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| Title     | A review of artificial intelligence applications in libraries in Southeast Asia:<br>Where are we now? |
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# **A Review of Artificial Intelligence Applications in Libraries in Southeast Asia: Where are we now?**

## **Abstract**

**Purpose** – The purpose of this review is to examine the current state-of-the-art in artificial intelligence (AI) implementations within library settings across Southeast Asia.

**Design/methodology/approach** – The study uses the Artificial Intelligence Library Services Innovative Conceptual Framework (AI-LSICF) to evaluate the AI initiatives in Southeast Asian libraries. Sources include relevant libraries and association's websites, mainstream newspapers across Southeast Asia, together with academic papers published between 2019 and 2024, with a focus solely on English-language literature.

**Findings** – Most of the Southeast Asian libraries are in the decision and implementation stages in utilising AI technologies into library operations. It is evident that most the libraries have made the decision to embrace AI techniques in the workplace and have started to implement the AI-enabled applications. Nevertheless, those implementations are not yet comprehensive and most of the projects are still in the trial stage. This suggests a unanimous decision concerning the use of AI in the libraries across the region has not been reached. Librarians may still face challenges and concerns in adopting AI, including resource constraints, application maintenance, staff reluctance, staff training, data security concerns and more.

**Originality/value** – The originality of this paper lies in its unique perspectives on library settings in Southeast Asia, showcasing successful projects while also pinpointing areas and countries in need of further development.

**Research limitations** – A limitation of this study is its focus on completed and published projects, due to limited access to ongoing or unpublished initiatives. Non-English publications were excluded which may have omitted relevant studies and insights from non-English-speaking countries.

**Keywords:** Artificial Intelligence; AI; Southeast Asia; ASEAN; Library; Information Studies; Information Science; Application

## **Introduction**

The rapid advancement of artificial intelligence (AI) technologies has not only redefined numerous industries but has also begun to make significant transformation in library services across Southeast Asia. While the definition of artificial intelligence (AI) continues to evolve, a universally accepted definition has yet to be established. Nevertheless, there is a growing consensus among scholars that AI refers to technologies enabling machines to emulate a range of complex human abilities, allowing these entities to operate effectively and with foresight within their environments (Boden, 1996; Cox and Mazumdar, 2022; Fetzer, 1990). AI has been catalysing transformative shifts across diverse sectors including healthcare, military, business, education, gaming and more (Omame & Alex-Nmecha, 2020). Libraries are no exception.

At this unique crossroads, libraries grapple with the question: "How do we adapt?" In libraries, incorporating AI into services plays a significant role in enhancing information acquisition, sharing, and access. Worldwide, the use of AI in library services spans across areas including reference services, cataloguing & classification, user experience enhancement, information retrieval and more (Mali and Deshmukh, 2021; Massis, 2018; Omehia, 2022). However, despite the transformative potential of AI in library services, there is a notable absence of studies on its implementation within libraries in Southeast Asia.

This paper seeks to address the gap by conducting a review of the current landscape of AI applications within libraries across Southeast Asia. It aims to provide valuable insights for libraries in Southeast Asia seeking to leverage AI advancements, ultimately

supporting more user-centric and technologically adept library services. The study aims to address four questions:

- In Southeast Asia, what are the main areas in libraries where AI is being implemented?
- In Southeast Asia, which AI technologies are being implemented in libraries?
- For libraries in Southeast Asia, what are the gaps in the implementations of AI?
- In Southeast Asia, how does the development of AI impact library service provision?

## **Methodology**

In this review, Artificial Intelligence Library Services Innovative Conceptual Framework (AI-LSICF) is used to categorise and evaluate various AI applications implemented in libraries within the region. Four service provisions of AI-LSICF, capitalised in the review, include New Client Interface, New Service Concept, Service Delivery System, and Technological Options. AI-LSICF was developed by Okunlaya, Abdullah, and Alias (2022) to provide new insight into how AI technologies can be used to deliver value-added innovative library services. The framework consists of AI application and functions, alongside principles from both the Digital Transformation Framework (DTF) and the Service Innovation Framework (SIF). The DTF outlines how institutions could leverage digital tools to transform operations in four dimensions, which are financial aspects, structural changes, technology use, and value creation. On the other hand, the SIF examines how technologies could drive innovation in services delivery through four areas including client interface, service concept, service delivery, and technological options

(Hertog, 2000; Matt *et al.*, 2015). By adapting elements from these two frameworks specifically for the library contexts, the AI-LSICF provides a structured approach to evaluate AI-driven library services (see Figure 1 for AI-LSICF).

