ARTIFICIAL INTELLIGENCE IN LIBRARIES.

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Chapter 8
Artificial Intelligence in Libraries

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ABSTRACT

Artificial intelligence (AI) is one of the emerging trends and applications of computing in libraries. It involves programming computers to do things, which if done by humans, would be said to require intelligence. The ultimate promise of artificial intelligence in libraries is to develop computer systems or machines that think, behave, and in fact rival human intelligence, and this clearly has major implications on librarianship. The application of artificial intelligence in the library has become pervasive. They include expert systems for reference services, book reading and shelf-reading robots, virtual reality for immersive learning among others. Although the incorporation of artificial intelligence in libraries can be perceived to alienate librarians from their users, it will probably help libraries do more rather than taking over the jobs of librarians. It will enhance their services delivery. Artificial intelligence will greatly improve library operations and services and will upgrade and heighten the relevance of libraries in an ever-changing digital society.

INTRODUCTION

Intelligence is the ability to think and learn facts and skills and also apply them when necessary. The prospect of developing computers or machines that perceive, learn, reason and behave like human beings has fascinated many people. Humans are born with an innate ability to perceive, reason/think and act, which develops and improves over time as a result of so many factors. Intelligence in humans is measured by the Intelligence Quotient (IQ) obtained through series of aptitude test focusing on different aspects of intellectual functioning. Similarly, developing intelligent computers that perceive, think and behave like humans is the crux of Artificial Intelligence. Intelligence in computers or machines depicts their ability to accomplish specific task in the presence of variability and monitor its environment and appropriately adjust its actions based on what it has sensed as prerequisites for intelligence. Intelligences in machines is an anthropomorphism in that intelligence is defined by the criterion that the actions would appear intelligent if a person were to do it (McGraw-Hill Encyclopedia of Science and Technology, 2007). According to Ex Libris (2019), intelligence in machines not only gives such devices the ability to learn but they are also configured to improve with use to perform functions better without being explicitly programmed because they are built to recognize and imbibe patterns efficiently on much higher scales than humans.

Artificial intelligence already touches many of our daily computing activities, most of the computer systems and mobile phones being developed today have artificial intelligence features and we have probably used them not knowing that they are intelligent machines. Examples of Artificial intelligence in computers are speech recognition, natural language processing, self-driving or autonomous cars, machine learning, deep leaning and robotics. Artificial intelligence works based on perceptual recognition unlike human beings that operate on deep cognition. The power and advantage of Artificial intelligence lies in the fact that computers can recognise patterns efficiently at a scale and speed that human beings cannot.

The development of societies in recent times have been facilitated by the growing demand of access to information, and libraries are the prime source in providing this access. The paradigm shift in the format and dynamics of information and knowledge as a result of the rapid advancement in computer technology and software applications especially artificial intelligence, have shifted libraries to a demand of the commensurate supply of the same technologies. Unless libraries begin to exploit the new technologies and innovate their information and services delivery, they may face obsolescence in this era.

Artificial intelligence is used in many areas such as medicine, military, business, education, gaming, libraries etc. The idea of creating artificial intelligence systems in libraries dates back to 1990. These intelligent library systems provide knowledge-

based services to both the library staff and patrons (Asemi & Asemi, 2018). Application of artificial intelligence in library system encompasses descriptive cataloguing, subject indexing, reference services, technical services, shelf reading, collection development, information retrieval system etc. These has gone beyond Natural Language Processing (NLP), and knowledge-based services. With the advancement in artificial intelligence programming, creating a smart library is not only a possibility but a matter of time. Corroborating this assertion, Corke (2013) reported that researchers and experts in the field of artificial intelligence are creating intelligent systems which can think and behave like librarians – library robots.

Justification for Applying Artificial Intelligence in Libraries

Libraries have evolved structurally and content-wise through different eras: the ancient, medieval and modern era. In the ancient times, clay tablets and stones were used as media for transmitting information, through the medieval era of papyrus and parchments and the modern era of paper, microform and now the digital or electronic media (Gustavsson & Hedlund, 2011). Libraries have acquired and maintained various forms of information resources throughout these eras so as to meet the information needs of its user communities. Similarly, a library was formally defined as a function of the physical building where books were kept for reading and other purposes. However, the definition of library today has gone beyond the physical building, it now centers on the collections and services offered, since virtual libraries have no physical walls and services could be rendered to users from remote locations. Consequently, in the effort to satisfy the dynamic information needs of its clientele at the same time uphold its relevance in this ever-changing technological society, libraries have explored, incorporated and metamorphosed through different technological revolutions of clay tablets, stones, papyrus, parchments, paper, microforms, computers, Internet, virtual libraries, library 2.0, cloud computing etc.

Interestingly, artificial intelligence is the current technology that has evolved with huge prospects and promising applications in libraries. Hence, the need to also explore this tech, its pros and cons, in order to adequately maximize its rich benefits for innovative and optimal services delivery in libraries, as Corke (2013) asserted that artificial intelligent systems (robots) will be an important technology in this century. In a nutshell, the crux for applying artificial intelligent systems in libraries is the fact that they are less prone to errors unlike human beings; they can work for 24 hours/7 days without getting tired thereby freeing the librarians to do other jobs. Ultimately, since computers can operate efficiently at a scale and speed beyond human abilities, it will maximize speed, efficiency and effectiveness in processing library materials and enhance library services delivery at all levels.

