

Intelligent libraries: a review on expert systems, artificial intelligence, and robot

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Abstract

Purpose – This paper reviews literature on the application of intelligent systems in the libraries with a special issue on the ES/AI and Robot. Also, it introduces the potential of libraries to use intelligent systems, especially ES/AI and robots.

Design/methodology/approach – Descriptive and content review methods are applied, and the researchers critically reviewed the articles related to library ESs and robots from Web of Science as a general database and Emerald as a specific database in library and information science from 2007–2017. Four scopes considered to classify the articles as technology, service, user and resource. It is found that published researches on the intelligent systems have contributed to many librarian purposes like library technical services like the organization of information resources, storage and retrieval of information resources, library public services as reference services, information desk and other purposes.

Findings – A review of the previous studies shows that ESs are a useable intelligent system in library and information science that mimic librarian expert's behaviors to support decision making and management. Also, it is shown that the current information systems have a high potential to be improved by integration with AI technologies. In this researches, librarian robots mostly designed for detection and replacing books on the shelf. Improving the technology of gripping, localizing and human-robot interaction are the main concern in recent librarian robot research. Our conclusion is that we need to develop research in the area of smart resources.

Originality/value – This study has a new approach to the literature review in this area. We compared the published papers in the field of ES/AI and robot and library from two databases, general and specific.

Keywords Library system, Intelligent systems, Artificial Intelligent (AI), Intelligent library, Smart library, Expert System (ES), Robot

Paper type Literature review

1. Introduction

In computer science, artificial intelligence (AI) is an important topic. In this context, the focus is on human behavior and how machines can imitate intelligent human behavior. AI involves

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amongst other expert systems (ESs), fuzzy logic, artificial neural network, evolutionary algorithms, case-based reasoning, image processing, natural language processing, speech recognition and robotics. These areas are not separate, and in many intelligent systems at the same time, two or more AI techniques contribute in problem to solving. AI techniques or tools have utilized in many areas such as business, management, medicine, military etc. Library and information science also have developed in using intelligent systems. "Library management and its activities apply repetitious and time-consuming activities. Hence, in order to increase efficiency and effectiveness, many libraries are moving toward automation of their activities" (Dwivedi *et al.*, 2013). AI techniques give more accuracy to the automation of libraries. The ideas of the utilization of intelligent systems instead of the classic systems in libraries started in 1990. Intelligent systems are used in the library to provide knowledge-based services to users of the library system and end-users. These systems, as a complementary system to the main library system, can make intelligent decisions for the retrieval and use of information resources. The careful decision making of these systems is based on the knowledge created by users in the library system. These systems are an important competitor of human activities in the library. This could have implications for librarians. The presented papers at the 27th Annual Clinic on Library Applications of Data Processing dealt the capabilities relate to the library applications: descriptive cataloging, technical services and collection development, subject indexing, reference services, database searching and document delivery (Lancaster and Smith, 1990). A lot of research has already been made of the various uses of AI technologies in libraries. Even Hsieh and Hall (1989) examined the definition and history of AI and investigates the body of literature on AI in "Library Literature" and Lisa. In the same year, O'Neill and Morris (1989) looked at the challenge and implications of ESs technology for LIS. In 1998 under the direction of NCR, Inc. and its Future Mapping® process, experts worked together to map out the best scenario for the libraries of the future (Leslie, 1999). After several years, a fully automated 24/7 online librarian system designed to respond to routine and repeat inquiries from distance learners (Payne and Bradbury, 2002). It seems that AI's applications have been considered in various aspects of library and information science. Based on the review of the major models that exist, the following factors are effective in using human intelligence in information systems:

- (1) Understanding the nature of the information needs and defining this need for the system,
- (2) Identifying information resources that are relevant to information needs,
- (3) Evaluation of existing information resources, evaluation of retrieved information,
- (4) Organizing existing information resources, organizing selected information from items retrieved,
- (5) Managing existing information resources, managing retrieved information,
- (6) Using existing information resources, using retrieved information,
- (7) Information and knowledge analysis,
- (8) Converting information to knowledge,
- (9) Dissemination and transfer of information and knowledge,
- (10) Interaction and exchange of information and knowledge.

The above is a very useful list for using AI in scientific databases and library and information affairs. For example, recommender systems are very important in identifying information resources and selecting them. These systems can be very helpful in selecting the right resources

based on user behavior in using the retrieval system. "However, we probably cannot consider the system to be intelligent by human standards. The fact that we are transient organic beings that possess five senses and feel, as well as think. In short, computers lack: all that man is, all mere complexities, the fury and the mire of human veins." (Bailey, 1991 and Bailey, 1992). Today, many years have passed since research into AI programming techniques and the use of WSSs for providing technical services to libraries and information databases and providing public services to end-users. Now the dream of smart libraries has become a reality. Cao *et al.* (2018) have paid to the conceptualization of the smart library, and scientists and professionals have created systems that can be thought of and decided instead of the librarian. Cox *et al.* (2018) studied on the intelligent library. They paid to the thought leaders' viewpoints on the impact of AI on the libraries. Even these systems can mimic the librarian's behavior. The purpose of the study is to review the articles on intelligent libraries and the use of Artificial Intelligence (AI), Expert Systems (ESs) and robots in the libraries. The articles retrieved from Web of Science (WoS) as a cumulative database and Emerald Insight as a professional database in library and information science. The research questions are the following:

- (1) In WoS, which articles did authors write about ES/AI and robots' application in the library?
- (2) In Emerald Insight, which articles did authors write about ES/AI and robots' application in the library?