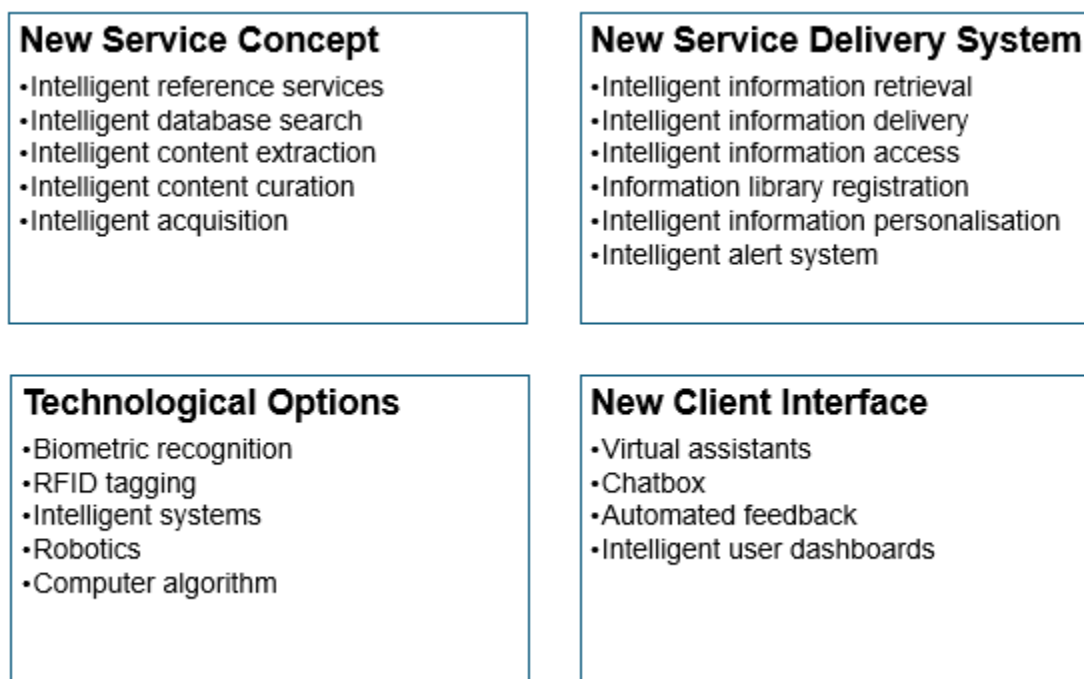


Figure 1: AI-LSICF (~~Source: Okunlaya *et al.*, 2022~~) (table courtesy of Okunlaya *et al.*, 2022)

The literature search was conducted in July 2024. Please refer to Table 1 for search string and data sources. Databases searched included Library, Information Science & Technology Abstracts (LISTA), Library Literature & Information Science (LLIS), Scopus, and Web of Science. The first 1000 search results of Google Scholar were also reviewed. The search was restricted to material published from 2019 onwards. These databases and search engines were selected based on their broad content coverage and strong reputation for source reliability. However, despite the growing pervasiveness of the topic, academic research in this area remains notably limited. Consequently, grey literature sources including news articles, conference papers and presentations, webinar

presentations, website articles of relevant organisations and associations are included to provide up-to-date information on this rapidly evolving field. By synthesising findings from both scholarly and grey literature, this review aims to provide an understanding of the current landscape of AI applications in libraries in Southeast Asia, as well as to identify gaps and opportunities.

| Database/search engine                                      | Search String  | Date of search | Number of Results                      |
|---|--|----------------|--|
| Google Scholar  | ("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "ML" OR "robot") AND ("library" OR "libraries") AND ("Southeast Asia" OR "ASEAN" OR "Singapore" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor-Leste")<br>Filter results by 2019-2024           | 30 July 2024   | Screened the first 1000 search results |
| Library, Information Science & Technology Abstracts (LISTA) | TX ("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "ML" OR "robot*") AND TX ("library" OR "libraries") AND TX ("Southeast Asia" OR "ASEAN" OR "Singapore" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor-Leste")<br>Filter results by 2019-2024 | 25 July 2024   | 38                                     |

|   |   |              |     |
|---|---|--------------|-----|
| Library Literature & Information Science (LLIS) | ("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "ML" OR "robot*") AND ("library" OR "libraries") AND ("Southeast Asia" OR "ASEAN" OR "Singapore" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor-Leste")<br><br>Filter results by 2019-2024                                   | 25 July 2024 | 61  |
| Scopus  | TITLE-ABS-KEY ( "Artificial Intelligence" OR "AI" OR "Machine Learning" OR "ML" OR "robot*" ) AND TITLE-ABS-KEY ( "library" OR "libraries" ) AND TITLE-ABS-KEY ( "Southeast Asia" OR "ASEAN" OR "Singapore" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor-Leste" ) AND PUBYEAR AFT 2018 | 24 July 2024 | 102 |
| Web of Science                                  | TS=("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "ML" OR "robot*" ) AND TS=("libraries" OR "library") AND TS=("Southeast Asia" OR "ASEAN" OR "Singapore" OR "Malaysia" OR "Indonesia" OR "Thailand" OR "Philippines" OR "Vietnam" OR "Myanmar" OR "Cambodia" OR "Laos" OR "Brunei" OR "Timor-Leste") AND PY=(2019 OR 2020 OR 2021 OR 2022 OR 2023 OR 2024)      | 23 July 2024 | 43  |