This chapter will be focus on the concepts, foundations, application and advancement in the field of artificial intelligence in libraries, application of robots, virtual, augmented and mixed realities in libraries, their promises, benefits and demerits they hold for future libraries.

Concepts of Artificial Intelligence (AI)

The sound of the term artificial intelligence often conjures images of robots or computers that talk. Artificial intelligence is an aspect of computer science that focuses on how computers learn (Machine Learning), interpret information, vision: character recognition, picture analysis, 3D perception, and modelling of the function of the eye; furthermore, it encapsulates speech recognition, speech production, understanding and use of natural language (Natural Language Processing), and Expert System which continues to gain more attention. Furthermore, artificial intelligence is the programming and development of computers to perform human required-intelligence task, such as speech recognition, decision-making, visual perception, language translation, talking and emotional feelings (Irizarry-Nones, Palepu & Wallace, 2017). According to Heath (2018), artificial intelligence is the technology that enables machines be to have the abilities to plan, learn, reason, solve problems, move, and be creative to some extent.

Three main focus of artificial intelligence is perception, reasoning and action. Reasoning is fundamental in intelligence gathering, it involves internal processes or programming logic/algorithm, that makes computers think of the best way of action before performing the action. Similarly, McGraw-Hill Encyclopedia of Science and Technology (2007) maintained that artificial intelligence is a subfield of computer science focused with understanding the nature of intelligence and constructing computer systems with ability to make intelligent behaviour. Moreover, it is primarily concerned with representations of knowledge and heuristic methods of reasoning using common assumptions and rules of thumb. Other definitions of artificial intelligence include: creating machines with minds (Haugeland, 1985), the study of mental faculties through the use of computational models (Charniak & McDermott, 1985), the explanation and emulation of intelligent behaviour in terms of computational processes (Schalkoff, 1990), the science and engineering of making intelligent machines and computer programs (John McCarthy). Artificial intelligence is concerned with the concepts and methods of symbolic inferences and representation of knowledge by machines. It is aimed at performing intelligent tasks such as logical thinking, learning new abilities and adopting to new situations and problems (Nilson, 1998 cited in Shohana, 2016). In a nutshell, artificial intelligence is making computers or machines intelligent just like human beings, in order to make them find solutions to complex problems in human fashion.

Furthermore, Asemi and Asemi (2018) asserted that the field of artificial intelligence deals with the study and development of computer systems or machines that exhibit some forms of human intelligence, such as learning new concepts and tasks, reasoning and drawing useful conclusions about a specific task, natural language processing or perception and comprehension of visual scene etc. The intelligence of computers can be measured using the 'turing test', developed by Alan Turing in 1950s. Although there are controversies and objections over this method. Irizarry-Nones, Palepu & Wallace (2017) however asserted that the artificial intelligence of computers or machines could be strong or weak. A computer with strong artificial intelligence is able to think and make decisions like human beings, it is also capable of learning from experience and re-programme itself to improve on past mistakes like in the movies. Weak artificial intelligence computers cannot think, learn or re-programme themselves, rather, they are specifically designed to respond to specific situation.

Trends in the Field of Artificial Intelligence (AI)

Advancement in the field of artificial intelligence include autonomous vehicles or self-driving cars, navigation systems, human versus computer games, fraud detection, robotics and machine learning – the application of artificial intelligence which give computers or machines the ability the learn from data gathered of past experience, re-programme and improve on itself without human intention (Irizarry-Nones, Palepu & Wallace, 2017). Machine learning simply implies the computer teaching itself through iteration and past experiences with data. In addition, artificial intelligence encompasses the following general areas of research: automatic programming, computer vision, intelligent control systems, expert systems, intelligent computer-assisted instruction, image processing, natural language processing, planning and decision support, robotics, and speech recognition (Asemi & Asemi, 2018). The application of artificial intelligence has gained usefulness in most fields of study and its thriving fast with the development of smart phones, smart homes, Internet of Things (IoT) and Internet of Vehicles (IoV).

Interestingly, Artificial Intelligence is being used to generate and evaluate content including artistic and creative work (LeFebvre, 2017). Washington Post newspaper uses an AI system – Heliograf to cover elections while IBM's Watson machine learning suite provides assessments, analytics, real-time scores and captions for sports and cultural events (Melendez, 2016; Alpert, 2016). According to Harris (2016), AI has made a significant inroad into education as IBM has come up with the Teacher Advisor an AI system which has been built to help teachers draw up personalized lesson plans by pointing them to best lessons in math and then customizing the lesson to fit their unique classroom needs. The Teacher Advisor has a database of open

educational math resources that provides over 2,000 free lessons, teaching plans and videos that can quickly search and bring up relevant answers (Fine, 2017). Semantic Scholar uses machine learning and other AI systems to assist the academia search more effectively and efficiently through resources as more and more research get published (Metz, 2016).