2. Artificial intelligence

AI applies to different sciences. We can say in the library and information science, it more uses in scientific databases and library systems. Such as behavioral science, social sciences, psychology, management and library science and information science. It is related to some of the systems that apply different forms of intelligence such as learner systems, inferior systems, systems with natural language understanding or natural language interpretation, systems with visual scene perception and systems that perform other types of feat that require human types of intelligence (Bavakutty and Salih, 2006). In this branch of the science that involves machines, solutions are utilized to solve complex problems of human behavior. We can present computer-based algorithms based on human behavior and knowledge in using systems. "It is an interdisciplinary field making use of concepts from various fields like cybernetics, information theory, psychology, linguistics, logic, etc. it can use to simulate human behavior and for computer aided instruction, ES, robots and for NLP. It can also use for Intelligent Retrieval from databases" (Bavakutty and Salih, 2006). In this way, computer software and the use of various computer-based products help in the operation of various types of libraries and their public services and the generation of output products. Automation implies the degree of mechanization where the routines and receptive jobs or operations are left to be performed by machines with little or no intervention by human beings. Lesser the degree of human intervention, greater the degree of automation; this does not mean that automation does away with human beings. On the contrary, human beings are relieved of routine chores, giving them more time for tasks, which require their intelligence. In view of the various features of a modern computer system, we find that it has been applied in several areas of library work. Book acquisitions, cataloging, serials control, and circulation, information retrieval and dissemination, interlibrary loan, cooperative acquisition and cataloging have been automated in the library (Lakshmikant and Vishnu, 2008).

3. Intelligent systems

Intelligent systems (ISs) are defined as any formal or informal system that is able to obtain and process data, to interpret the data by applying technologies of artificial intelligence and

business intelligence and to provide reasoned judgments based on that to decision makers as a basis for action (Sharda *et al.*, 2017).

ISs are computer-based systems that help in the task of subject indexing can be thought of as an ES (Lancaster, 1997). Lancaster has a clear statement relating to the scope of AI: “Computer programs have been developed, which exhibit human-like reasoning, which may be able to learn from their mistakes and which quickly and cleverly perform tasks normally done by scarce and expensive human experts.” AI has a wide application area. Figure 1 gives a good idea of this coverage.

Technologies that are frequently used in intelligent systems: machine learning, case-based reasoning, genetic algorithms, fuzzy logic and natural language processing (NLP).

NLP is another facility of an intelligent system that can use to retrieve information needs from different scientific databases. In the information retrieval process, the user can state his information requirement in natural language, making the searching more easily and fruitful this allows users to state complex retrieval languages (Bavakutty and Salih, 2006).

Business intelligence (BI) as is the set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis/decision support purposes (Sharda *et al.*, 2017). BI solutions include data access, storage, data analysis and visualization technologies to support better decision making.

4. Expert systems

Expert systems (ESs) are computer-based systems that simulate human decision making. They can integrate with information systems to improve their accuracy and performance (Singh *et al.*, 1996). Various librarian ES has been developed. Waters (1986) designed the National Agricultural Library’s microcomputer-based ES to help users obtain answers to simple reference questions. In general, they ask questions from the user and take the user’s answer as input, then explain the rationale for decision results. In general, these systems consist of two main elements: A knowledge base and inference engine. The knowledge base encompasses all the information needs that human/librarian experts are using to decide. This information is present in the knowledge base as facts and rules. ESs can make much better decisions than librarian decision makers because their knowledge base can involve the experiences of a team of the best experts. The manner of librarian experts to make decisions is emulated for the design rules of the knowledge base. The rules are consisting of two main phases: “if phase” and “then phase.” The “if phase” is consisting of conditions, and the “then phase” is consisting of results. ESs are distinguished from other computer systems with the application of reasoning through the inference engine. The inference engine simulates human decision makings based on the knowledge base and a rule base (Figure 2).

The creation of an ES includes the extraction of the relevant knowledge from the expert human, and it is often nature heuristic. ESs use problem-solving in different areas such as

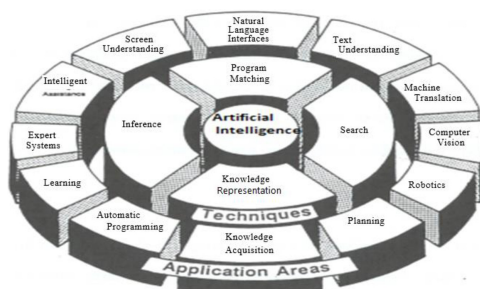


Figure 1.
AI Coverage
(Lancaster, 1997)

medicine, business, computer science, law, defense, education, mathematics, engineering, geology, etc. (Bavakutty and Salih, 2006). Many of the library's activities are specialized. For this reason, library software should be used to improve the library's performance. The efforts have been made in this regard. Denning and Smith (1994) had a survey on the "Electronic Library Search Assistant." Kruk and Krawczyk (2004) studied about intelligent resources search in virtual libraries. Devadason and Vespry (1996) studied about planning for the library staff. It encapsulates the expert knowledge of a library staff planner. They presented the LISPA (Library and Information center Staff Planning Advisor). By reviewing the research and literature, specialized library systems can have the following applications in the area of providing library and information services:

