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Understanding the research landscape of smart libraries using text mining and data visualization : A use case of Voyant Tool

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Text mining has become one of the most common methods used to analyze natural language documents today. In this study, 81 open access journal articles on the topic of "smart libraries" from Google Scholar were analyzed using text mining techniques. Articles were chosen based on the criterion that they had to be open access and have smart libraries as their main component. To analyze the articles and discover interesting text patterns within the retrieved articles, Voyant Tool, an open-source text-mining tool, was used. It assists in finding Corpus Collocates that are closely related in texts as well as identifying n-grams in the field of smart libraries (sequences of words occurring together with the context that surrounds them). Results showed that the most frequently used words in the corpus were smart (3533); information (2253), data (1753); technology (1382); service (1327). Furthermore, findings showed that the longest document had 14210 words and the shortest had 1012. Overall, the study findings will help in understand the smart libraries ecosystem with deeper insight.

Keywords: *Text mining, Text analysis, Smart libraries, SL, Voyant Tool, Data visualization, Content analysis.*

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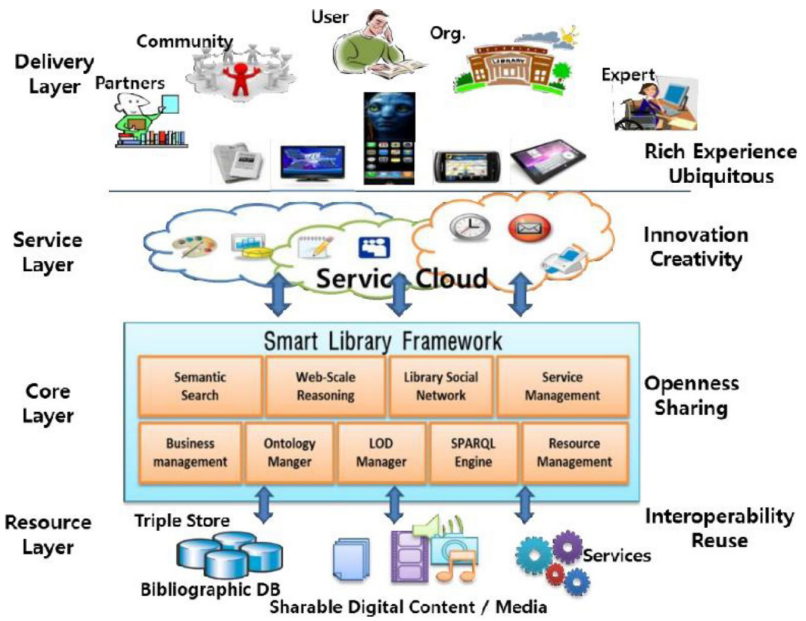
1. Introduction

As libraries move into the digital era, they need to modernize and apply smart technology to attract more users. Using this smart technology, library users are able to fulfil their needs without the help of the staff and without

wasting their precious time. The term "Smart Library" (SL) was coined by Aittola, Ryhanen, and Ojala in 2003, and librarians have been striving to implement smart libraries in different ways ever since. It was, probably, first mentioned in an academic publication in 2003(Zimmerman, Tara & Chang, Hsia-Ching, 2018). The meaning of a smart library has grown over the years as smart technologies have evolved. Smart libraries are the new generation libraries, which work with the amalgamation of smart technologies, smart users and smart services. Implementing the smart technologies in the libraries has bridged the gap between the services offered by the libraries and the rapidly changing and competing needs of the users (Gul and Bano, 2019). Conceptually, the initial functionality of the Smart Library has grown over time from internet-enabled appliances and devices to include the application of contemporary IoT technologies (Hahn, Jim 2020).

"Smart library is a hardware and software complex with a wide range of opportunities for searching and providing necessary information to virtual users according to their inquiries and requirements" (Shah, Anubhav & Bano, Rukhsar, 2020). "Such libraries offer services, which are interactive, innovative, informative, actual, changing and international". It is a set of various electronic resources, accompanied by specialized library services, which are provided by the use of information and communication technologies" (Shah, Anubhav & Bano, Rukhsar, 2020). The Smart library is a conceptualization of the IoT (Internet of Things) that depends on some sort of data signal sensing and actions based on a radio frequency. Technologies associated with the **smart library** include machine



Framework of Smart Library (Moon et al., 2014)

learning, beacons (or iBeacons), mobile kiosks (tablet-based kiosks), mobile apps, and RFID, among others (What Is Smart Library | IGI Global, 2022). Recently, Internet of Things (IoT) is the popular trend used for creating and managing smart libraries. IoT refers to the utilization of inter-connected devices and framework to acquire information accumulated by implanted sensors other monitors (Vijaykumar Mahamuni, Chaitanya 2020).