Table 1: Search string and data source (Source: table by authors)

The literature search excluded papers that did not meet the following criteria: 1) written in English; 2) pertaining to Southeast Asia; 3) focusing on AI applications; 4) relating to libraries; and 5) available for full text viewing. A total of 142 papers were identified in the preliminary search across the databases LISTA, LLIS, Scopus and Web of Science. However, after a careful assessment based on the exclusion criteria, only four papers were deemed eligible for inclusion. To supplement these, grey literature was searched through websites of Southeast Asian libraries, resulting in an additional 26 eligible sources for analysis. Please refer to Figure 2 for search and screen flowchart.

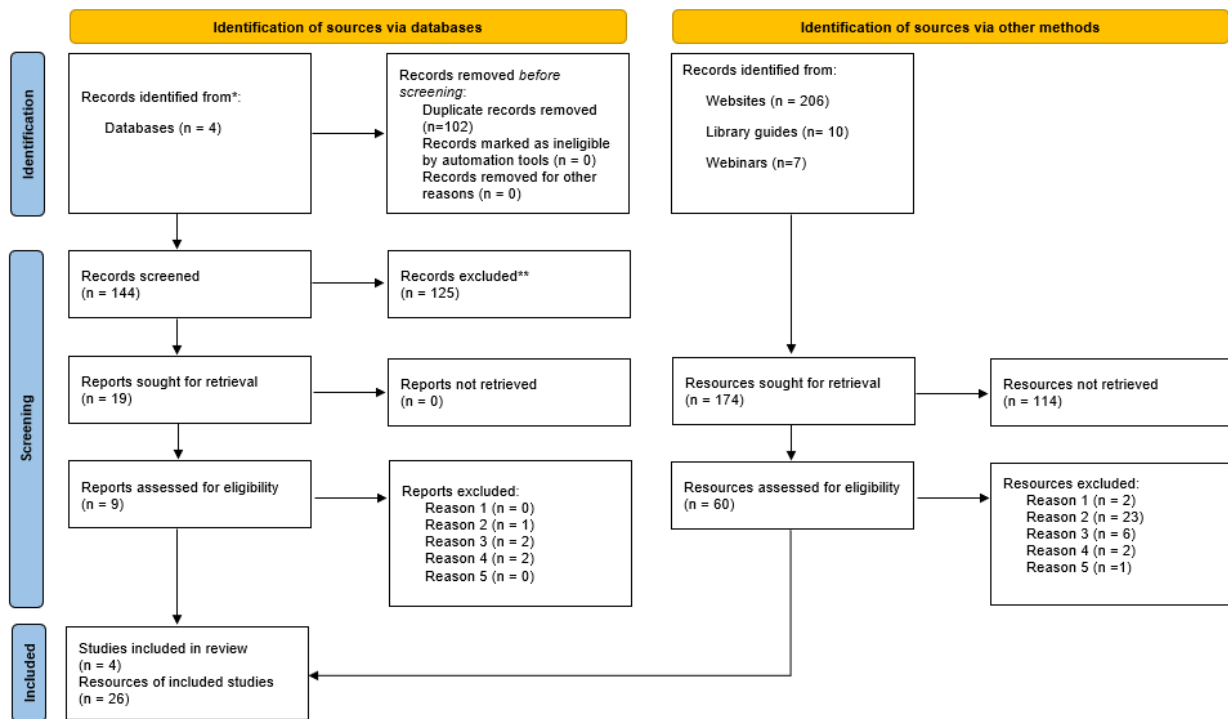


Figure 2: Search and screen flowchart (Source: figures by authors based on PRISMA)

## **Findings**

This section details the findings of this study, based on data from the past five years. The findings are discussed into four categories, each corresponding to one service provision of AI-LSICF. For each category, a table summarizes key details, including service types, tasks involved, AI techniques employed, countries where libraries implemented AI applications, and relevant references. In-depth discussions, including the impact and challenges of each AI application are provided in the subsequent subsections where applicable.

### ***New Service Concept***

The first service provision in the AI-LSICF framework is New Service Concept, which encompasses AI implementations which enhance traditional library services, including intelligent reference services, intelligent database search, intelligent content extraction, intelligent content curation, intelligent acquisition. However, there is a notable lack of literature demonstrating significant progress in these areas in libraries across Southeast Asia. The majority of AI implementations in libraries across Southeast Asia pertains to reference services, with the aim of addressing inquiries through means such as concierge robots, chatbots, and virtual assistants ((Mohammed Ali, 2019; Newsbytes.PH, 2023; Suthiprapa and Tuamsuk, 2022)Please refer to Table 2).

