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Enhancing Communication and Access: The Role of Internet of Things Technologies in Developing Library Services for Persons with Disabilities

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تعزيز الاتصال والإتاحة: دور تقنيات إنترنت الأشياء في تطوير خدمات المكتبة للأشخاص ذوي الإعاقة

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ABSTRACT

This paper explores the role of IoT technologies in developing library services for persons with disabilities. It highlights the challenges faced by individuals with disabilities in accessing and navigating library resources, such as physical barriers, limited mobility, visual or hearing impairments, and cognitive disabilities. However, by integrating IoT technologies, libraries can proactively address these challenges and create inclusive spaces where everyone feels welcome and supported. The paper includes a literature review that examines studies on using IoT in different settings to cater to the needs of people with disabilities. It emphasizes the importance of ongoing research, investment, and collaboration to address challenges and maximize the benefits of IoT technologies in improving the lives of individuals with disabilities. The research methodology section outlines a study conducted on individuals with physical and visual impairments to identify the challenges they face in utilizing university libraries and their requirements for programs and devices that would enable them to access information sources. The data analysis reveals the need for devices and software, such as tablets, voice recognition software, specialized keyboards, text enlargement software, screen readers, page-turners, and Braille printers, to facilitate access to library resources. Furthermore, the paper presents IoT services required by persons with disabilities to access library resources independently. It discusses twelve IoT services that can be implemented to enhance accessibility and improve the library experience for this group. In conclusion, the paper emphasizes the transformative potential of IoT technologies in improving the lives of individuals with disabilities. By embracing IoT and adopting inclusive practices, libraries can fulfill their mission of providing equitable access to information and knowledge for all community members.

Keywords: Internet of Things (IoT), Persons with Disabilities, Library Services, Smart Libraries.

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الملخص

تستكشف هذه الورقة دور تقنيات إنترنت الأشياء في تطوير الخدمات المكتبية للأشخاص ذوي الإعاقة. وتسلط الضوء على التحديات التي يواجهها الأفراد ذوو الإعاقة في الوصول إلى موارد المكتبة والتنقل فيها، مثل الحواجز المادية، ومحدودية الحركة، والإعاقات البصرية أو السمعية، والإعاقات المعرفية. ومع ذلك، فمن خلال دمج تقنيات إنترنت الأشياء، يمكن للمكتبات معالجة هذه التحديات بشكل استباقى وإنشاء مساحات شاملة يشعر فيها الجميع بالترحيب والدعم.

تتضمن الورقة مراجعة للأدبيات التي تتناول استخدام تقنيات إنترنت الأشياء في بيئات مختلفة؛ لتلبية احتياجات الأشخاص ذوي الإعاقة. وتؤكد على أهمية البحث المستمر والاستثمار والتعاون لمواجهة التحديات، وتعظيم فوائد تقنيات إنترنت الأشياء، في تحسين حياة الأفراد ذوى الإعاقة.

ويتضمن قسم منهجية البحث دراسة أجريت على الأفراد ذوي الإعاقات الجسدية والبصرية؛ للتعرف على التحديات التي يواجهونها في الاستفادة من المكتبات الجامعية واحتياجاتهم من البرامج والأجهزة التي تمكنهم من الوصول إلى مصادر المعلومات. ويكشف تحليل البيانات عن الحاجة إلى أجهزة وبرامج، مثل الأجهزة اللوحية، وبرامج التعرف على الصوت، ولوحات المفاتيح المتخصصة، وبرامج تكبير النص، وقارئات الشاشة، ومقلبات الصفحات، وطابعات برايل، لتسهيل الوصول إلى موارد المكتبة. علاوة على ذلك، تعرض الورقة خدمات إنترنت الأشياء التي يحتاجها الأشخاص ذوو الإعاقة للوصول بلى مستقل إلى موارد المكتبة. ويناقش اثنتي عشرة خدمة من خدمات إنترنت الأشياء التي يمكن تنفيذها لتعزيز إمكانية الوصول وتحسين تجربة المكتبة لهذه الفئة.

وفي الختام، تؤكد الورقة على الإمكانات التحويلية لتقنيات إنترنت الأشياء في تحسين حياة الأفراد ذوي الإعاقة. ومن خلال تبني إنترنت الأشياء واعتماد ممارسات شاملة، يمكن للمكتبات تحقيق مهمتها المتمثلة في توفير الوصول العادل إلى المعلومات والمعرفة لجميع أفراد المجتمع.