Thus, it is concluded that Smart library creation is only possible due to the new information and communication technologies and library technology. Such technologies contain Smart technology of content formation, Smart detection of knowledge, Smart interface (organization of interactions with the user), Smart services, and Mobile applications usage (Galal 2020). The services of smart libraries are delivered to the user via smart phones, internet and other handheld gadgets. Smart libraries must focus on improving library services to reach all library users through mobile devices. They provide advanced services such as computer-aided design, hypertext services, knowledge mining services, and personalized services, cross-media services which make the library more active, professional and intelligent.

Functions and Dimensions of Smart Library

The primary function of SL is to make systematic development of the collections, store, and organize information and knowledge in digital form. It provides easy and affordable internet access to it from various locations. SL's basic functions include providing web-based library services to readers and providing access to online learning materials. Also, it provides ICT-based access to a wide variety of digitally available educational publications **(Nahak & Padhi, 2019).**

The SL has seven dimensions such as smart economy, smart mobility, smart environment, smart people, and smart technology, and smart governance, Smart services. Out of these, prominent dimensions are discussed below:

Smart Services: It is the first dimension which can be described as the application of the "spirit of innovation" of smart readers to the development of modern library services. SL services include RFID, mobile and wireless access, remote assistance, semantic web, artificial intelligence, IoT, machine translation, voice recognition, image recognition, sensor, CCTV, natural language processing, and augmented reality for providing readers with new experiences (Schöpfel, 2018).

Smart Technology: A smart library is based on advanced technology, including wearable technology, mobile internet, intelligent processing technology, cloud computing, and virtual and ubiquitous technology. IoT, AI, and data mining are at the core of current smart library technology development (Cao, Gaohui, et al., 2018).

Smart People: A smart library's primary goal is to meet users' changing needs so they can become smarter. Consequently, users should be a crucial factor when building

a smart library. Staff at smart libraries should be smart since they handle not only smart technology but also serve smart clients (Gul, Sumeer & Bano, Shohar, 2019).

2. Study Scope and Research Objectives

The scope of this study is to analyse and visualize all open access articles on the topic "Smart Libraries" using free, open-source, web-based applications with numerous text mining and data visualization tool "Voyant Tools". A Text Mining process uses preprocessing tools, algorithms, and visualization tools to identify and explore patterns in a corpus of unstructured textual data. There were 95 open access articles as on 26.04.22, out of them 14 articles that were in different languages were excluded. The presence of the linguistic noise is a common problem in the content of the extracted articles and we have dealt with (Salloum et al., 2017). Then, the cleaned data are uploaded into Voyant tools, which includes 81 articles pdfs. The main aim of this study is to extract interesting information from the collected articles using the text mining tool.

The following are the objectives of this research:

- to analyze, explore and visualize a large corpus of text to produce a series of customizable visualizations for text analysis in the area of smart libraries
- to identify and count frequently used words within a large corpus in the area of smart libraries using the Cirrus tool
- to find Corpus Collocates that are closely related in texts using Collocates Graph.
- to identify n-grams (sequences of co-occurring words with surrounding context) in the area of smart libraries using the Contexts Tool
- to examine large-scale patterns and trends and explore topics in the area of smart libraries using the trend tool
- to identify collocates (words that occur in proximity) of high-frequency terms using the TermsBerry tool.
- to locate the total number of documents/words, unique words, and longest and shortest documents within a large corpus using the Summary Tool
- to identify the most frequent terms in the corpus with the exact number of occurrences/ their count using the Terms View tool.
- to visualize the entire corpus in terms of the length of document using Prospect View

3. Study Methodology and Limitations

3.1 *Data*

The data source for the current study was Google Scholar, and for text mining and visualization, Voyant Tool was used. The "Advanced search" feature of Google scholar was used that limits the result to "Smart Library or smart Libraries" to download the exact research articles on the topic. This investigation/research involved collecting/

extracting a corpus of open access articles pdfs on the topic "Smart libraries" and running this corpus through "Voyant Tool" (https://voyant-tools.org/). The study is limited by the fact that open access journals emphasize increasing visibility and accessibility, so only open access articles were considered. The inclusion of both open access and closed access journals can be considered in the future. Thus, the results are based entirely on all open access articles found on Google Scholar about smart libraries.