| Service Types                  | Applications/Projects   | Tasks   | AI techniques   | Countries                        | References   |
|--------------------------------|---|---|---|----------------------------------|--|
| Intelligent reference services | <ul style="list-style-type: none"> <li>• Chatbot</li> <li>• E-Library Data Assistant</li> </ul> | <ul style="list-style-type: none"> <li>• Virtual support agent to answer enquiries</li> <li>• Analyse users' intentions and sentiments</li> </ul> | <ul style="list-style-type: none"> <li>• NLP</li> <li>• Expert Systems</li> </ul> | Singapore; Philippines; Thailand | (Mohammed Ali, 2019; Newsbytes.PH, 2023; Suthiprapa and Tuamsuk, 2022) |
| Intelligent database search    |   |   |   |                                  |  |
| Intelligent content extraction |   |   |   |                                  |  |
| Intelligent content curation   |   |   |   |                                  |  |
| Intelligent acquisition        |   |   |   |                                  |  |

Table 2: AI applications and projects under New Service in Southeast Asian libraries (Source: table by authors based on AI-LSICF)

### Intelligent reference services

Notably, expert systems are fundamental to many bots and virtual assistants. Those knowledge-based systems "employ knowledge about their application domains and use reasoning procedures to solve problems that would otherwise require human competence or expertise" (Rastogi, 2016, p. 104). Examples of bots using expert systems include LibAnswer and the Temi robot (discussed further in section Robotics). By accessing knowledge bases and retrieving information based on predefined rules, these applications have been significantly facilitating the handling of simple reference inquiries (Asemi *et al.*, 2021; Gupta and Nagpal, 2020; Morris, 1991).

However, with the recent advancement in Natural Language Processing (NLP) — a computerised approach to analyse and represent naturally occurring texts at one or more levels of linguistic analysis for the purpose of achieving human-like language processing (Liddy, 2001) — and Large Language Models (LLMs), chatbots no longer rely solely on predefined playbooks. Instead, they can now address inquiries beyond traditional parameters. An emerging trend observed in libraries is the adoption of AI-enabled chatbots and virtual assistants for reference enquires, exemplified by the University of Malaya Library's LiveChat, which utilises commercial AI-enabled chatbot trained on over 2,000 transcripts.

Additionally, certain libraries are developing customised AI chatbots that can connect to library databases to answer queries on loans, new arrivals, and upcoming events, as well as facilitate communication with librarians. Research indicates that chatbots and virtual assistants can enhance library services and improve user experience. They are particularly beneficial in making services more inclusive for users with hearing or speech

impairments (Mohammed Ali, 2019; Thalaya and Puritat, 2022) and in reducing staff costs (Suwannatee and Suwanyangyuen, 2019).

Institutions such as the Boromarajonani College of Nursing Library in Thailand, Mahidol University Library and Knowledge Center, and Singapore Management University (SMU) Libraries have explored the use of Dialogflow, a cloud-based Natural Language Understanding (NLU) platform, to create these customised chatbots on their social media accounts for a 24/7 chatbot (Mohammed Ali, 2019; Suwannatee and Suwanyangyuen, 2019; Thalaya and Puritat, 2022). A post-implementation survey conducted by the Boromarajonani College of Nursing Library revealed a 4.32% improvement in user satisfaction. Users appreciated the 24/7 support provided by the chatbot, noting that the "consistent notification of information related to the service, new activities, and information resources of the library" (Thalaya and Puritat, 2022, p. 250) was particularly useful. Similarly, a survey by the University of Malaya Library (UML) found that 90% of users rated their chat sessions as good (Abu Bakar *et al.*, 2019), further supporting the positive impact of AI chatbots on user experience.

Despite their benefits, AI chatbots have limitations that require attention, particularly regarding the quality of responses and connectivity issues such as integration with library databases and internet connectivity (Mohammed Ali, 2019; Thalaya and Puritat, 2022). A survey conducted by the UML highlighted these issues, with 10% of users providing negative feedback on the LiveChat Service. Among the negative responses, over half were related to connectivity problems, including no response (39%), delayed response (9%), and technical issues (9%). The remainder of the negative feedback concerned the quality of answers, such as unresolved problems (33%) and lack of alternative solutions

(6%) (Abu Bakar *et al.*, 2019). These findings underscore the ongoing challenges associated with AI chatbots.

To address these challenges and further enhance user experience, improvements in training data and NLP models are needed for more relevant responses (Mohammed Ali, 2019; Thalaya and Puritat, 2022). Additionally, involving users in chatbot development could also be beneficial. For instance, the SMU Libraries organised the “Generate Your L(AI)brary Hackathon 2023” to crowdsource innovative AI chatbot solutions, highlighting a proactive approach to refining and advancing chatbot technology (Tay, 2023). Addressing these issues with improved training data, and proactive initiatives can enhance the effectiveness and user satisfaction of AI chatbots in libraries in the future.