ا**لكلمات المفتاحية:** إنترنت الأشياء، الأشخاص ذوي الإعاقة، خدمات المكتبات، المكتبات الذكية.

Introduction:

The In today's digital age, libraries are evolving beyond traditional repositories of books and resources into dynamic centers of information and innovation. With the advent of emerging technologies, particularly the Internet of Things (IoT), libraries have an unprecedented opportunity to revolutionize their services and cater to the diverse needs of their patrons, including those with special needs. By harnessing the power of IoT, libraries can create inclusive environments that empower individuals of all abilities to access information, engage with resources, and participate fully in the library experience.

According to the latest statistics provided by the World Health Organization's website, the number of Persons with disabilities in Egypt has reached 14 million, which is not a negligible percentage. It requires further care and attention due to its unique nature. The library and information studies observer finds that efforts have been directed towards employing emerging technologies to serve this category and meet their information needs. Hence, the study aims to address the most prominent Internet of Things services that can be adapted to serve this category, enabling them to quickly and comfortably use information sources in their university libraries. It also explores the main obstacles preventing their use and their current and future requirements from these library services to communicate them to decision-makers and draw their attention to this category so they may incorporate it into their plans for developing library services.

The Internet of Things refers to the network of interconnected devices embedded with sensors, software, and other technologies that enable them to collect and exchange data. In the context of libraries, IoT can encompass a wide range of applications, from smart sensors that monitor environmental conditions to wearable devices that assist patrons with disabilities. These technologies have the potential to enhance accessibility, improve efficiency, and expand the reach of library services in ways previously unimaginable.

Accessing and navigating library resources can present unique challenges for people with disabilities. Physical barriers, limited mobility, visual or hearing impairments, and cognitive disabilities can all impact an individual's ability to engage with library materials and services entirely. However, with the integration of IoT technologies, libraries can proactively address these challenges and create inclusive spaces where everyone feels welcome and supported.

This paper explores how emerging technologies, particularly IoT, can be employed in libraries to serve Persons with disabilities. From assistive devices and adaptive technologies to smart infrastructure and digital accessibility initiatives, libraries have many innovative solutions. By embracing these technologies and adopting inclusive practices, libraries can fulfill their mission of providing equitable access to information and knowledge for all community members.

Literature review:

The rapid integration of Internet of Things (IoT) technologies into various aspects of life has spurred significant advancements to enhance the quality of life for individuals with disabilities. This comprehensive scientific review delves into several vital studies focusing on the utilization of IoT in different settings to cater to the needs of people with disabilities. Alsalmiya (2020) conducted a study to elucidate the concept of IoT and its implications within academic libraries. Analyzing data from the Scopus database spanning 2010-2018, the study revealed a substantial interest in IoT, particularly in the field of Computer Science. The findings underscored the necessity of further research and investment in IoT technologies to prepare for future developments. Qanawi's (2019) research explored the awareness and utilization of IoT applications in Egyptian libraries. Despite moderate awareness levels among library professionals, there was considerable support for incorporating IoT to enhance user services. Recommendations included specialized research and the development of automated systems aligned with IoT to improve efficiency. Lee et al.'s (2020) study focused on assessing the needs of elderly and physically disabled individuals for smart home IoT services. The research highlighted a strong demand for IoT services tailored to specific disabilities, emphasizing the importance of prioritizing these needs. Zoulikha (2020) examined the availability of information technology for individuals with disabilities in Algerian libraries, identifying significant challenges, including a lack of specialized sections and inadequate resources. Recommendations included the establishment of dedicated sections equipped with modern technologies and the creation of Braille guides. Furthermore, studies such as Al-Shuwaier (2015), Addai-Wireko et al. (2020), and Sanaman & Kumar (2014) emphasized the importance of training library staff, employing individuals with disabilities, and integrating assistive technologies to ensure equal access to library resources and services.

In conclusion, these studies collectively highlight the transformative potential of IoT in improving the lives of individuals with disabilities across various domains, underscoring the importance of ongoing research, investment, and collaboration to address challenges and maximize the benefits of these technologies.