3.2 *Text Mining and Visualization*

The process of text mining involves analyzing natural language texts, then detecting lexical patterns to obtain valuable information (Tandel et al., 2019). It turns text (unstructured data) into data (structured format) for analysis, using natural language processing (NLP) methods and tries to extract meaningful information that is useful for a specific purpose (Kumar, 2013). For the present study, Voyant Tool was used for text analysis. It was launched in 2003, is a web-based text analysis, reading and visualization environment (Sampsel, 2018). It was developed by a small team of digital humanities scholars led by Stefan Sinclair and Geoffrey Rockwell (S. G Sinclair, 2021). Voyant Tool is a free "web-based reading and analysis environment for digital texts" (Sinclair & Rockwell, 2020). It is an open-source collection of 20+ interactive tools, which allows for data extraction and provides textual and statistical analysis to uncover insightful patterns or trends within or across texts (Jocelyn, 2020). The tagline of Voyant Tool is, "see through your text" and allows to visualize large corpus in several different ways (Sampsel, 2018). Texts/documents can be uploaded/imported in several digital formats (plain text, PDF, Microsoft Word, XML, HTML, etc.). It offers several tools which can be used to study term frequencies and distributions within documents and within a collection of documents (a corpus). It allows users to investigate patterns of words/concepts and to explore and visualize large corpus of text systemically, that may be difficult to perform by simply reading.

4. Results and Discussion

Voyant, allows multiple documents to be uploaded together and is called a "corpus." Once it is uploaded, the research analysis can begin by selecting the different tools, also called "skins" (Sinclair, 2015). Here, Batch of 81 Open access articles on "Smart Libraries" were loaded to the Voyant tool. The default skin shows five different tools like Cirrus, Summary, Trends, Reader, and Contexts, but the analysis is not limited to just those tools, and the tools can be changed within the skin that configure data in various visualizations. Out of the 24 different text analysis tools, this paper attempts to demonstrate the use of the following attributes (Lyus D, et al., 2011):

4.1 *The Cirrus tool*

It is a word cloud that visualizes the top frequency words of a corpus. It positions the words such that the terms that occur the most frequently are positioned centrally and are sized the largest and it will also include small words within spaces left by larger

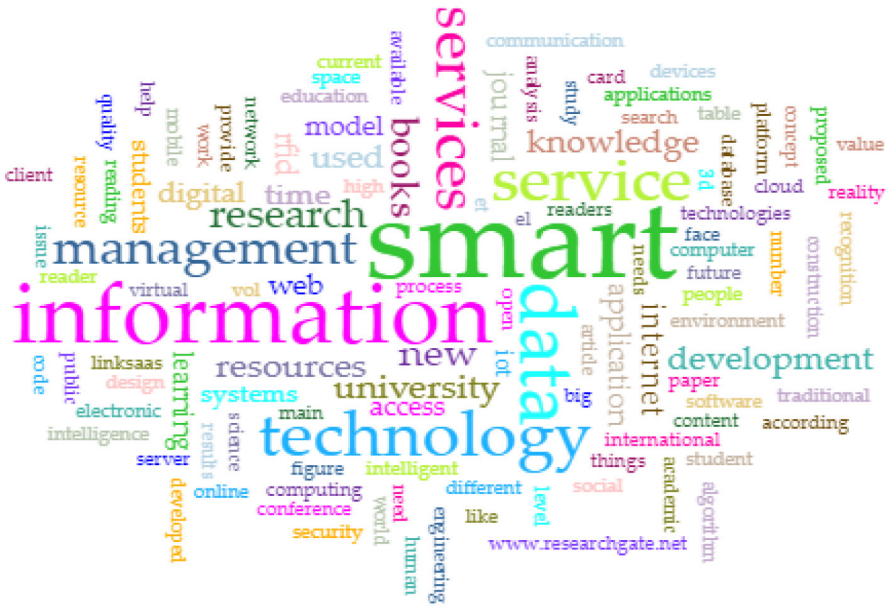


Figure 1

Display the Cirrus (115 words) on "Smart libraries" Corpus

words that do not fit together snugly. It is possible to exclude words using the, stop words, function or specify the maximum number of words to be fetched from the corpus (Lyus D, et al., 2011).