### ***New Service Delivery System***

The second service provision in the AI-LSICF framework is New Service Delivery System, which includes service types such as intelligent information retrieval, delivery, access, personalisation, alert system and information library registration (Okunlaya *et al.*, 2022). A few studies have shown libraries across the region are actively exploring these service types (Please refer to Table 3).

| <b>Service Types</b>              | <b>Applications / Projects</b> | <b>Tasks</b>     | <b>AI techniques</b> | <b>Countries</b> | <b>References</b>     |
|-----------------------------------|--------------------------------|------------------|----------------------|------------------|-----------------------|
| Intelligent information retrieval | E-library Data Assistant       | AI search engine | NLP                  | Philippines      | (Newsbytes. PH, 2023) |
| Intelligent information delivery  |                                |                  |                      |                  |                       |
| Intelligent information access    |                                |                  |                      |                  |                       |

|   |  |   |    |           |              |
|---|--|---|----|-----------|--------------|
| Information library registration        |  |   |    |           |              |
| Intelligent information personalisation | <ul style="list-style-type: none"> <li>• Email recommender</li> <li>• Content recommender</li> </ul> | Personalised title recommendations to individual subscribers or users | ML | Singapore | (Atoh, 2021) |
| Intelligent alert system                |  |   |    |           |              |

Table 3: AI applications and projects under New Service Delivery System in Southeast Asian libraries

(Source: table by authors based on AI-LSICF)

### Intelligent information retrieval

In terms of information retrieval, many librarians believe that AI can significantly aid researchers in efficiently locating relevant sources (Harisanty *et al.*, 2022). For example, libraries at institutions like SMU and Supreme Court in the Philippines have discussed the possibility of using AI technologies such as Dialogflow to query and retrieve library resources and/or databases, but no mature product has been fully developed or implemented yet (Mohammed Ali, 2019; Supreme Court of the Philippines, 2023). The rapidly evolving nature of AI also poses challenges in keeping up with changing search trends and user behaviours (Subhankar *et al.*, 2024). To address those challenges, the Supreme Court of the Philippines Library is trialling Anycase.ai, a commercial AI-powered legal research platform, to enhance information retrieval capabilities for lawyers and legal professionals in the Philippines (VRITIMES, 2024).

### Intelligent information personalisation

Integrating AI technologies into library systems to provide users with personalised recommendations for library resources by analysing user inputs, database contents, and

browsing histories has become quite common (Chen and Chen, 2007; Chowdhury *et al.*, 2023; Yi *et al.*, 2017). However, in the region, only one project was found discussing this approach – specifically, the AI recommenders implemented by the National University of Singapore (NUS) Libraries. In 2019, the AI recommender project team, in collaboration with AISG (a national programme to catalyse, synergise and boost Singapore's AI capabilities), developed and launched two AI models aimed at enhancing user experience and improving resource discovery. One of these is a search-based recommender that was integrated into its unified search system called FindMore. This model suggests alternative resources for users in real-time by learning the natural language features of the search queries, the titles and descriptions of items in the database, and the transaction histories of the users. The list of alternative resources is from both internal and external databases, which increases the diversity and novelty of the resources provided to users (Atoh, 2021).

Another model is the email recommender incorporated into library subscribers' email newsletters. This model leverages user profiles, reading history, the titles and descriptions of items in the database, and the users' transaction history to provide personalised recommendations for library resources. Both recommenders are helpful in surfacing library resources that are more relevant to individual user. This may save users' time and effort by reducing the need to search through multiple databases and platforms and screen large amounts of content to locate relevant resources. It may also enhance their experience with the library website, as they are more likely to find contents which are truly relevant and engaging to them (Jing, 2021).

Although there is no information on whether feedback on the recommender tools developed by NUS Libraries have been gathered or the impact examined, it is worth noting that analysing user profiles to deliver personalised recommendations might raise user concerns about data privacy and security (Belen Saglam *et al.*, 2021). Therefore, libraries need to address these concerns to prevent deterring users from using such tools or platforms.

### ***Technological Options***

The third service provision in the AI-LSICF framework is Technological Options, which includes service types such as biometric recognition, RFID tagging, intelligent systems, robotics, and computer algorithm. The advancement in AI technology allows libraries to improve efficiency and capabilities in processing key information in those areas. There are relatively more studies discussing the AI implementations related to the service types under Technological Options compared to other categories (Please refer to Table 4).