Artificial intelligence systems have been broadly classified from two different perspectives as outlined by Liu (2011):

1. The degree of their intelligence. In this perspective, artificial intelligence systems are classified into: (1) reflex agents able to respond to stimulus from sensors such as heat sensor, light sensor, motion detection etc; (2) utility-based system; (3) goal-oriented systems; and (4) learning system such as machine learning systems that can teach computer programming.
2. The nature of their functionality. In this view, artificial intelligence systems can be categorised into (1) collaborative systems; (2) reactive systems; (3) Internet-based systems; and (4) mobile systems that can autonomously travel from one place to another to perform a task.

Foundations of Artificial Intelligence

According to McGraw-Hill Encyclopedia of Science and Technology (2007), the four foundations of artificial intelligence are representation, search, reasoning and learning. These four foundations are basic requirements present in any artificial intelligence system.

1. Representations. This denotes the internal description of the problem or related knowledge of the intelligent system. Representation include knowledge-based of the system to identify problems and the architecture on which it can be manipulated. Representation of an expert system for diagnosis would be the description and symptoms of a person with a disease. For a moving robot, it could include the symbolic 3D description of a room.
2. Search. This is one important aspect of artificial intelligence systems that is used for problem-solving methodology. In some cases, a heuristic search is used to modify itself in response to the problem at hand. Example of search could be a database search of previous problems and solutions for the closest match to the current problem.
3. Reasoning. This is designed to turn knowledge into solutions to problems. This is the crux of the intelligence of the system. Reasoning could be deductive and inductive reasoning in which problems knowledge is used to deduce a set of possible solutions, or used to build a hypothesis that best explains the existing

knowledge and possibly the current problem. Example of reasoning include expert systems, where the solutions to problems are reasoned based on some set of rules or knowledge-based developed by human expertise to identify the rules of the problems.

4. Learning. The learning feature of intelligent systems makes them adapt and gather intelligence by learning the history or knowledge of the system. Learning covers the aspect of reconfiguring the representation, adjusting the search to be heuristic, updating the knowledge and augmenting the reasoning. Some of the most common learning methods used in artificial intelligence systems are statistical learning (using the number of the different types of historical events to base future actions or to develop inductive hypotheses, typically assuming that events follow some known distribution of occurrence), neural networks (networks are trained on existing knowledge and then applied to the problem, and interpret the value of the outcome as a solution), reinforcement learning (actions taken by an artificial intelligent system are rewarded or penalized based on their ability to solve the problem more or less accurately). These falls within the subject of machine learning and deep learning.

Application of Artificial Intelligence in Libraries

Artificial Intelligence matters to libraries because it be used for organizing and making available large collections of information (ALA, 2019). According to Sridevi and Shanmugam (2017), artificial intelligence is the modern technology which is used to manage the digital library. The ultimate promise of artificial intelligence is to develop computer systems or machines that think, behave and in fact rival human intelligence, and this clearly has major implications on librarianship. Artificial intelligence is not just an intelligent system or software program, it is a biologically motivated technology used to replicate human ways of perceiving and processing information (Sridevi & Shanmugam, 2017). Intelligent library automation systems rely on artificial intelligence technologies to provide knowledge-based services to library clientele and staff. Artificial intelligence in libraries should not be misconstrued with library automation. While the later implies the degree of mechanisation to routine library operations, the former goes beyond just automating library activities, and create intelligent rational systems that behave and act like librarians and requires little or no human intervention. Artificial intelligent systems can replicate and thus replace a human being in the library, although Li, Huang, Kurniawan and Ho (2015) believed that this invention will never replace librarians, but will center on menial and time-consuming library operations such as shelf reading and leave the librarians to engage with the patrons. Corroborating this assertion, Murphy (2015)

maintained that the application of robots in libraries will bring librarians and users closer together, against the notion that robots will alienate librarians from their users.

Some fields of artificial intelligence that are used in library management system include: Natural Language Processing (NLP), Expert Systems (ES), Pattern Recognition, Robotics etc (Sridevi and Shanmugam, 2017). Succinctly, Natural Language Processing (NLP) is the analysis and generation of natural language text by computers. The goal is to enable natural languages such as French, English, or Chinese, to serve either as the medium through which users interact with computer systems or as the object that a system processes. In libraries, NLP can be used to design intelligent expert reference system or information retrieval system, where users can interact directly with the system using natural languages. The computer takes in the natural language as input, analyses and processes it, then respond accordingly with the needed information. NLP has been used as medium of interaction in database management systems and as object/input for processing in automatic text translation or text summarization (McGraw-Hill Encyclopedia of Science and Technology, 2007).