Figure 1 show the Visualization of Corpus on smart libraries that are represented with different colors and sizes depending on the Frequency of words. Thus, it can be seen that frequently used words are smart (3533); information (2253); data (1753); technology (1382); service (1327) followed by management (920), research (788), university (711), internet (696), resources (668). Information and technology comprise the core of smart libraries, which explains why those words are frequently used. The corpus also frequently uses words like "resources" and "Internet" in relation to information resources that are accessible to users via the "Internet" in smart libraries. Few words that are smaller in size having very less frequency in corpus are mobile, 3d, network, design, environment, IoT etc. However, in this tool there is a default "stop-word" list containing the most typical non-content words such as "the, and, but, etc.". It was supplemented by other common words such as "Library, libraries, based, using, use, support, provides, make, various etc." to focus more on in-depth terminologies.

4.2 *Collocates Graph*

It represents keywords and terms that occur in close proximity as a force directed network graph.

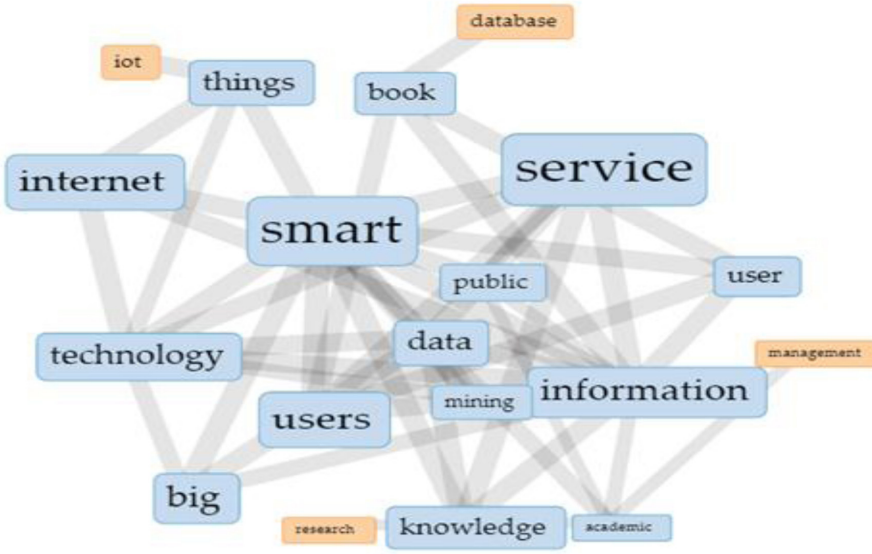


Figure 2

Network Graph of Corpus

The figure 2 above represents a network graph of the whole corpus where keywords in blue are shown linked to collocate in orange. Hovering over a term shows its frequency (for keywords it's the corpus frequency, for collocates it's the frequency in the context of the linked keywords). Here all words in blue are keywords like smart (n=3533), service(n=1327), information(n=2253), technology (n=1382) etc. and words in orange like database(n=193), management(n=84) etc. are collocates.

4.3 *Collocates of the Keyword "SMART"*

Figure 3 reveals the collocates of the keyword "Smart" by Choosing the option "Centralized" in Collocates graphs. Terms that appear in close proximity to the word "Smart" are shown/depicted in the above graphic. The literature indicates the "design" aspect of the smart library as few studies are focusing on it. Authors have also drawn attention toward an increase in "demand" for smart libraries. The "Security" element in smart libraries is also considered important as security via cameras installed in a smart library helps monitor the people visiting the library. It also focuses on the development of a smart "architecture" for smart libraries. A few authors also highlight" IoT" based library services, including Cloud computing and "RFID". IoT is a network through two-dimensional code reading equipment, radio frequency identification (RFID) devices, infrared sensors, global positioning systems and laser scanners and other information sensing devices, that can make anything connected to Internet in order to achieve intelligent identification, tracking, monitoring and management (Sun, 2014). The text/corpus also focused on the "innovation" of library services to reach all library users.