| Service Types         | Applications/<br>Projects   | Tasks   | AI techniques  | Countries  | References  |
|-----------------------|---|---|--|--|---|
| Biometric recognition | Entry system  | Access system for entry security  | <ul style="list-style-type: none"> <li>Computer Vision</li> <li>Image Recognition</li> </ul>         | Malaysia   | (Khor, 2019)  |
| RFID tagging          | <ul style="list-style-type: none"> <li>Grab-n-Go Libraries</li> <li>Manga Library</li> </ul>  | Loan books automatically to users   | ML   | Singapore  | (National Library Board Singapore, 2022, 2023; Nolan, 2022)   |
|                       | <ul style="list-style-type: none"> <li>Auto-sorter</li> </ul>   | Automatically sort returned books based on pre-defined categories                             | ML   | Singapore  | (Nolan, 2022)   |
|                       | <ul style="list-style-type: none"> <li>Mobile bookdrop</li> </ul>   | Books can be returned to mobile bookdrop automatically  | ML   | Singapore  | (Liau, 2019)  |
|                       | <ul style="list-style-type: none"> <li>Shelf-reading robot</li> </ul>   | Stock Taking & Shelf-reading  | ML   | Singapore; Malaysia  | (Ignatius, 2023; Liau, 2019)  |
| Intelligent systems   |   |   |  |  |   |
| Robotics              | <ul style="list-style-type: none"> <li>Temi</li> <li>Mobile bookdrop</li> <li>Shelf-reading robot</li> <li>Mobile Telepresence Robotics (MTR)</li> <li>LibraryAnywhere van</li> </ul> | Navigate within the library   | Simultaneous Localization and Mapping (SLAM)   | Singapore; Malaysia; Thailand  | (Global Education News, 2020; Ignatius, 2023; Liau, 2019; Library Learning Space, 2022; Mustapa, 2023; Temasek Polytechnic Library, 2022; Wong, 2023) |
|                       | <ul style="list-style-type: none"> <li>LibraryAnywhere van</li> </ul>   | Fetch and deliver materials   | <ul style="list-style-type: none"> <li>SLAM</li> <li>Manipulation and grasping algorithms</li> </ul> | Thailand   |   |
|                       | <ul style="list-style-type: none"> <li>Temi</li> <li>Alpha Mini</li> <li>Mr. Kiasu</li> <li>Big Max</li> </ul>  | Provide Information<br>Interact with users  | <ul style="list-style-type: none"> <li>Speech recognition</li> <li>ML</li> <li>NLP</li> </ul>        | Singapore  | (National Library Board Singapore, 2023; Ow, 2024; Temasek Polytechnic Library, 2022; Wong, 2023)   |
|                       | <ul style="list-style-type: none"> <li>Temi</li> </ul>  | Monitor the cloud data and perform pre-defined actions automatically                          | ML   | Singapore  | Wong, 2023  |
|                       | <ul style="list-style-type: none"> <li>Shelf-reading robot</li> </ul>   | Stock Taking & Shelf-reading  | <ul style="list-style-type: none"> <li>Self-localisation algorithm</li> <li>ML</li> </ul>            | Singapore; Malaysia  |   |
|                       |   |   |  | <ul style="list-style-type: none"> <li>Dijkstra's algorithm</li> </ul> | Singapore   |
| Computer algorithm    | <ul style="list-style-type: none"> <li>Pathfinding of E-Directory</li> </ul>  | Compute and visualise the shortest path for users   | <ul style="list-style-type: none"> <li>Dijkstra's algorithm</li> </ul>                               | Singapore  | (Library Association of Singapore, 2020)  |
|                       | StoryGen  | Customise stories based on users' choices of characters, genres, locations, and story endings | NLP  | Singapore  | (National Library Board Singapore, 2024a)   |
|                       | Playbrary   | Gamify literary classic books using ChatGPT   | <ul style="list-style-type: none"> <li>NLP</li> </ul>  | Singapore  | (National Library Board Singapore, 2024b)   |

| Service Types         | Applications/<br>Projects   | Tasks   | AI techniques  | Countries                     | References  |
|-----------------------|---|---|--|-------------------------------|---|
| Biometric recognition | Entry system  | Access system for entry security                                  | <ul style="list-style-type: none"> <li>Computer Vision</li> <li>Image Recognition</li> </ul> | Malaysia                      | (Khor, 2019)  |
| RFID tagging          | <ul style="list-style-type: none"> <li>Grab-n-Go Libraries</li> <li>Manga Library</li> </ul>  | Loan books automatically to users                                 | ML   | Singapore                     | (National Library Board Singapore, 2022, 2023; Nolan, 2022)   |
|                       | <ul style="list-style-type: none"> <li>Auto-sorter</li> </ul>   | Automatically sort returned books based on pre-defined categories | ML   | Singapore                     | (Nolan, 2022)   |
|                       | <ul style="list-style-type: none"> <li>Mobile bookdrop</li> </ul>   | Books can be returned to mobile bookdrop automatically            | ML   | Singapore                     | (Liau, 2019)  |
|                       | <ul style="list-style-type: none"> <li>Shelf-reading robot</li> </ul>   | Stock Taking & Shelf-reading                                      | ML   | Singapore; Malaysia           | (Ignatius, 2023; Liau, 2019)  |
| Intelligent systems   |   |   |  |                               |   |
| Robotics              | <ul style="list-style-type: none"> <li>Temi</li> <li>Mobile bookdrop</li> <li>Shelf-reading robot</li> <li>Mobile Telepresence Robotics (MTR)</li> <li>LibraryAnywhere van</li> </ul> | Navigate within the library                                       | Simultaneous Localization and Mapping (SLAM)   | Singapore; Malaysia; Thailand | (Global Education News, 2020; Ignatius, 2023; Liau, 2019; Library Learning Space, 2022; Mustapa, 2023; Temasek Polytechnic Library, 2022; Wong, 2023) |