Another practical application of artificial intelligence in libraries is subject indexing. This task requires the technical expertise of the librarian or indexer and his intellectual judgement to peruse, analyse and suggest the appropriate terms to be used as index terms or keyword of a given document. Any computer system or machine that can undertake this task can be said to be intelligent. An Expert System can be designed to handle subject indexing or reference services. Moreover, Expert Systems are computer programs that simulate human decision making. They incorporate methods and techniques with specialized problem-solving expertise. Expertise consists of knowledge about a particular domain or subject, wide coverage or understanding of the domain problems and techniques at solving some of these problems. In designing an intelligent system for subject indexing or reference services, first, relevant knowledge from a subject indexer or expert is extracted and fed to the system, subsequently, the system will learn (Machine Learning) from the knowledge-base and experience to index documents or response to reference queries from users, as the case may be. According to Asemi and Asemi (2018), Expert Systems have been used in several fields to solve problems including: medicine, computer science and engineering. The library is another fertile ground for the application of expert and intelligent systems. Furthermore, Expert Systems can provide reference assistance, help in management policy decision making, assist in applying cataloguing rules, determine vendor assignments in acquiring library materials etc. In order to carry out these intelligent tasks, Expert Systems imitate human thinking/reasoning, by means of a "knowledge base" which serves as a set of rules culled from various human experts.

Furthermore, an Expert System consist of two modules: the knowledge base and the interface engine. Similarly, Sridevi and Shanmugam (2017) reported that the knowledge base of an Expert System contains the complex structured and unstructured information, while the interface engine subsystem is used to apply logical rules over the knowledge base in order to iteratively decipher the new information. Expert Systems can be designed to function in the reference unit of the library. In fact, it can provide better answers to users query than just a single librarian, since the knowledge base of the Expert System is created and updated from the submissions of team of best/experienced experts in the field – like the saying: two heads are better than one. The Expert System is designed to response to users query based on the keywords or phrases in the users query. If certain keywords or phrases are in the query, then the system intelligently respond to the user accordingly.

It should be added that artificial intelligence systems could also be developed to handle resource development or collection development of the library. Note that, collection development deals with the resource selection, acquisition and development in the library, or simply the process of meeting the information needs of library users in a timely and economical manner mainly through acquisitions (purchase), or gifts from sister organization and various other bodies (Udensi & Akor, 2016). After the selection of books that would be purchased by a library, a list is normally sent to book sellers and vendors to submit the prices with respect to the quality and format (print or electronic, paper-binding or hardcover-binding). Likewise, the intelligent system can learn from past experiences and submit the list of items to be acquired based on the previous performances of the book-sellers or vendors, especially now that most book-sellers and vendors can be accessed via their emails or homepage. Corroborating this assertion, Romero (2018) reported that artificial intelligence systems can give suggestions based on past purchases or user interests - a strategic method to improve acquisition of library materials and enhance the user experience via recommendations of magazines, journals, authors, books, etc.

Information retrieval is another aspect of librarianship that has felt the touch of artificial intelligence. Library information retrieval deals with the recall of information or resources from a file or database, it is concerned with the structure, analysis, organization, storage, searching, and retrieval of information stored in a library's collections, information centre or the Internet (Croft, Metzler & Strohman, 2015). As the information held in libraries grew, several types of information retrieval tools were invented to cope with the vast amount of information therein and make them accessible to users. Nowadays, the quantity of new information being generated is at an exponential rate, this led to the invention and use of computerised and artificial intelligence retrieval systems to facilitate information searching and retrieval from the library's collection, be it paper-based or electronic (Unagha, 2010).

The modern information retrieval tools now used in libraries to provide quick and innovative access to information include: electronic databases, Online Public Access Catalogue (OPAC), web search engines, and robotic systems customised for book retrieval and delivery. Most web search engines today such as Google, incorporates speech recognition to their system. This enable their users to speak the word or phrase they want to search and the web search engines types it into the search box via the use of Natural Language Processing (NLP) before searching and displaying the search results. In addition, Murphy (2015) reported that robotics technology is being used to free space restraints and make information resources readily accessible to users. Example is the enormous automated storage and retrieval systems acquired by the University of Technology, Sydney (UTS). The system, designed as robotic cranes underneath the library, tend to thousands of closely packed bins of books. The robotic cranes stores and retrieves materials for users on request from the online catalogue of stored books. Once the request is made, the robotic crane automatically search for the item and retrieves it from the appropriate bin to the library staff in charge, who then retrieves the requested book and delivers it to the library's hold shelf where the user can pick it up. The advantages of the system are: maximisation of retrieval speed, about fifteen minutes from the time of request till when the item is delivered; minimization of storage space; and minimization of cost, obviating the need to build an expensive off-site storage facility.

Artificial intelligence has gained tremendous application in library information services, these include but are not limited to:

1. Automatic cataloguing and classification using Optical Character Recognition (OCR)
2. Automatic translation of foreign language materials using Natural Language Processing (NLP)
3. Automatic indexing using Expert Systems
4. Retrieval of audiovisuals materials Optical Character Recognition and Speech Recognition. Music and pictures in the library's collections can be called-up as fast as printed records – a new dimension to knowledge storage and management.
5. Interactive bibliographic instruction using various media
6. Intelligent gateways to online sources,
7. User-structured information environment
8. Portable computer reader services for the handicapped
9. Intelligent Document Delivery Services (DDS)

Robots in Libraries

Robotics is a subfield of artificial intelligence and it focuses on the perceptual and motor tasks. It also refers to the branch of technology that deals with the design, construction, operation, and application of robots (Abram, 2019). A robot is a machine that performs automation tasks and carries out series of complex operations under the supervision of a human or automatically (autonomous) under the control of pre-defined program using artificial intelligence techniques (Shohana, 2016). According to Corke (2013), the term robot was first used to depict artificial people or androids coined in a 1921 Czech science fiction play. Following these, so many robot stories were written including Isaac Asimov's robot series. These stories influenced subsequent books and movies which in turn have shaped the public perception of what robots are.