Methodology:

The research was carried out on a group of individuals with disabilities, totaling (109) people with physical and visual impairments. The sample was reached by publishing the questionnaire on the Egyptian University Libraries Consortium page on Facebook, which includes 41,000 users of university libraries. Due to the delicate nature of interacting with individuals with special needs and the potential psychological discomfort or harm that personal interviews may cause participants, a questionnaire was used as a data collection tool. The questionnaire comprised (11) questions spread across (5) main sections to identify the challenges encountered by the sample population in utilizing their university libraries, their satisfaction with the services offered, and their requirements for programs and devices that would enable them to access information sources. Furthermore, their feedback was sought on appropriate Internet of Things technologies for future implementation. When designing the questionnaire, it was ensured to be brief, utilizing closed-ended (Yes/No) and multiple-choice questions while excluding open-ended questions that necessitate written responses. This decision was made considering the characteristics of this group and the potential fatigue they may experience when responding to such questions.

Data Analysis:

People with physical disabilities were the most engaged in the study, totaling (75) individuals, representing 68.80% of the total sample. Those with partial disabilities numbered (101), representing 92.66% of the total sample, while individuals with complete disabilities numbered (8) people, representing 7.33%.









Results & Discussion:

The quality of service:

Most participants, (62) individuals totaling 68.75%, were dissatisfied with the services provided by the university library, primarily due to budget constraints affecting service quality. Libraries facing financial limitations struggle to afford necessary devices and software for individuals with special needs, as Addai-Wireko et al.'s study (2020) indicates. Due to limited financial resources, Suweifi (2011) suggested exploring free software as an alternative. However, (31) participants (34.37%) noted some level of service provision by the university library, while 16 participants (17.74%) felt the library adequately meets their needs. Specific university libraries prioritize this group by offering equipped reading rooms with devices and software for improved access to collections.



Figure3: User satisfaction with service quality

Devices and Software:

The study monitored seven forms of hardware and software that enable persons with disabilities (the motor and visually impaired) to use the information resources available in the library efficiently and quickly. Tablets came at the forefront of the most needed devices with a frequency of (81) and a percentage of (26.29%), as the presence of smart devices will help people with motor and visual disabilities to interact with the holdings and reduce their movement within the library. While Voice Recognition software was one of the most requested programs with a frequency rate of (60) and a rate of (19.48%), people with motor disabilities face difficulty when using the keyboard. They are unable to press more than one letter at a time. This problem has been

overcome by using this program so that the user can give voice commands to the computer instead of using the keyboard.

On the other hand, several respondents (52) (16.88%) indicated they need the Clavier Arganda Keyboard, characterized by its large buttons and specially designed for people with hand motor disabilities. While text enlargement software was among the programs people with partial visual impairment needed to enlarge texts displayed on the computer screen, it came with a frequency selection rate of (38) and a rate of (32.46%). Screen reader software is also considered one of the programs that received the attention of the sample, as it came with a frequent choice rate of (31) and a rate of (10.06%), which is considered a form of assistive technology directed to people with complete or partial visual impairment, which enables reading any text appearing on the device screens. To audible speech, the user can know what is on the screen and then deal with it. Another essential device for serving people with motor disabilities, which libraries must provide, is Page Turners, where people who cannot move their hands partially or wholly can turn the pages of a printed paper book using a button pressed by the foot, as it came at a frequency of (22) At a rate of (7.14%) among the sample members. Parilli Printers came at the bottom of the sample's needs with a frequency of selection (21) and a rate of (6.81%). Braille printers have allowed people with complete visual impairment to read text easily, as it is printed in relief.

Other devices and programs include the electronic script device, which enables blind people to read the content of a computer screen in Braille; the Ibsar program, one of the most prominent programs for reading written texts; and the Scanner Reader device, which recognizes letters and converts them into audio signals.



Figure 4: Devices and software required.