- (1) Knowledge-based indexing (Amin and Razmi, 2009);
- (2) Natural Language Processing and abstracting (Albayrak and Erensal, 2004);
- (3) Reference work (Amin and Razmi, 2009);
- (4) Cataloging (Weiss, 1994) and (Amin and Razmi, 2009);
- (5) Online information retrieval (Bellman and Zadeh, 1970), (Sacchanand and Jaroenpuntaruk, 2006) and (Bavakutty and Salih, 2006);
- (6) Using intelligent interfaces in online information storage and retrieval systems;
- (7) Information needs analysis and representation, including different services, such as classification, indexing and abstracting;
- (8) Reference services;
- (9) Development of collection;
- (10) Hypertext and hypermedia (Bavakutty and Salih, 2006).

5. Methodology

Descriptive and content review methods are applied to the study. The researchers critically reviewed the articles related to ES/AI and robots in the library. According to this review, the application of ES/AI and robots classified as the following:

Technology: The articles surveyed and evaluated the information management systems in the libraries belongs to this group. These articles relate to usability and implementation. They do not propose or propose an information system or model.

Resource: These articles related to information resources. This category may include the selection, acquisition and use of information resources.

User / End-user: Existing information and knowledge systems/models are usually working based on the opinion of experts/users and end-user behavior. Therefore, applying ES

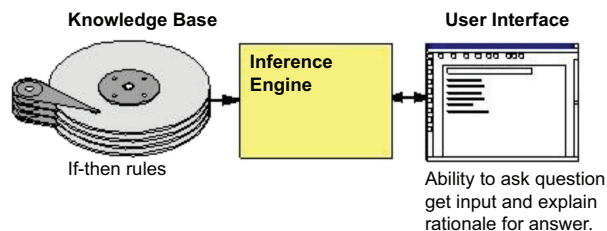


Figure 2.
ES elements

technologies such as inference engine and fact/rule base will improve the performance and accuracy of considered systems.

Service: The articles in this group have proposed an ES or related technology and methods that can be connected and included in ESs to present public or technical services. The public services present to end-users to fulfill their information needs and technical services present to the librarians or any professional user in library activities.

6. Findings

The purpose of the study is to review the articles on intelligent libraries and the use of ES/AI and robots in the libraries. Based on the research questions, the findings presented in two sections. The first section is related to the review of the articles in WoS as a general database in different subjects. The second section is related to the review of the articles in Emerald as a professional database in the Library and Information Science. According to this review, the application of ES/AI and robots classified into four classes such as technology, resource, user/end-user and service.

6.1 ES/ AI and robots' application in the library (WoS)

The topics of “expert system” and “library” were searched in the WoS database on 10th Oct 2017. We found 1,208 documents related to this topic. Then we have refined the topics through “Research Area,” “Document Type.” In the research area, we selected the area of “Information Science, Library Science.” We chose “article” for “document type” and excluded unrelated articles. Finally, found 14 articles as a result, which are shown in [Table 1](#).

The review of papers shows the fading of the ES/AI in recent studies. It is found that the majority (46%) of the paper worked on the experts'/users' behavior. This is even though no research has been done on the use of intelligent resources using ESs between the years 2007–2017 on the WoS ([Figure 3](#)). However, the studies that are related to information systems have a closed relation with the knowledge and opinion of experts. Using ES technologies such as inference engine and fuzzy rule base may increase the accuracy of them. Therefore, the current information systems can be improved by integration with ES technologies. ESs use in intelligent libraries. In general, the information provided to users in a library leads to a change in the behavior of the user's knowledge and creates learning. The intelligent library uses an appropriate protocol for the exchange of information. This protocol is unique, and it is designed to help, confirm or perform the terms of the agreement. The terms of the agreement include a series of guidelines that will be carried out automatically. These guidelines relate to information sources, services, and technology for distributing and exchanging information. For operating a smart library, resources and services must be available under the agreement. All users must use the digital signature and agree to the terms of the agreement. Smart libraries can exchange information based on the internet of Things (IoT).

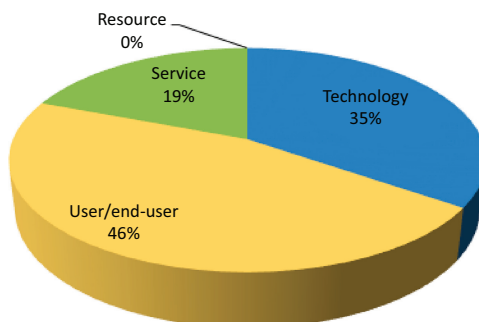
Recently the researchers tried to increase the ability of librarian robots by applying the new methods. We searched for the topic of “Librarian robot” using WoS on 10th Oct 2017. Then we limited the results to the duration of 2007–2017. We excluded unrelated articles and finally found 15 articles and proceeding papers as a result, which is shown in [Table 2](#). In this table, we determine the research area related to applied methodologies of papers in the “Research area of publication source.” A summary of the applied method is explained in “Method,” and the main contribution of papers is mentioned in “contribution.”