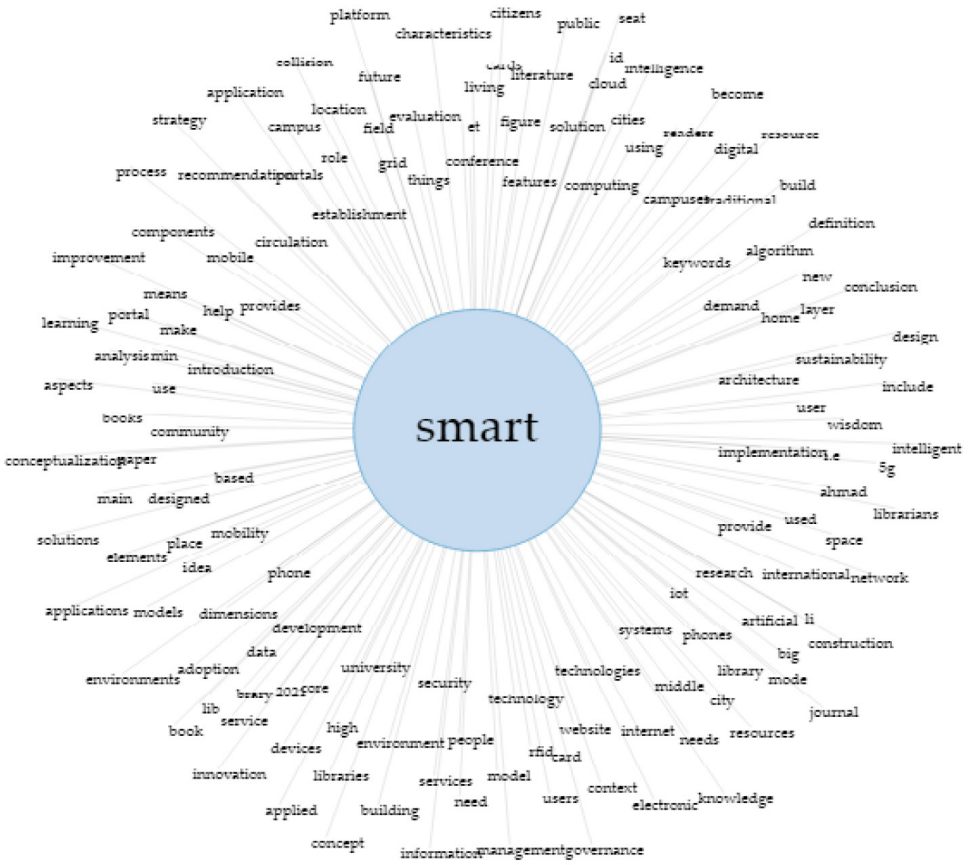


Figure 3

Collocates of "Smart" Keyword

4.4 *Contexts Tool*

The Contexts (or Keywords in Context) tool shows each occurrence of a keyword with a bit of surrounding text (the context).

In the above figure 3 "RFID" word is chosen to examine its occurrence with a bit of surrounding text (the context). It is useful for studying more closely how terms are used in different contexts. Here, in one of the row's left columns, it reads "The RFID was successfully implemented", and in the other, it reads "speed up library procedures". In light of the above statement, RFID is an important part of the smart library management system and its integration makes both library users and staff's tasks more easy, convenient, automated, and practical (Younis, 2013).

Contexts

Document	Left	Term	Right
1) A Proposed...	M. Tang, "Development of an	rfid	- enabled mobile smart library system
1) A Proposed...	management system based on an	rfid	technology," International Journal of Reasoning
2) A Smart...	system throughout the library. The	rfid	technology, scanners and monitors, alarms
2) A Smart...	Network issues for using ELMS.	rfid	-Based Library Management System with
2) A Smart...	cycle, deployment and testing. The	rfid	tags store information which is
2) A Smart...	which is read digitally with	rfid	reader. RAD software prototypes produced
2) A Smart...	prototypes produced are reusable, using	rfid	in the library system saves
2) A Smart...	technologies used in smart library -	rfid	, Arduino and Raspberry Pi boards
2) A Smart...	2018) Work is done using	rfid	system where the books are
2) A Smart...	swiping students ID tag and	rfid	tag attached to book. Provides
2) A Smart...	vi. Title of the Paper:	rfid	-Based Library Management System with
2) A Smart...	library management system. b. The	rfid	was successfully implemented. RFID speeds
2) A Smart...	The RFID was successfully implemented.	rfid	speeds up library routine procedures
2) A Smart...	more user-service activities. The	rfid	tags could store information that
2) A Smart...	with the aid of the	rfid	reader. The system was able
2) A Smart...	issue and return books via	rfid	tags and also calculates the
2) A Smart...	the book. The use of	rfid	in the library management system
2) A Smart...	noted that using technologies like	rfid	, software applications, user-friendly and
2) A Smart...	purposes. ii. Less memory of	rfid	tags: RFID tags mostly used

Figure 4

Keywords in Context

4.5 *The TermsBerry Tool*

TermsBerry tool helps to explore high frequency terms and their collocates (words that occur in proximity).