The application of robots in library activities is one of the current trend in the application of artificial intelligence in libraries. Accessibility to the vast collection of information available on the web is a hallmark of the digital age. However, much of knowledge in the world still remains between the pages of printed books. Tracing these books in libraries is laborious and often time consuming (Li, Huang, Kurniawan and Ho, 2015). Book shelving and retrieval robots are now being developed to undertake this task. Example is the enhanced robotic library system for off-site shelving designed by Suthakorn, Lee, Zhou, Choudhury and Chirikjian (2002), which gains comprehensive access to printed materials on shelves, and retrieves books from the shelves to an off-site scanning station. The robotic system was designed to allow users gain comprehensive access to printed library materials, on demand that are off-site, through a web interface. First, the user will identify the material he/she wants to retrieve/read, then a sequence of operations will be initiated that will eventually trigger the robot to retrieve the requested item. Thereafter, another robotic system will open the item and turn the pages automatically via the use of scanners, Optical Character Recognition and automatic indexing software, which will allow the user to browse through the material, search and analyse the full-text generated from the scanned images of the item. Another robotic book retrieval system is the bookBot technology. According to Stone (2019), this technology has been in existence and used in manufacturing for years, but now being applied in libraries. The bookBot is a book-delivery system that automatically retrieves books for users on demand through the library automated catalogue. Within minutes of receiving a request, one of the bookBot's robotic cranes retrieves the requested item from the shelves and delivers it the unit in-charge for onward delivery to the user within or outside the library when the user intends to borrow the material.

Libraries are embedding Radio Frequency Identification (RFID) tags into their collections. These tags in form of barcodes, contains unique identifying labels for

each book in the library, and is used to quickly scan the library's collection using wireless, handheld RFID scanners/readers. According to Li *et al* (2015), smart shelves containing several RFID antennas can automatically register when books are removed from their stacks or returned. This can be used for automatic shelve reading and generate reports for miss-shelved or missing books. Similarly, robots are also being designed to navigate through library shelves to scan and retrieve materials such as the robot designed by Li, Huang Kurninam and Ho (2015), at Agency for Science, Technology and Research (A*STAR) Institute for Infocomm Research. These intelligent systems offer greater accuracy than humans although they are expensive to design and maintain. The technicalities involve will include outlining detailed map of the entire library for the movement of robot, computing and processing the distance between the robot and an obstacle (shelf, books, tables, users) to anticipate direction changes.

According to Shohana (2016), Connecticut's Westport Library acquired two robots that will assist in teaching coding and computer programming skills to users/students. In addition, two students, Pasi William Sachiti and Ariel Ladegaard at Aberystwyth University, created an artificial intelligent library catalogue by combining existing robot technology with information from the university's online public access catalogue. This robot was designed to accept users book request verbally and process, eventually leading the user to the exact location of the printed material on the shelf. Closely related to this is the robotic cranes used at the British Library's National Newspaper Building. The robot cranes is capable of retrieving newspapers from any time and date from a vast collection of over 60 million newspapers and periodicals spanning over three centuries.

It should be added that museums and archival centres also are exploring the capacity of artificial intelligence to improve their services delivery to patrons. According to Murphy (2015), the de Young Fine Arts museum in San Francisco acquired a pair of tele-presence robots that give patrons with disabilities the opportunity to visit the museum remotely. The robots, called BeamPros, 5'2 tall frame on wheels, has a screen, microphone, speakers and a camera to display the picture of a remote patron, allow the patron to speak and communicate/interact with others and also view the items arrayed in the museum respectively. To operate a BeamPros robot, a patron will first log into the robot via their computer at home or at work, then begins to pilot it and tour around the museum. The screen of the robot displays a live video feed of the patron's face, while the camera captures the live video feed of the museum for the patron to view. In addition, the robot has a second camera which captures the floor, allowing the patron to navigate around the museum to avoid obstacles. The advantage of this technology is the physical presence it gives the patron as he/she tours around the museum, and the interactive features: the

microphone, speaker, camera and screen, which allows a patron to interact with others – unlike a pre-recorded video tour.

From the foregoing, the practical application of robots, artificial intelligence in libraries, museum and archival centres as reviewed, shows that artificial intelligence has a great promise in libraries and information centres. Whether it is used for library instructions (education), organisation of knowledge (shelving and shelf-reading), information retrieval and delivery or remote accessibility of information material, this technology maximises the efficiency and effectiveness of library operations, and facilitates the library's connection with users.