The most recent papers that are related to librarian robots are in the area of service ([Figure 4](#)). Improving the technology of gripping, localizing and human-robot interaction are the most discussed issues in librarian robots. Librarian robots can be used in large libraries. This robot reduces a lot of common and duplicate activities in different places of the library,

No.	Author	Contribution	Application based on the reference	Class
1	Asemi et al (2012)	Management Information System (MIS)	Supportive tool for library operations and provides suitably detailed reports in an accurate, consistent and timely manner	Technology User/end-user
2	Black (2011)	Web Content Management System (CMS)	Support a large distributed content model and shares the CMS trail method used, which directly included content provider feedback side-by-side with the technical experts	Technology User/end-user
3	Chu et al (2010)	learning system	Support context-aware ubiquitous learning	Technology User/end-user
4	Chu et al (2010)	electronic library with supporting context-aware ubiquitous-learning	Supporting learning activities conducted in real-world environments	Technology User/end-user
5	Ding and Sølberg (2007)	Rule-based metadata interoperation	Support querying across distributed digital libraries created in heterogeneous metadata schemas, without requiring the availability of a global schema	Service User/end-user
6	Golub et al (2014)	Terminology registries (TRs)	Provide the content of knowledge organization systems (KOS) available both for human and machine access	Technology User/end-user
7	Huili and Bo (2017)	Smart library, Library robot	Making the robot more like a librarian, focus on key technologies to take the robot into the real library environment, and cultivate relevant technical talents	Service User/end-user
8	Hwang et al (2011)	A grid-based knowledge acquisition approach and a Mind tool is proposed	Help students organize and share knowledge for differentiating a set of learning targets based on what they have observed in the field	Technology User/end-user
9	Iglesias (2013)	Application Robots in Library	Advancements in Library Automation Automating Reference, Storage, Technical Services, Circulation desketc.	Service User/end-user
10	Ismail and Kareem (2011)	Identifying how novice researchers search, locate, choose and use web resources	Supporting information-seeking behavior of novice researchers by specific research tools	Technology User/end-user
11	Kao and Wu (2012)	personalized knowledge integration platform for digital libraries	Providers users with personalized information and knowledge services	Technology User/end-user
12	Mehtab Alam Ansari (2008)	Online Public Access Catalogue (OPAC)	Allowing a user to search online and retrieve records/catalogue and depending on the underlying library management software/online reservation, circulation and so on	Technology User/end-user
13	Mei et al (2017)	Intelligent Use of Library	proposes a general framework to establish the dynamic movement primitives library (DMPL) for a mobile robot path planning in an unknown environment	Service
14	Phillips (2017)	AI in Library, Library Automation	Development in robotics and AI, and the potential implications for library services. It explores the impacts of automation of human work, with a particular focus on recent advances in robotics and AI and how these may affect library services and library work in future	Service

Table 1.
Articles related to ES/
AI and library (WoS)

Figure 3.
The scope of the
articles in the field of
ES/AI and
library (WoS)



especially at the library's repository. For example, this robot can be helpful in shelf-reading activity. There are some imaginations that the use of librarian robot creates a gap between information and people. Smart libraries and librarian robots are always faced with this challenge. But not a way out of using new technologies, because the development of information does not coincide with the development of expert human resources. In many libraries, librarian robots can be helpful in solving library problems. Only the small number of the studies are related to resources. It is shown that we need to develop our research in this area.

The library should take special care of every aspect related to the man-machine interface: favoring systems standardization, avoiding the accumulation of different equipment, using a clear, brief and direct language, including images and sound, representing reality and reflecting the human mental patterns (De Prado, 2000). AI techniques such as genetic algorithms, artificial neural networks, ESs, and fuzzy logic or hybrid methods can improve librarian robots to reflect human mental patterns.

6.2 ES and robot's application in the library using Emerald Insight [1]

Table 3 shows the review of the papers in the field of ES/AI and robots, and library exported from the Emerald Insight as a specific database in the library and information science.

Figure 5 shows the most recent papers exported from Emerald Insight, which are related to ES/AI and robot in the library are in the area of service. The finding is the same as the exported papers from the WoS database.

The following trends show a line graph of the relative frequencies across the main category in the abstracts of the articles (Figure 6). The thematic interaction was observed in the main categories of the articles based on their keywords. Most common categories in the abstracts are digital, information, library, search, and user.

Figure 7 shows a line graph of the relative frequencies across the main category of the keywords of the articles. The thematic interaction was observed in the main categories of the articles based on their keywords. Most common categories in the abstracts are digital, information, Internet, library, and systems.