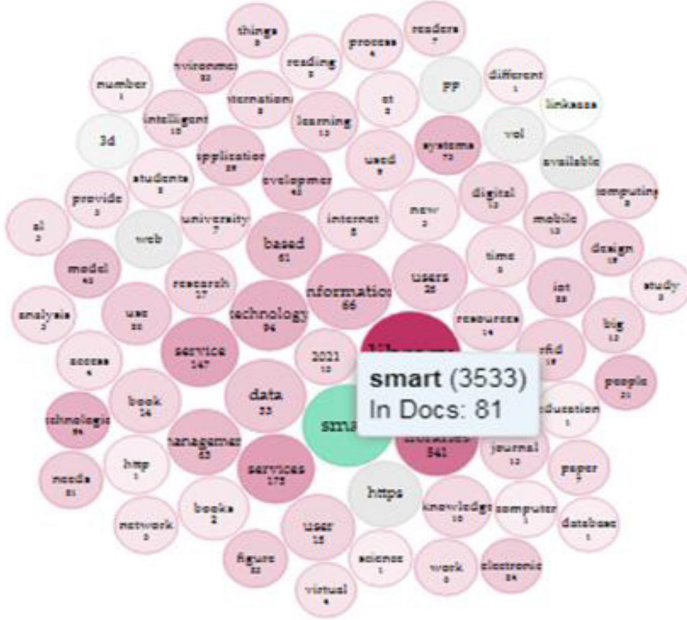


Figure 5

High frequency terms with Collocates

In the above figure, smart, information, services, and data are among the terms with the highest frequency. The darkness of the terms represents the proportion of the documents where the term appears (darker means that it appears in more documents). Hovering over any term provides the term frequency as well as the number of documents in which that term appears. For example when we hover over a term like "smart" (frequency= 3533, documents=81) it becomes the keyword, and then each of the other bubbles, like data=33, technology= 94, RFID =19 etc., indicates the collocate frequency for the term "smart".

4.6 *The Reader Tool*

The Prospect Viewer in the Reader tool shows an overview of the entire corpus.

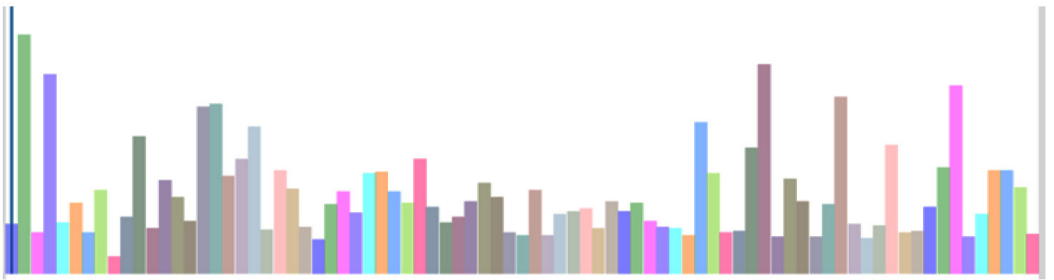


Figure 6

Prospect View of Corpus

In the above figure 6, the bars (81) represent each document in the order they appear in the corpus. The relative length of the document is represented both vertically and horizontally (the taller and wider a document is shown, the longer it is). Here it can be viewed that 2nd document titled" A Smart Library System based on the Internet of Things (IoT) with Integration of Moodle, in addition to the use of Collaborative Filtering for Book Recommendation and Sentiment Analysis for Improvisation of Resources "is the longest document and 9th document in corpus titled" Analysis on the Application of LoRa Technology in University Smart Library" is the shortest document.

4.7 *Terms View*

The terms' view is a brief list of the most frequent terms in the corpus with the exact number of occurrences.

The Table-1 provides information about Term in the corpus with its count (frequency of the term in the corpus) in descending order. It can be seen that the terms like "library," "smart", and "information" dominate research output in corpus followed by technology, HTTP, internet, resources, RFID, digital, design, environment, etc. as mentioned in the above table. Text analysis reveals that "information" and "technology" are both seen more frequently than "service(s)", while "book(s)" was comparatively less important.