Artificial Intelligence and Virtual Libraries

Virtual libraries are electronic libraries that provides access to distributed information resources in electronic format to users in remote locations. It is a term used to denote libraries without walls, an organised collection of links to various information resources on the network or Internet. It is a collection of electronic information resources in form of e-books, journals, online databases, media and other forms of data. Typically, virtual libraries provide remote access via an online portal or gateway, of information resources in varieties of contents/formats, including online databases, e-books, e-journals, e-magazines, e-newspapers etc, and provides other services traditionally offered by libraries. The virtual library environment means virtual communication between the library and the patrons, virtual services delivery, virtual information access etc (Trivedi, 2010 & Koganurmath, 2007). Users are able to view and request or access the library's information resources from their various offices or homes over the Internet. All forms of communications to the library is through e-mails, phone, fax or the video/audio/text communication system offered via the library's portal. Such libraries organises tele-training for their users, webinars, online video conferences etc. to keep their users abreast with their services and development. An interchangeable or closely related term is the digital library.

Digital and virtual libraries have their services fully automated. Moreover, automation is the process of using machineries to facilitate human activities and saving the human power and time. Library automation refers to the use of computers to automate the routine procedures in libraries such as cataloging, user registration, charging and discharging of books, shelf-reading etc., it the technology concerned with the design and development of the process and system that minimizes the necessity of human intervention in library operations. The main purpose of library automation is to free the librarians and library staff and to allow them to contribute more meaningfully to spread of knowledge and information. Artificial intelligence play a vital role in library automation especially in digital and virtual libraries where their resources and services are fully computerised. In fact, most automated library

systems incorporates one or more areas of artificial intelligence in the design and implementation of the system such as:

1. Automatic keyword indexing and abstracting of electronic resources via the use of Expert Systems.
2. Internationalisation/translation of electronic resources (text, audio) through the use of Natural Language Processing and Optical Character Recognition.
3. Digitisation of printed materials. This deals with the conversion of traditional library materials into electronic format through scanning or Optical Character Recognition to facilitate searching and retrieval.
4. Automatic textual analysis through the use of Decision Support System (DSS).
5. Information retrieval through the use of speech recognition and Natural Language Processing.
6. Automatic analysis and retrieval of audiovisual resources via the use of Expert Systems/ Optical Character Recognition.
7. The application of data processing systems to support clerical and repetitive functions found in technical processing of books (cataloguing), circulation control (charging and discharging of books) and serial management (tracking magazines, journals and newspaper holdings).
8. Multiple access to information resources and round the clock services delivery via the use of intelligent/ advanced automated systems.

Other digital and virtual library systems built based on intelligence system approach/algorithm include the online public access catalogue and online database gateways. These systems use meta-control and memory management to map knowledge in their various storage locations and control various processes involving data structure, characteristics and description in an intelligent manner.

Virtual Reality and Artificial Intelligence in Libraries

Virtual Reality (VR) is the use of computer technology to create a simulated environment. It is a computer technology that uses multi-projected environments, sometimes in combination with physical spaces, to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual or imaginary environment (Jackson, 2015). Virtual reality headsets are built with artificial intelligence features such as computer vision, image processing and speech recognition, to create an artificial 3D world that immerses users in a 360-degree digital world. Until now, libraries have not fully explored the potential of virtual reality (VR), augmented reality (AR), and mixed reality (MR) (Marcotte, 2019). Augmented reality enhances users vision/sight by overlaying 3D objects over real

word, while mixed reality allows digital created objects to interact with the real word. The combination of virtual reality, augmented reality and mixed reality can be used in libraries to enhance user experience and give opportunities for disabled or remote users to visit the library virtually. Like the traditional library environment, a patron using virtual reality headset is able to move around the artificial library environment and by simulating as many senses as possible (vision, hearing, touch, smell), interact with virtual library resources.

Furthermore, virtual reality gives the patron a virtual presence (tele-presence) in the library by immersing him/her inside the virtual library environment rather than viewing it from a computer screen. Like the BeamPros tele-presence robot used in de Young Fine Arts museum in San Francisco as reported by Murphy (2015), which give patrons with disabilities the opportunity to visit the museum remotely. Virtual reality is another option to bridge the distance barrier for distant or disable patrons. It can be incorporated with the work of Suthakorn *et al* (2002), the enhanced robotic library system which gains comprehensive access to printed materials on the shelves and allow patrons to remotely turn the pages of books automatically through the use of scanners & optical character recognition, to browse and search through physical materials in the library.

Since creating a virtual reality of all the information material in the library might seem to be difficult or time consuming, the combination of mixed reality & virtual reality can be used to link the enhanced robotic system for browsing/reading materials, so that when patrons from the virtual reality environment initiate an action to read a particular book, the book-reading robot is signalled/triggered to locate the physical book in the library in order to enable the virtual patron to browse through it via a live-feed of the pages of the book captured from the book-reading robot and transmitted to the virtual reality headset of the patron. Marcotte (2019) reported that virtual reality, augmented reality and mixed reality could be used in libraries for immersive virtual field trips for patrons, such as a walk through the solar system, previewing sea animals or test-driving a new car. Already, applications exist that libraries can use to stimulate reality for their users for deeper learning experiences (Abram, 2019)

It should be added that, the virtual reality headsets are a product of artificial intelligence systems that have gained applications in various field of science and engineering, medicine, aviation, military etc. It is mostly used in these fields for live training of students especially when it involves hazardous or sensitive activities in real life situations. The library should not be left out of the fun!