7. Discussion

The ES should be considered only when development is: "possible," "appropriate," and "justified" (Lancaster, 1997). This question must be answered before we initiated an ES project. Waters (1986) gives some good guidelines on when we should consider using ESs. An

No	Author	Contribution	Application based on the reference	Class
1	Comsa et al. (2014)	Presenting some similar state-of-the-art developments, CAD models of two book manipulators and also an innovative design approach in designing library book handling gripper mechanisms	Gripper prototype is manufactured using light-weight thermoplastic reinforced material for the mobile finger	Technology Service
2	Du et al. (2011)	Designing an embedded controller for the pneumatic manipulator of library robot	Using PC/104 boards system and emphasizing parameter self-tuning fuzzy-PID algorithm of the controller	Technology Service
3	Grigorescu et al. (2010)	Propose a robust feature extraction for 3D reconstruction of segmented boundary objects	Using means of including feedback control at image segmentation level for boundary feature extraction. The objective of feedback is to adjust segmentation parameters in order to cope with scene uncertainties, such as variable illumination conditions. Robustly extracted 2D object features are provided as input to the 3D object reconstruction module of the FRIEND vision system	Technology Service
4	Heyer et al. (2012)	Propose a new approach for detecting and grasping the book reliably	Combination of two algorithms for book detection and grasping and users stereo vision together with hand camera to achieve a high rate of success	Resource Service
5	Huili and Bo (2017)	Making the robot more like a librarian, focus on key technologies to take the robot into the real library environment, and cultivate relevant technical talents	Based on extensive research literature and best practices of library robots, this paper states robot technology can effectively solve some problems in library management and service, and improve user satisfaction to a certain extent	Technology Service User/end-user
6	Iglesias (2013)	Advancements in Library Automation: Automating Reference, Storage, Technical Services, Circulation Desk, etc.	Different Methods. In this book presented different articles about Automating Reference, Storage, Technical Services, Circulation Desk, etc.	Technology Service User/end-user
7	Kim et al. (2009)	Propose an information structured environment called u-RT to enable a librarian robot to arrange books on bookshelves using ambient intelligence	The librarian robot consists of a manipulator to recognize and manipulate books, and a mobile platform to localize itself and navigate using ambient RFID tags embedded in a floor. The proposed u-RT space connects physical and virtual space using physical hyperlinks	Resource Service

Table 2.
Articles related to
library and
robot (WoS)

(continued)

No	Author	Contribution	Application based on the reference	Class
8	Kim et al. (2008)	Realize ambient intelligence in the ubiquitous robot technology space	The ubiquitous space for the robotic library is introduced and an RFID technology-based approach for the librarian robot proposed	Technology
9	Kim et al. (2013)	Investigates whether assigning a caregiving role to a robot or to its human interacting has psychological effects on the quality of human-robot interaction (HRI)	College students interacted with a social robot in a between-subjects experiment with two manipulated conditions: one where the robot played the role of an ophthalmologist and one where participants played the role of the ophthalmologist	User/end-user Service
10	Lin et al. (2013)	Incorporates the robotic assistance in investigating the book locating behaviors of child patrons, and develop a service robot for child patterns in library settings	Describe the process of developing an assistant robot with locating resources in libraries. Consulting the stakeholders, including child patrons and librarians. Analyzing the needs and incorporating into the design of library robot	User/end-user Service
11	Mei et al. (2017)	Proposes a general framework to establish the dynamic movement primitives library (DMPL) for a mobile robot path planning in an unknown environment	Mathematical model: before the library is building, the workspace of the mobile robot is divided into multiple sectors through a unique sampling technique. Then, using a joystick, a user operates the mobile robot moving from start to any sample point, simultaneously recording the states such as position, velocity and acceleration. The primitives will be extracted from the recorded state sequence, and the learned weights will be stored in the DMPL. In the second phase, the DMPL is used online to supply the path planning decision	Service
12	Mikawa (2010)	A practicum Track Using Librarian robot in a support program for contemporary educational needs	Providing a training ground for creating new types of contents for the Internet age, where students of several specialized fields come together	User/end-user Service
13	Modler et al. (2014)	Presents an innovative design approach in grippers for library automation context	The gripper CAD model and the experimental gripper prototype, developed using light-weight thermoplastic reinforced material for the mobile finger	Resource Service
14	Modler et al. (2012)	Proposes one CAD gripper model designed in solid works software. The CAD model for the gripper and FEM simulation is presented	The parallel gripper prototype is still in the manufacturing process using light-weight glass-fiber reinforced material	Resource Service

*(continued)***Table 2.**

No	Author	Contribution	Application based on the reference	Class
15	Phillips (2017)	Developments in robotics and AI, and the potential implications for library services. It explores the impacts of automation of human work, with a particular focus on recent advances in robotics and AI and how these may affect library services and library work in future	An in-depth literature review, and the results of original research. The research consisted of a survey of the general population, including library users and workers, and a focus group with library workers only. Key themes explored include: general perceptions and experience of automation in libraries, potential acceptance levels of robots being used in libraries, and the predicted positive and negative outcomes	Service

Table 2.

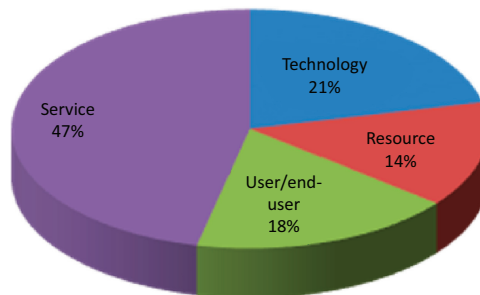


Figure 4.
The scope of the articles in the field of library and robot (WoS)

ES has received a lot of attention from the research community in the 1980s. Unfortunately, much of the writing sensationalized the field expectations dramatically ([Lakshmikan and Vishnu, 2008](#)) fueled by public expectations began to over-promise misconceptions about what AI can and cannot do arise and they persist today. Many rushed into the field in search of quick answers and quick profits. Several AI researchers saw what was happening and feared a backlash. Once all the excitement wore off during 1988–90, things did begin to change some of the realities and limitations of the AI techniques became evident. An AI backlash has resulted in ascertaining to an extent, but fortunately, it has not been wide-scaled instead. The optimism remains with a better sense of realism than before, and both the benefits and limitations are better appreciated.