IoT services required:

To identify the needs of the study sample for Internet of Things services, enabling them to access the library's resources without assistance independently, the researcher presented twelve Internet of Things services for selection. These services are tailored for individuals with physical and visual disabilities. This selection was based on a review of academic works in Arab and foreign studies (Ben Tayeb, 2021; Qenawi, 2019; Domingo, 2012; Khasseh et al., 2020; Lee et al., 2020; Liang, 2018); the results were as follows:

The Digital Assistant is at the top of the services most needed by faculty members and their assistants, with a frequency of choice (82) and a percentage of (14.59%); It is considered one of the primary services in European libraries, provided to both ordinary people and those with special needs. The digital assistant represents the new generation of the Ask Librarian service, utilizing the FAQ network stored in the assistant software (Ramos-Garijo et al., 2003). It enables people with mobility disabilities to interact with the library's resources and services remotely through its website or via a mobile phone application within the library. The robot came in second place for the Internet of Things services needed by the study sample, with a frequency of selection (72) and a percentage of (12.81%); The reason for this is that the robot will reduce the effort expended by

people with motor and visual disabilities to access information sources and reduce possible human error when dealing with them.



Figure 5: Needs of people with disabilities from emerging

The Smart Wheelchair secured the third position, meeting an essential requirement of the study sample with a selection frequency of (68) and a percentage of (12.09%). Individuals with physical disabilities can utilize the smart chair to navigate different library sections effortlessly through voice commands, thanks to its sensors connected to the internet. It has objects and an internal navigation system that stores all library sections and facilities in its digital memory. According to Kumar, Sumathi, Prithi, and Suriya (2019), this chair is believed to enhance the user's experience, providing comfort and promoting self-reliance.

The Library App is a service offered by libraries in developed countries to provide beneficiaries with access to information sources worldwide without any barriers. It is a crucial resource for users, ranking third in selection frequency (65) and percentage (11.56%). The application facilitates user interaction and the library's services and collections (Yoon, 2016), which enables individuals with mobility disabilities to browse books, search the electronic catalog,

communicate with library staff, pay fines, and access other services remotely, without the need to visit the library (Wei et al., 2015; Pu et al., 2015).

Among the services that sample members consider essential to benefit from library services, particularly for individuals with mobility disabilities, the Library Drone service ranked fourth with a selection frequency of (54) (9.60%). This service involves a remote lightweight drone with precise imaging and GPS positioning techniques. It is utilized in libraries to deliver reserved books to users without them having to visit the library. The service heavily relies on the library application for sending requests and determining the beneficiary's location (McNabb, 2020).

Fingerprint/Facial recognition technology emerged as a crucial requirement for Internet of Things services, with a selection frequency of (51) and a percentage of (9.07%). This technology enables user authentication through facial or fingerprint recognition, granting access to the library anytime (Cao et al., 2018). Moreover, it monitors user behavior and alerts the security system of any misconduct, such as theft or damage to property, as all library items are equipped with Internet of Things sensors interconnected for tracking purposes. Continuous monitoring ensures a safe environment, allowing individuals with disabilities who may feel uncomfortable or lack confidence in social interactions to visit the library with the assistance of a companion during non-peak hours. This approach ensures that the library remains free from judgmental onlookers, as highlighted in psychological and educational studies focusing on the characteristics of such individuals (Al-Talawi, 2002; Fatouh, 2012).

While iBeacon technology ranked sixth among the sample requirements for Internet of Things services, with a selection frequency of (48) (8.54%), it was developed by Apple company and announced at its 2013 conference. This technology operates through small wireless transmitters using Bluetooth Low Energy Technology to automatically send text notifications to nearby devices via Bluetooth pairing (Newman, 2014; Bahaa & Hamad, 2019). It does not require Internet service and is used in smart libraries for ongoing briefing services. When the beneficiary approaches the library site, they receive notifications of recent acquisitions and upcoming events and activities through SMS text messages (Dalkılıç et al., 2017). This allows people with total visual impairment to activate the feature of reading text messages by voice on their smartphones to learn about recent acquisitions at the library and request them through the library's Lib App application.

Blockchain technology emerged as a crucial tool for individuals with mobility impairments, with a selection frequency of (42) and a percentage of (4.47%). It enables the

completion of transactions (such as loans, returns, seizures, and fine payments) without the need to be physically present at the entity or institution (Dai et al., 2019). Additionally, it is utilized to generate digital IDs for recipients, containing detailed information like name, date of birth, workplace, field of expertise, and credit card details for conducting library-related transactions remotely (Al-Rehaili & Al-Dahwi,2020; Rodrigues & Cardoso, 2019).