Table 1

Highest frequency terms in the Corpus of Smart libraries

S. N.	Term	Count
1	Library	6469
2	Smart	3533
3	Information	2253
4	Data	1753
5	Technology	1382
6	Service	1327
7	Https	973
8	Management	920
9	Book	828
10	Research	788
11	Internet	696
12	Resources	668
13	RFID	656
14	Knowledge	621
15	Digital	618
16	Learning	567
17	IoT	525
18	Web	516
19	Education	388
20	Mobile	375
21	Design	370
22	Environment	356

This moves away from physical books and services and towards technology, data, etc. which indicates a key change in what the term smart library has come to mean.

4.8 *Summary Tool*

This tool provides information about the total number of documents and words in a corpus. It also gives information about unique words, longest and shortest documents by the number of words in the corpus, top and the lowest vocabulary densities, average number of words per sentence (highest and lowest) and five most frequent words in the corpus. Table below provides summarized information about corpus.

Table 2

Summary Information of Corpus

SN	Summary Information	
1	Total number of documents in corpus	81 documents
2	Total number of words in corpus	385,045
3	Unique words	28,211
4	Document with Longest Length	A Smart Library System based on the Internet of Things (IoT) with Integration of Moodle, in addition to the use of Collaborative Filtering for Book Recommendation and Sentiment Analysis for Improvisation of Resources (14210 words)
5	Document with Shortest Length	Analysis on the Application of LoRa Technology in University Smart Library (1012 words)
6	Document with Highest Vocabulary Density	Analysis on the Application of LoRa Technology in University Smart Library (0.455)
7	Document with Lowest Vocabulary Density	Smart Libraries: Best SQE Practices for Libraries with an Emphasis on Scientific Computing (0.152)
8	Document with Highest Average Words Per Sentence	Innovative Service Mode of Smart Library in 5G Era (45.4)
9	Document with Lowest Average Words Per Sentence	Facilitating Machine Learning-Guided Protein Engineering with Smart Library Design and Massively Parallel Assays (8.1)
10	Document with Highest Readability Index	UHF RFID Label Nanometer Printing Technology and its application in Smart libraries (53.198)
11	Document with Lowest Readability Index	Enactment of Smart Library Management System Exercising Ubiquitous Computing (9.203)
12	5 Most frequent words in the corpus	smart (3533); information (2253), data (1753); technology (1382); service (1327)

The above table 2 provides the total the number of documents in the corpus are 81 with 385,045 total words and 28,211 unique words. The longest document has 14210 words and shortest document has 1012 words. 0.455 is the top vocabulary density (the ratio of the number of words in the document to the number of unique words in the document) and 0.152 is the lowest vocabulary density. 45.4 and 8.1 is an approximation of the average number of words per sentence, both the highest and lowest values. The five most frequent words in the corpus are smart (3533); information (2253), data (1753); technology (1382); service (1327).

4.9 *The Trends Tool*

Trends tool is a visualization that represents the frequencies of terms across documents in a corpus.