In general, in the protocol of an intelligent library, clear the subject of the agreement, the digital signature, and the divisional platform must be clear. Smart library agreements can be applied in various fields, including the acquisition of information resources, presenting public services to the end-user, technical services, management, and many other library activities in many library activities. Advantages of intelligent libraries are the security of information, the cost of services, the speed of service to the user community, the pursuit of activities within the framework of the standard. Problems that may be encountered in intelligent libraries are human factor problems, the cost of implementing intelligent library agreements, and copyright issues. One of the key elements in the smart library is digital identity. Based on the intelligent library protocol, users can create or control their digital identities. This digital identity includes information, reputation and information resources used or required by the users. Smart library users in the context of the IoT can decide which information to be

No	Author/s	Keywords	Application based on the reference	Class
1	Ataman Kemal (2009)	Archives management, library Information science, Records management, Information profession	Library services present by the smart talking robot Xiaotu based on artificial intelligence	Service
2	Bi et al. (2017)	Internet of things, Planning and control, Robot, System interaction, Wireless sensors network (WSN)	The application of intelligent agents in library services	Service
3	Bilandzic and Foth (2013)	Library as a place, Technology-enhanced learning, Library 2.0, Commons 2.0, Coworking, Urban informatics, library, User studies, Australia Learning	Using library 2.0 tools in the library services and user learning	User/End-user Service
4	Borgman (2000)	Electronic publishing, library, Computer networks	The application Web 2.0 tools for the electronic publishing	Resource
6	Chen and Hsiang (2009)	Generation and dissemination of Information, Digital storage, Academic Library, Open systems	Web information seeking and retrieval in digital library contexts based on the artificially intelligent	Resource Service
7	Chowdhury (1999)	Internet, Information services, Information retrieval	Digital library using context-awareness technology	Resource Service
8	Connolly (2008)	Artificial intelligence, Robotics, Pattern recognition	The application mobile for library services	Resource Service
9	Dimić et al. (2010)	Cataloging Bibliographic standards Extensible Markup Language Information systems	RFID integrated systems and libraries	Technology
10	Dutton (2014)	Open systems, Communication technologies, Surveillance, Internet of Things, Consumers, Social behavior	Users and electronic libraries	End-user
11	Frederick (2016)	Data, library, Fourth Industrial Revolution	Enterprise knowledge portals based on the industry 4.0	User
12	Gelfand (1998)	Grey literature, Internet, Publishing Science	: The application a roboti digital content: Breedbot	Resource
13	Hahn (2012)	Mobile computing, Library software, Augmented reality, Computer vision, Smartphones, Mobile applications, Library systems, Mobile communication systems, Citation	Networked library services	Service
14	Islam and Ikeda (2014)	Knowledge management, Library services, Digital library, Online services, WWW	Online digital reference	Resource Service
15	Joint (2009)	Communication technologies, University library, Worldwide web	Sharing technology of the experiences in the library	Technology
16	Kapoor et al. (2014)	Adoption, TAM, RFID, Use	Library Web site management	Technology
17	Kesselman (2017)	Library Education Technology Conferences Emerging Technologies Consumer electronics	Virtual reference librarians (Chatbots)	Service
18	Lam and Chan (2007)	Archiving, Digital library	Libraries, data and the fourth industrial revolution	Recourse

(continued)

Table 3.
Articles related to ES/
AI and Robot in the
library (Emerald
Insight)