The Benefits of Artificial Intelligence in Libraries

Generally speaking, artificial intelligence is installed in machines or computers to reduce human casualties in wars, hazardous work environments, car accidents, plane crash, fire explosion or disasters as a result of human error. Furthermore, artificial intelligence facilitates human work with greater speed, efficiency and effectiveness in work environments such as the library. According to Vijayakumar and Vijayan (2011), artificial intelligence and expert systems are used in classification, cataloging and indexing of library materials. Via the use of optical character recognition and neural network, the system is able to obtain the bibliographic records of books and classify them accordingly. According to Asemi and Asemi (2018), natural language processing can be used to reduce language barriers. For instance, one has to learn Chinese in order to study in China. The availability of Natural Language Processing systems in their libraries can assist the foreign students to translate and understand Chinese. Moreover, Natural Language Processing systems can also assist in searching for information in Multilanguage databases. In addition, expertise is needed in the provision of qualitative service delivery in libraries, as such, artificial intelligence and expert systems will improve the performances of library services and reduce the rate of human errors and defects and can perform task faster than a human being can most likely (Shohana, 2016).

Romero (2018) submitted that artificial intelligence could facilitate searching and retrieval of new media with greater efficiency and effectiveness by library patrons and introduce them to new material they may never have found otherwise. In addition to convenience and entertainment value, using artificial intelligence to suggest similar materials could also help library clientele who are carrying out research by combing the library database in an instant. Generally speaking, artificial intelligence systems can read to you, inform you, advice you, teach you, correct your mistakes, and patiently respond to your myriads demands. Thus artificial intelligence holds great potentials for library and information service.

A good librarian, through working with a user, can provide a much better tailored service, potentially using up time freed up by using AI. – IFLA Library Policy and Advocacy Blog

The benefits of artificial intelligence in libraries can be summarized as follows:

1. According to Ex Libris (2019), artificial intelligence in libraries can make research more discoverable which can boost research productivity among faculty members,

2. **Bridge in Time:** Round the clock accessibility to information resources and services just in time.
3. **Bridge in Space:** The space occupied by piles of books, journals, bound newspapers and other information materials has been reduced by the introduction of digitization, electronic copies and use of robotic cranes that stores and retrieve books from a compact off-site storage location.
4. **Maximization of Efficiency:** This refers to efficiency in library operations: selection and acquisition of materials, technical services, circulation services, references services, serial management etc.
5. Maximization of effectiveness in form of improves services delivery and elimination of human errors in library operations.
6. **Minimization of Effort:** The effort expended by librarians in technical services, circulation services, references services, serial management etc, can been minimized by the use of artificial intelligence systems in libraries.
7. Enhanced and immersive user experience in library services delivery.

Demerits of Artificial Intelligence in Libraries

Although artificial intelligence is a promising innovative idea in the library system, it is not without disadvantages. Shohana (2016) outlined some of the disadvantages of artificial intelligence as follows:

1. Artificial intelligence systems have the ability to replace human jobs thereby increasing the rate of unemployment in the society. This is an issue of concern among librarians for decades. The fear is that intelligent machines with capabilities of shelving books, retrieving information, answering reference queries and attending to users have great potentials of replacing librarians, leaving them unemployed. Jasrotia (2018) also opines that as intelligent machines in libraries can read digitized resources, analyse and offer customized insights, answers and services faster than librarians, the possibility of AI being a 'threat' to librarians but not to libraries does exist. This is probably why many librarians do not like the idea of artificial intelligence in libraries. Nevertheless, Guion (2019) argues that librarians would still be needed because machines with AI systems would still not be able to fully discern what a library user wants as sometimes search terms do not fully explain the need or even judge how well their outputs conforms to basic library principles of intellectual freedom, copyright and privacy.
2. Artificial intelligence systems can malfunction and perform task they were not programmed to do. The fear, according to Ex Libris (2019), is the possibility

of AI systems propagating misinformation if the algorithms powering them become problematic.

3. Artificial intelligence systems can be misused leading to mass scale destruction.
4. Over dependence on artificial intelligence systems can make librarians forget the basic and fundamental processing involved in library operations such as cataloguing and classification, since a robot now handles that.
5. Lacks the 'human touch'. Some users will prefer to interact with human beings directly and express their feelings rather than to a machine.