Despite the significance of investing in hologram technology in libraries to cater to both regular individuals and those with special needs, the participants in the study failed to recognize its benefits. It ranked eighth in frequency of selection (32) and a rate of (5.69%). The concept of utilizing hologram technology to assist individuals with special needs in libraries can be encapsulated in Smart Shelves. These shelves have successfully addressed the issue of overcrowded bookshelves and the challenges associated with accessing them. Consequently, the entire library collection can be stored on a single hologram tablet. This innovation eliminates the need for individuals with mobility impairments to navigate between library shelves searching for books. Moreover, one of the critical features of holographic browsing is the ability to adjust the font size to accommodate individuals with partial visual impairment. (Al-Sobhi, 2017).

While the Finger Reader ranked lower with a frequency of choice (22) and a rate of (3.91%), this technology is aimed at individuals with disabilities such as impaired vision and blindness. It is a compact device resembling a finger ring that can be worn to read printed materials. The device has a tiny camera for scanning text and a sound output feature. Additionally, it includes special software that monitors finger movements to alert the user if their finger strays from the designated path, either upwards or downwards (Ingber, 2015).

Smart glasses are an essential technology that should be implemented in libraries to assist the visually impaired. This service had a consistent selection rate of (18) and a rate of (3.20%). Smart glasses, developed by Google, utilize artificial intelligence and are equipped with a front camera to identify objects such as places and currencies, alerting users through sound (Kim et al., 2016). This enables visually impaired individuals to navigate library corridors and sections easily and have their favorite books instantly translated into sound for reading.

The RFID service came in last place as one of the services that assist in using the library's holdings, even though it represents the backbone of the technical activities and operations within it, with a frequency of selection (11) and a rate of (1.95%), as this technology can be used to serve people with disabilities. Mobility in two primary services: The first is Smart Cards, in which the entire beneficiary data is stored through a small RFID SIM chip integrated into the card. Thus, the

beneficiary's identity can be automatically identified, and the electronic library portal can be opened directly as soon as one approaches it. In addition, when the user exits the same portal and owns the books he wishes to borrow, which also have RFID tags embedded, the portal reads them. It records them automatically without returning to the librarian to issue the borrowing order. The second is Smart Chairs RFID, where the beneficiary passes his smart card in front of the part of the seat designated for it. Then, the seat moves behind the beneficiary between the library shelves to sit on at any time.

Challenges:

Most participants (81) individuals, totaling 40.29% of the sample, identified a significant barrier: the lack of software and devices for reading. This scarcity is attributed to budget constraints within the library or the absence of a dedicated department for individuals with special needs. Furthermore, (55) participants (27.36%) noted that service providers may impede access due to inadequate training tailored to the needs of individuals with special needs. Additionally, (32) participants (15.92%) highlighted that the library's location could be a hindrance if not properly equipped, as recommended by studies (Alzahimi, 2012; Jadhav & Shenoy, 2020), emphasizing the necessity of accessibility features like clear signage, GPS navigation, and reduced physical barriers. Psychological factors also play a role, as mentioned by (22) participants (10.94%), who emphasized feelings of inferiority, loneliness, anxiety, and stress among individuals with disabilities, affecting their daily lives and societal integration. Moreover, some participants (11 individuals, 5.47%) pointed out additional barriers such as insufficient collection size, lack of electronic books (textual and auditory), failure to adapt to the library's internal research environment, and inadequate marketing of services and collections.



Figure 6: Challenges of using the library.

Conclusion:

In conclusion, Internet of Things technologies have the potential to revolutionize library services for individuals with special abilities, fostering greater inclusivity and access to information. By leveraging IoT solutions, libraries can create dynamic and adaptive environments that cater to diverse needs and preferences.

It is necessary to work on adopting continuing education and training programs for librarians to qualify them to deal with people with disabilities and to work to employ people with disabilities in libraries, as their employment will remove the psychological factor and help their integration into the library community. In conclusion, agreements and partnerships between libraries and companies that manufacture software and technical devices are also important in providing services for people with disabilities in a way that suits their special nature. On the other hand, it is necessary to encourage researchers to prepare more research that employs Internet of Things technologies in libraries to serve people with disabilities.

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