No	Author/s	Keywords	Application based on the reference	Class
19	Liu (2011)	Intelligent agents, Artificial intelligence, library, Information services, Digital library, Library systems	Metadata and cataloging practices	Service
20	McDonnell and Shiri (2011)	Information retrieval, Search engines, Design, User interfaces, Worldwide web, Consumer behavior	Information retrieval and user interface	User/ End-user
21	Miglino <i>et al.</i> (2008)	Robotics, Evolution, Education, Entertainment	XML schema for UNIMARC and MARC 21	Service
22	Milella <i>et al.</i> (2008)	Surveillance, Radio waves, Robotics, Environmental management, Workplace security	Collaborative digital reference: An Ask a Librarian (UK) overview	Service
23	Noh (2013)	Context-aware computing, Next-generation digital library, Ubiquitous library, Context-awareness technology, Intelligent space, Sensor, library, Information systems	What is trending in libraries from the Internet cybersphere–AI and other emerging technologies	Resource Technology
24	Oyelude (2017)	AI Emerging technologies	The intelligent library: Thought leaders' views on the likely impact of AI on academic libraries	Technology
25	Park and Kim (2013)	Long-term evolution, Technology acceptance, Perceived mobility, Perceived adaptively, System and service quality, Satisfaction Mobile communication systems, User satisfaction	Libraries as coworking spaces: user motivations and social learning	User/ End-user Service
26	Park <i>et al.</i> (2015)	User studies, User satisfaction, Books	Reading e-book devices	Resource User/ End-user
27	Rudall (2006)	Automation, Computers, Cybernetics	Library automation	Technology
28	Taha (2012)	Networked library, Research information, Digital contents, Query processing, Academic library, Library networks	AI and robotic hand-eye coordination in the library	Resource
29	Vincze (2017)	Chatbots	Knowledge management in digital libraries	Service
30	Wu <i>et al.</i> (2010)	Digital library, Resources, Copyright law, Colleges, Students	Digital libraries and resources	Resource
31	Xiaobin and Jing (2009)	Computer applications, Innovation, User interfaces, Communication, Digital library	Teaching and exposing grey literature in the library	User/ End-user
32	Yao <i>et al.</i> (2015)	Artificial intelligence, Promotion, Participatory library service, Social networking, Talking robot, Virtual reference service	Intelligent search agent in the library	Service
33	Zimmerman (2012)	Digital natives , Search behaviour, Academic library, Millennials Information searches , Search engines, Searchers	Requirements for information professionals in a digital environment	User/ End-user Service

Table 3.

transmitted to them, and this opportunity provides an understanding of the user's information behavior. Smart library agreements can facilitate the post-exchange process of information so that the librarian and user will no longer need to be involved. The exchange of information in intelligent libraries will help smart city innovation. In the following is stated the requirements for the development of an ES:

- (1) An expert of the problem available;
- (2) Experts have the time for the ES development project;
- (3) Experts can articulate their knowledge and methods;
- (4) The problem is not too complex, but knowledge intensive;

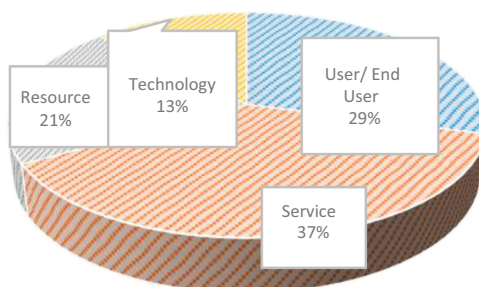


Figure 5.
The scope of the articles in field ES/AI and Robot in the library (Emerald Insight)

- (5) The problem is not poorly understood;

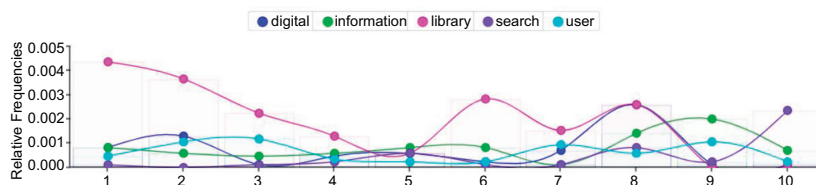


Figure 6.
Relative frequencies across the main categories in the abstracts of the articles and thematic interaction between them in the field of ES/AI and robot and library (Emerald Insight)

- (6) The problem requires cognitive skills only.

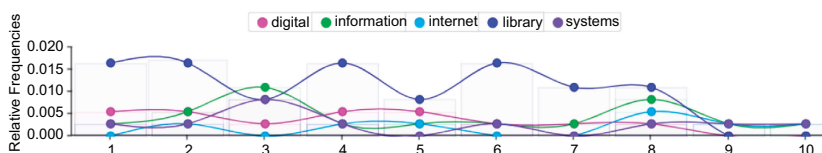


Figure 7.
Relative frequencies across the main categories in the keywords of the articles and thematic interaction between them in the field of ES/AI and robot and library (Emerald Insight)