|                    |  |   |  |                     |   |
|--------------------|--|---|--|---------------------|---|
|                    | <ul style="list-style-type: none"> <li>LibraryAnywhere van</li> </ul>  | Fetch and deliver materials   | <ul style="list-style-type: none"> <li>SLAM</li> <li>Manipulation and grasping algorithms</li> </ul> | Thailand            |   |
|                    | <ul style="list-style-type: none"> <li>Temi</li> <li>Alpha Mini</li> <li>Mr. Kiasu</li> <li>Big Max</li> </ul> | Provide Information<br>Interact with users  | <ul style="list-style-type: none"> <li>Speech recognition</li> <li>ML</li> <li>NLP</li> </ul>        | Singapore           | (National Library Board Singapore, 2023; Ow, 2024; Temasek Polytechnic Library, 2022; Wong, 2023) |
|                    | <ul style="list-style-type: none"> <li>Temi</li> </ul>   | Monitor the cloud data and perform pre-defined actions automatically                          | ML   | Singapore           | (Wong, 2023)  |
|                    | <ul style="list-style-type: none"> <li>Shelf-reading robot</li> </ul>  | Stock Taking & Shelf-reading  | <ul style="list-style-type: none"> <li>Self-localisation algorithm</li> <li>ML</li> </ul>            | Singapore; Malaysia |   |
| Computer algorithm | <ul style="list-style-type: none"> <li>Pathfinding of E-Directory</li> </ul>                                   | Compute and visualise the shortest path for users   | <ul style="list-style-type: none"> <li>Dijkstra's algorithm</li> </ul>                               | Singapore           | (Library Association of Singapore, 2020)  |
|                    | StoryGen   | Customise stories based on users' choices of characters, genres, locations, and story endings | NLP  | Singapore           | (National Library Board Singapore, 2024a)   |
|                    | Playbrary  | Gamify literary classic books using ChatGPT   | NLP  | Singapore           | (National Library Board Singapore, 2024b)   |

Table 4: AI applications and projects under Technological Options in Southeast Asian libraries (Source: [table by authors based on AI-LSICF](#))

### Biometric recognition

Computer vision enables computers to derive information from images, videos and other inputs from the real world to produce numerical or symbolic information (Klette, 2014; Shapiro and Stockman, 2001). Advancement in AI-driven computer vision for identifying individuals or objects have improved security while maintaining convenience for library patrons (Hussain, 2023). One notable application can be found in Tun Hussein Onn Sunway (THOS) Library which implemented facial recognition technology for entry purposes in 2019 (Ignatius, 2023). This approach streamlines the authentication process and enhances security by accurately identifying authorised individuals (Sharma et al., 2021; Khor, 2019). Furthermore, facial recognition technology offers a personalised

experience for library users, eliminating the need for traditional access cards or keys. However, THOS Library's facial recognition system requires users to submit their photos for identification purposes. This may raise concerns about user data security, particularly regarding the storage, usage and potential misuse of sensitive biometric data.

### *Radio Frequency Identification (RFID) tagging*

The use of RFID tags in libraries has significantly improved inventory management and streamlined the process of locating materials, beginning with the installation of the first system in 1999 at the National Library Board (NLB) Singapore (Ayre, 2012). Advances in AI have enabled innovative applications of RFID technology, automating mundane manual tasks, enhancing user experiences, and reducing staff workload. Notable developments include the integration of RFID with robots and machines, leading to services such as shelf-reading robots, mobile bookdrop robots, and auto-sorters.

NLB, for example, launched the mobile bookdrop, which allows patrons to return books instantaneously at convenient locations using RFID signals. When the bookdrop bin is full, it automatically returns to the sorting station and alerts staff to replace it. The auto-sorter then categorises the books, thereby enhancing staff productivity and reducing the time and effort needed to manage returns. According to NLB, this system has saved S\$750,000 annually in manpower costs (National Library Board Singapore, 2020). Additionally, the time saved from mundane and manual tasks allows library staff to focus on "providing higher value work to serve the community" (Liau, 2019, p. 2).

While these advancements provide benefits for library staff, such innovations also enhance users' experience. For instance, shelf-reading robots at the NLB and THOS

Library scan RFID-tagged books on the shelf and generate reports on mis-shelved and missing items. This helps staff locate and return books to their correct places more easily, improving collection management and eliminating users' frustrations associated with the failure to locate certain books (Ignatius, 2023; National Library Board Singapore, 2020).