Challenges of Implementing Artificial Intelligence in Libraries

Artificial intelligence systems are generally not in operational use in most libraries today. The limitations to implementing artificial intelligence systems in libraries include the following:

1. Lack of technical know-how to use and operate artificial intelligence systems among the library staff.
2. Lack of adequate funding to develop or procure artificial intelligence systems in libraries. Since the budgets for hardware and software are frequently tight, there's always constrain to the type of system the library can purchase or develop.
3. High system development and maintenance cost of artificial intelligence systems in libraries.
4. Erratic power supply to power artificial intelligence systems in libraries especially in developing countries.
5. Inherent complexities of expert/artificial intelligence systems' development.
6. Limited natural language capabilities.
7. Intelligent systems lack that common base of human knowledge, severely constraining the types of functions that they can perform.
8. Level of effort and technical expertise needed to create artificial intelligence systems in libraries. The level and nature of effort that must be invested to develop an intelligent library system is directly proportional to the power and complexity of the system. This implies that, the more intelligent the system is, the more the effort that must be invested therein. Currently, the required skilled personnel with expensive development tools or techniques, needed to develop sophisticated intelligent system in libraries are lacking or costly, hence, the lack of such systems in libraries.
9. Limited amount of artificial intelligence experts among library automation vendors. The field of artificial intelligence is complex and thus, requires a specialised knowledge in that aspect far beyond the development of conventional

library automation systems. Consequently, this will require hiring new personnel in that area before any significant, widespread work can be done in the area of artificial intelligence systems in libraries.

The Future Libraries

The development of shelf reading robots by Li, Huang, Kurniawan and Ho (2015) and others shows that, it is now only a matter of time, the present generation libraries will be flooded with the impact and utility of new applications based on artificial intelligence (Shohana, 2016). Like the invention of the electric bulb that appeared to be a quasi-magical thing, and no one could predict that it will lead to the development of telephones, radio, TVs, computers and other electronic gadgets. Artificial intelligence is the new quasi-magical thing that has surfaced in recent times. And just like in the early days of the development of electricity, we are yet to completely fathom the application of artificial intelligence not only in libraries, but in every aspects of our lives. In the future, artificial intelligence will revolutionise many sectors of life, including the library.

Bourg (2017) had asked a critical question 'what happens to libraries and librarians when machines can read books?' and provided an example with the GeoDeepDive, a tool with AI systems which geologists use to extract data in texts, tables, and figures in journal articles and websites. Times are changing! Librarians may not have to read a library book to get information to inform their users or take a decision, because a machine would have already read all of the books and is more skilled at analyses and decision making. We will not spend hours on library computers researching a question when artificial intelligence can do it for us in seconds. And we certainly would not go to a human librarian with an information need when artificial intelligence is able to deliver a better answer in a fraction of the time (Johnson, 2018). Library activities in the future will be fully automated. The future libraries will incorporate robots and intelligent machines that will perform library task such as reference services, shelf reading/arrangement, circulation activities (registration, charging and discharging of materials), generating library statistics, cataloguing and classification etc. artificial intelligence will tremendously change the face of the library as we know today. The promise is a perfect librarian that respond to users reference queries based on speech recognition, natural language processing and neural network; Fast, efficient and effective processing of library materials; and state-of-the-art service delivery to patrons even from remote locations. Libraries of the future are the ones that react and adapt to new technology, not run away from it (Stone, 2019). The American Library Association asserted:

The Center for the Future of Libraries works to identify trends relevant to libraries and the communities they serve; promote futuring and innovation techniques to help librarians and library professionals shape their future; and build connections with experts and innovative thinkers to help libraries address emerging issues. – ALA

However, according to Bourg (2017) and Coleman (2017), pertinent questions need to be asked of how can the skill-set of librarians, scholars and others can be built up and used to ensure an intelligent information system with the infusion of the core values of libraries such as inclusivity, privacy, intellectual freedom, social justice and that fosters imagination, knowledge creation and supports human learning as well; how libraries can create an interface between users and AI generated information to ensure that it is accurate and relevant; and how texts can best be discovered by both humans and machines especially scholarly communication so that intelligent machines can be relied to produce 'intelligent' answers to queries? The President of ALA, Garcia-Febo (2019) had recently advocated the inclusion of artificial intelligence in library's professional agenda and national conversations so that these questions and more can be scrutinized and answered. In addition, the President stated that, the wave of artificial intelligence including vice assistants and machine learning is still uncertain in many fields but has already gained recognition and application in the library. In this infancy stage of Artificial Intelligence, libraries are using it to teach information literacy, critical-thinking skills like computer programming, to help their patrons formulate questions for these machines and learn to evaluate responses (Garcia-Febo, 2019) and access information resources remotely via robotic cranes. All these are giant steps implemented in library practices around the world and it points to a large-scale application of artificial intelligence that will shape the future libraries. Therefore according to Jacknis (2017), the question is never 'either AI or libraries', rather it is how libraries can use the technology to offer the best services to user communities.

CONCLUSION

If libraries are to thrive in the new knowledge economy, they must innovate their services and re-examine their practices, a veritable means to achieve this is the application of artificial intelligence in libraries. Libraries will greatly benefit by the development of artificial intelligence systems for technical services, reference services, circulation services, resource management and information retrieval/dissemination. Although there are speculations that this technology will render librarians jobless, artificial intelligence will greatly enhance library operations and services delivery, and will upload the relevance of libraries in an ever changing digital society. In

addition, as it is with many emerged technologies, artificial intelligence is also viewed as thread to librarians and the touch of humans in libraries, the eventual acceptance and incorporation of artificial intelligence into library services will no doubt reveal the many potential promise it has in librarianship. Artificial intelligence will not diminish the human touch in libraries, nor will it erode the library's connection with their patrons any time soon.

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