Results are measurable and can be agreed upon by the experts (Lancaster, 1997). An obvious potential application of ES within libraries is for the selection of booksellers or other vendors of library materials carried to its logical conclusion. A system might be developed to select a vendor to automate ethical based on past performance in the supply of publications of a particular type such a capability would be especially valuable in the acquisition of material that is less routine-conference proceeding. A similar system, known as the Monographic Acquisitions consultant, was developed at Iowa State University in 1944. The system was designed to optimize the decision on which vendors are preferred. Types of monographs in the knowledge base of the system includes both descriptive and evaluative data on each supplier. Descriptive data deal with the type of publisher (foreign, university press, the publication of science materials) and relationship with the library (blanket order, approval plan, standing orders on the exchange list (Lakshmikant and Vishnu, 2008). Edelman (2006) studied about an intelligent design in the American Research Library Collections. Fourie (2003) investigated Current Awareness Services (CAS) in library acquisitions. Carneiro (2001) explained the role of intelligent resources in knowledge management. Switching Brains is a cloud-based Intelligent Resources Management (IRM) for the internet of Cognitive Things (IoCT) (Francisco and Arsenio, 2015). Other ESs, designed to help library users satisfy their own needs, have also included document- orders aid (Lakshmikant and Vishnu, 2008). Systems have also been designed within the library community to aid in the selection process, systems of this type have been discussed by Sowell (1989) and Meador and Cline (1992) (Lakshmikant and Vishnu, 2008). The term “referral system,” as used here, relates to systems that and are designed to refer library users to information sources likely to provide the answer to a particular question of the factuality of “information” type within the library community more work has been done on a system of this kind than on any other ES. Bailey (1992) studied about reference information system. He tries to help the user to select the appropriate printed and electronic references by ES. Other research has studied about the remote reference service. This study explores the possibilities afforded for collaborative reference work (Davenport *et al.*, 1997). The application mostly such systems refer to users’ printed sources like Conventional reference books; but other types of sources, such as those in CD-ROM form, can also be included in the knowledge base. The objective of such systems is obvious: to guide library users with a reference suitable source when a librarian is not available to help them form reference, referral system cover knowledge as a whole in the coverage of a general reference library while others are restricted to the highly specialized domain (Mishra and Srivastava, 2008). One of the most important application of artificial intelligence in libraries is the use of recommender systems. Investigating user behavior in information retrieval and privatizing user services can effectively address his/her information needs in the least amount of time. The different techniques of recommender systems, the properties of these systems, and the evaluation’s methods of these systems, provide the best services and resources available to the user. Today, library systems include the hardware and software systems that are applied to different library process activities. As libraries present a huge content of printed materials, the automation of books handling becomes necessary (Comsa *et al.*, 2014). The librarian robot contains manipulation that can identify books. It moves using RFID tags installed on the library shelves. “Jaume” is a librarian robot, which was developed in the Robotic Intelligence Lab of Universitat Jaume I. The new Bordeaux Public Library (June 1991). It offers a special video collection of more than 600 of the information resources. It uses a robot to give the users’ consultant service or reference service (Giannattasio and Bruckmann, 1992). UJI librarian robot searches and retrieves the requested books by users. The process starts when the user requests a book by its title or code, either through the Internet or by voice. The robot locates the book and gives it to the user. The book’s initial information is read by the robot’s vision system. This general application integrates several inter-disciplinary skills like path planning, visual perception or

multisensory-based grasping, all linked together by reasoning capabilities (Prats *et al.*, 2008; Prats *et al.*, 2007; Ramos-Garijo *et al.*, 2003). A librarian robot evaluates with the following criteria:

- (1) Reliable visual localization;
- (2) Robust and fault-tolerant force-guided extraction;
- (3) Performance adequate for books of different sizes and thicknesses;
- (4) Active book searching;
- (5) Combine navigation and active vision;
- (6) Fault-tolerant probabilistic strategy.

In the context of robot librarians and AI has been investigated by limited number of studies. In the database of Emerald, only one article was found (Yao *et al.*, 2015). They introduced a collaborative library service based on artificial intelligence. They developed an intelligent robot called Xiaotu (female). The task of this robot is to provide online reference services. Four factors are important in the success of this robot: artificial intelligence, self-learning, vivid logo and language, and modular architecture (Yao *et al.*, 2011). Yuehu and Yanqing (2012) studied using the internet technology of objects. They have tried to look at smart sets along with the robot librarian. Then compare the smart library with other libraries. Kyrarini *et al.* (2017) presented a framework called “Skill Robot Library” (SRL). This framework has the authority to store key points of the route. In fact, this robot can store user’s behavior in information retrieval, and it will work based on this stored behavior. Behan and O’Keeffe (2009) designed a mobile robotic assistant, called “LUCAS” for the University of Limerick. This assistant is a help system that supports users intellectually. Kim and Kohtaro (2009) tried to provide robots based on the structured data. This study introduces a conventional and intelligent environment for a librarian robot. This environment is based on RFID technology for these systems. In another study, reference services were investigated using the instant messaging (IM) smart robot. The Shanghai Jiaotong University Library is presented for example. This library provides the IM robot’s intelligent library service using BotPlatform (Yi *et al.*, 2011).

8. Conclusion

A review of the articles shows that we can use expert and intelligence systems in different library activities and information services. The main goal is to provide specialized services with the help of librarians and information resources specialists. Library services include technical and public services. Both categories use intelligent systems and ESs. These activities include the provision of information resources, the organization of information resources such as classification, indexing, and abstracting, the storage and retrieval of information from library systems, reference services, and circulation desk. We classified the scopes of the researches into four classes “technology,” “user,” “service,” and “resource.” A review of the articles shows that users’ information behavior is a very good way to design intelligent systems. The storing information in cloud and non-cloud spaces allow for the development of these systems. In big data and social networks where scientific information resources are exchanged, intelligent agents can play an important role. User profiles can be a good source for designing ES algorithms based on user knowledge. ESs are the most useable intelligent system in library and information science, which mimic librarian expert’s behaviors to support decision and management. However, individually using this technology is reduced in recent studies. Most information systems have a closed relation with the knowledge and opinion of experts. Using ES technologies such as inference engine and fuzzy

rule base may increase the accuracy of them. Therefore, the current information systems can be improved by integration with ES technologies. The librarian robot can reduce the usual and repetitive activities on library shelves. Almost the third of the articles in Emerald Insight in ES have related to the "user" scope, and in librarian robot (18% in WoS), most of the articles have related to the "service" in Emerald Insight and in WoS as well. One of our conclusion is that we need to further research in the area of smart resources.

Note

1. <https://www.emerald.com/insight>

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