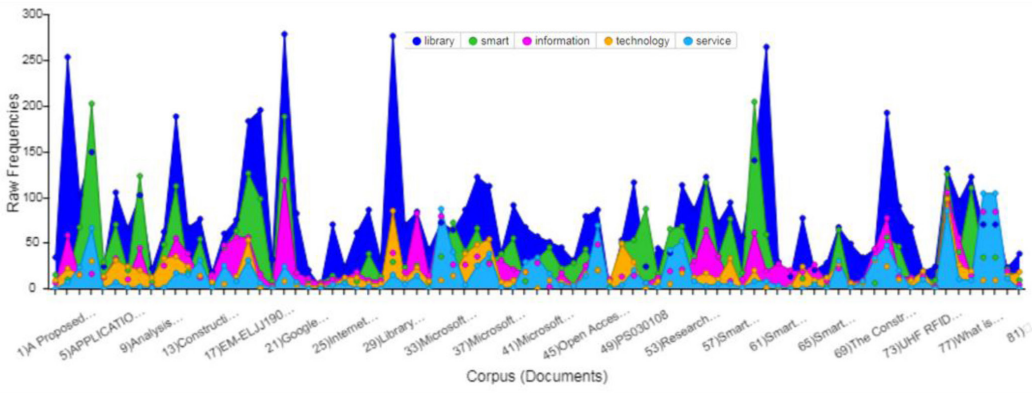


Figure 7 a

Term Frequency Chart

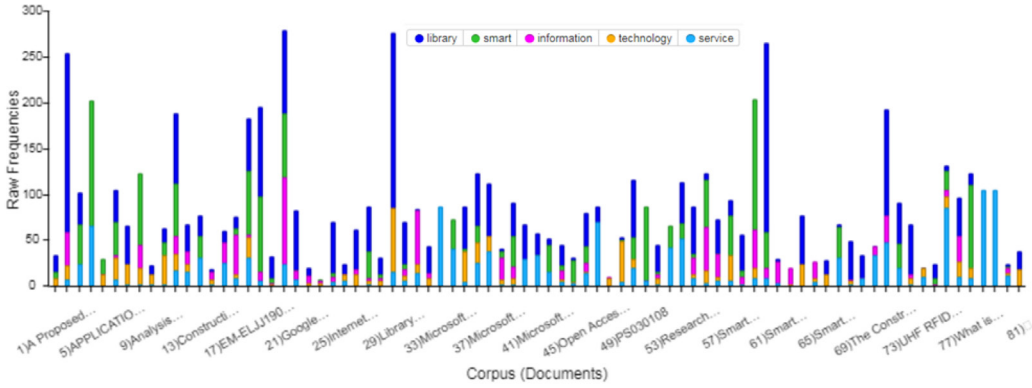


Figure 7 b

Term Frequency Chart (Trends- stacked)

The above Figures 7-a and 7-b show distribution plots representing the frequencies of terms across texts in the corpus. Most frequent words were selected like library, smart, technology, services, information that gives information about the number of times these words show up in corpus. Each series in the graph is colored according to the word it represents. At the top of the graph a legend displays which words are associated with certain colors. Clicking on the words in the legend to toggle their visibility. Hovering over any point in the graph causes a callout box to appear with information about the point, including the word and the frequency.

Findings and Conclusion

Using the text mining tool "Voyant Tool", the present study presents a comprehensive overview of articles from smart libraries and discovers different and interesting text patterns within the retrieved articles. As we know, it's difficult to read unstructured data and large text. So, the synergy between information extraction and data mining techniques helps to generate a wide range of knowledge patterns. Smart libraries have become one of the necessities in times of technology/digital era. Accordingly, it is perceived that information extraction and data mining techniques were never applied to the smart libraries. This creates a need for collecting a dataset that consists of several research articles in the field of smart libraries and applying the proposed approach on them. 81 open access journal articles from Google scholar were collected, and textually analyzed through text mining techniques. The selection of the collected articles was based on the criteria that all these articles should incorporate smart libraries in the title of the article. In the present study, word cloud, word frequency, collocates, large-scale patterns and trends and visualizing the entire corpus were the main tasks done in text analysis.

By applying the word cloud tool, results indicated that words like smart (3533); information (2253); data (1753); technology (1382); service (1327) followed by users (1066), https (973), user (958), management (920), book (828), research (788) are the most frequent keyword across all the collected articles. Collocates graphs applied to the keyword "Smart" revealed that terms such as design, demand, security, RFID, IoT, architecture, etc. are it's collocating, and the word "Smart" in the center is connected to all relevant terms. This can be referred to the fact that smart libraries are the need of the hour, and they are using IoT and RFID for security purposes. It can be seen in Terms view that the terms like "library", "smart", and "information" dominate research output in corpus followed by technology, HTTP, internet, resources, RFID, digital, design, environment etc. The increasing number of words "information" and "technology" could be attributed to the fact that information and technology form the core of smart libraries. According to the Prospect View of Corpus, the article entitled "A Smart Library System based on the Internet of Things (IoT) with Integration of Moodle, as well as Collaborative Filtering for Book Recommendation and Sentiment Analysis for Resource Improvisation" is the longest document with 14210 words, and the article titled "Analysis on the Application of LoRa Technology in University Smart Library" is the shortest with 1012 words. The fact that this smallest article has the highest vocabulary density (0.455) is noteworthy.

Today, smart libraries are changing the landscape of information service delivery. Libraries must adopt innovative methods and technologies as users become more sophisticated in their information-seeking endeavors. The above examples are intended to provide a guide to how text mining, and specifically Voyant Tool, can lend a hand in analyzing texts (Miller, 2018). Its use can help to provide different viewpoints for reading, visualizing, and interpreting texts. These tools are designed and very helpful for a very wide range of applications and users, from students to researchers.

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