caregivers, and integration with telemedicine platforms for remote clinical support.[34] Additionally, AI-powered service robots can assist with daily tasks such as object retrieval, medication reminders, and personal care. When embedded within IoT networks, these robotic systems can operate synergistically with other smart devices, contributing – at least in principle – to a cohesive and responsive assistive ecosystem.[35]

However, as these technologies generate vast amounts of sensitive personal data, it is crucial to consider ethical implications related to data privacy and user consent. Ensuring robust data protection measures, transparent data usage policies, and informed user consent protocols are essential to safeguarding individual privacy and fostering trust in these innovative systems.[36,37]

Cognitive impairment

Cognitive impairments can create distinct difficulties that affect daily activities and communication. Artificial intelligence-based cognitive support technologies utilise NLP and machine learning to enhance communication, memory, and decision-making. These systems are capable of organizing schedules, offering reminders, and providing contextually appropriate responses during interactions.[38,39] By addressing cognitive limitations, such technologies enable individuals to retain higher levels of independence and engage more fully in social and personal activities.

Discussion

The integration of AI in healthcare presents significant opportunities, yet it also necessitates careful consideration of ethical issues. The collection, processing and dissemination of personal health data raise concerns regarding privacy, security, and informed consent. Ensuring a balance between leveraging data for insights and maintaining individual autonomy is critical to aligning AI-driven healthcare innovations with ethical standards. Key factors such as algorithmic transparency, robust data protection measures, and the promotion of informed decision-making are essential in safeguarding the rights and dignity of individuals, particularly those with disabilities.

In the broader context of AI's impact on empowering individuals with disabilities, healthcare advancements offer promising prospects for positive transformation. Through personalised care, improved diagnostic precision and tailored interventions, AI not

only addresses the specific healthcare needs of individuals with disabilities but also shows promise for a future where health disparities are reduced, and overall quality of life is enhanced.

The future of emerging AI, IoT and AT in disability support looks bright, with trends indicating a shift towards more individualised and context-aware solutions. As a recent source notes,[8] AI tools encompass assistive technologies, in addition to virtual agents and rehabilitation tools. AI therefore has the potential to reduce health inequalities, enhance diagnostic precision, and support better communication with healthcare professionals, ultimately contributing to more equitable healthcare environments.

The integration of wearable technology for visually impaired users is expected to evolve significantly in the coming years, driven by advancements in AI and IoT.[40] AI tools are increasingly being used to automate accessibility evaluations and provide real-time feedback, enabling designers to create inclusive digital experiences from the outset. This shift towards inclusive design ensures that products are accessible to all users upon release, thereby reducing the need for subsequent adaptations or modifications. Wearable devices are anticipated to incorporate innovative features such as voice-activated systems, haptic feedback, and spatial audio, which can enhance the sensory experiences of visually impaired individuals. These technologies represent a move towards a "zero user interface" (No UI) paradigm, in which the user interface becomes intuitive and integrated into the user's environment, thereby unlocking new possibilities for interaction. The principles of universal design will therefore be critical in shaping future AI solutions. Universal design emphasises the creation of products that are usable by everyone, regardless of their abilities, ensuring that technology is genuinely inclusive.[41] As AI and IoT continue to advance, the emphasis on accessible design will play a key role in the development of solutions that empower visually impaired users, enabling greater mobility and independence in their daily lives.[42] The benefits of integrating these technologies include:

- increased autonomy, as users gain enhanced control over their environment and daily activities;
- greater personalisation, as AI systems adapt to individual patterns, preferences, and evolving needs;
- improved safety, through real-time monitoring and predictive alerts that mitigate risks, particularly during emergencies or for individuals living alone;
- enhanced communication, supported by NLP and multimodal interfaces such as voice, touch, and eye gaze, that facilitate interaction for users with speech or motor impairments.

However, several challenges and ethical considerations remain. The main issues are:

1. Privacy and data security – sensitive personal and health data must be protected with robust security frameworks and transparent data governance practices;
2. Affordability and accessibility – high costs and unequal access may exacerbate the digital divide, underscoring the importance of inclusive design and public funding initiatives;
3. User trust and acceptance – the systems must be intuitive, reliable, and respectful of user autonomy to foster adoption and sustained use;
4. Interoperability – seamless integration across diverse devices and platforms requires standardised protocols and open architectures.

The future of assistive technology lies in the development of intelligent assistive ecosystems, including (a) edge computing for privacy-preserving AI, in which data is processed locally to reduce latency and enhance privacy; (b) augmented reality interfaces, where contextual information overlies in real time for navigation and interaction;[43] (c) collaborative robotics (Co-bots), which facilitate human-robot collaboration in mobility and rehabilitation; and (d) participatory design approaches, which engage users directly in the design process to ensure relevance, usability, and empowerment. In addition, more attention and effort should be devoted to the applicability of assistive technology, especially AI- and IoT-enhanced, by rural populations and/or in rural environments.[44,45]

Conclusion

The integration of AI, the IoT and AT marks a major shift in the development of inclusive tools aimed at enhancing the independence, mobility, and quality of life for individuals with disabilities. This convergence enables the creation of intelligent, context-aware, and personalised support systems that address a broad spectrum of impairments, including visual, hearing, mobility, and cognitive challenges. From AI-powered smart glasses and autonomous wheelchairs to adaptive communication aids and predictive healthcare tools, these innovations are significantly reshaping assistive environments and promoting greater autonomy for users.

Importantly, the reviewed literature highlights that the synergy of AI and IoT with AT not only advances technological capability but also fosters social inclusion by facilitating access to education, employment, and public services. While the potential of these technologies is vast, their implementation must be approached with careful consideration of ethical concerns, such as data privacy, algorithmic bias, affordability, and user autonomy. Ensuring transparency, inclusivity, and security in design and deployment is essential for fostering user trust and ensuring equitable access.

Looking ahead, the development of intelligent assistive ecosystems – incorporating edge computing, augmented reality, collaborative robotics and participatory design – promises to further enhance the responsiveness and usability of these solutions. The adoption of universal design principles will be critical in ensuring that future technologies are inherently accessible and adaptable to diverse user needs, including rural populations. Ultimately, the responsible and inclusive advancement of AI- and IoT-enabled assistive technologies holds the potential to create a more equitable society, where all individuals, regardless of ability, can participate fully and independently in daily life.

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