Moreover, improved accuracy in RFID detection has made fully self-service libraries possible. Examples include NLB's "grab-and-go" and Manga libraries, where users can pick up a book and exit without visiting a counter; the book is automatically borrowed to their account (National Library Board Singapore, 2023). Library patron Anam Mukri praised the system for its seamless integration, resolving issues like undetected barcodes or users forgetting to scan (Mujibah, 2022). However, Liao (2019) noted that RFID technology has limitations, including detection failures caused by metallic shelves, reflective book covers, weak tags, and irregular shelf configurations. Despite these challenges, the integration of AI and RFID technology remains a promising advancement in library services.

### Robotics

With advancements in AI technology, a new area in library services called Robot as a Service (RaaS) has emerged, enhancing user experience. This development enables robots to perform a range of tasks including both mechanical functions and cognitive activities such as driving, natural language processing, translation, and facial recognition (De Sarkar, 2023). While robots are widely used in logistics and manufacturing, their application in library services remains in preliminary phase (Liao, 2019).

Robots implemented in libraries can be categorised into two types: movable robots and stationary robots. Stationary robots are designed to provide information or interact with users without moving around the library. These robots use voice recognition, NLP, and Machine Learning (ML) technologies – “an evolving branch of computational algorithms that are designed to emulate human intelligence by learning from the surrounding environment” (El Naqa and Murphy, 2015, p. 3) to accurately process users' speech and deliver precise answers. For example, the Mr Kiasu robot in NLB's Manga Library offers book recommendations, assists with the "Grab-n-Go" system, and shares "Kiasu" tips and stories (Kiasu is a term used in Singapore to describe a fear of falling behind) (National Library Board Singapore, 2023). Additionally, the National Institute of Education (NIE) Library has integrated the OpenAI API into a humanoid AI robot named AlphaMini, which facilitates live chat interactions. Users can engage in dialogue, ask questions, and explore various topics, providing the community with a firsthand experience of robotics and AI technologies (Ow, 2024).

Movable robots, by contrast, are designed to navigate library spaces and perform tasks such as guiding tours, answering questions, and interacting with users. Examples include the Big Max robot in Temasek Polytechnic Library in Singapore (Temasek Polytechnic Library, 2022) and the Mobile Telepresence Robotics (MTR) in Chulalongkorn University Central Library in Thailand (Chulalongkorn University Central Library, 2019). These robots often use Simultaneous Localization and Mapping (SLAM) technology to create a real-time map of their environment and track their location (Bailey and Durrant-Whyte, 2006; Fan *et al.*, 2024). This capability enables them to move accurately and efficiently throughout the library. However, their mobility can be restricted by

environmental factors such as narrow pathways, reflective surfaces, and obstacles like steps and wires (Liau, 2019).

The integration of ML and voice recognition capabilities has enhanced the functionality of movable robots in libraries. These advancements allows robots to respond more effectively to verbal queries from patrons and improve their navigation accuracy (TEMI, 2024). For example, Temi concierge robots are used in libraries such as Nanyang Technological University Art and Design Media (NTU ADM) Library, NIE Library, and Universiti Malaysia Pahang (UMP) Library (Library Learning Space, 2022; Mustapa, 2023; Wong, 2023). By leveraging these technologies, libraries can offer a more interactive and personalised experience for users. For instance, NIE Library reprogrammed the Temi to monitor near-real-time crowd data and automatically deliver friendly reminders in crowded areas during the COVID-19 distancing period, enhancing safety and user awareness (Wong, 2023). These innovations not only streamline library services but also contribute to a more responsive and user-centred environment.

In addition to customer service, movable robots like mobile bookdrop robots and shelf-reading robots in NLB and LibraryAnywhere delivery van at Chulalongkorn University Central Library can transform library operations by enhancing efficiency in quality control and automating various processes. This allows library staff to concentrate more on personal development and value-added tasks, such as “fostering meaningful connections with students” (Harisanty et al., 2022; Ignatius, 2023, para. 7). Furthermore, using robots reduces manpower reliance and saves costs, leading to a blended workforce (Liau, 2019).

Despite these benefits, challenges with robotics technology persist. High initial investment and budget constraints may limit adoption in many libraries. It is crucial for

libraries to assess the cost-benefit ratio of implementing such technologies. Additionally, robots face limitations such as navigation issues, problems with book detection, and situations that necessitate human intervention (Liau, 2019).

### Computer algorithm

A computer algorithm is a set of instructions to be followed in calculations or other operations and most AI applications rely on specific algorithms (Dourish, 2016). AI algorithms are commonly integrated into directory systems to find the most efficient path to selected locations. A notable example is the smart e-directory system implemented at Singapore Polytechnic (SP) Library in 2020. This system, which spans the library's seven levels of study areas, uses Dijkstra's algorithm to compute the shortest path from the user's current location to their destination. The e-directory then visually displays this path, offering clear directional guidance to users. As a result, library users can independently locate rooms and space, reducing the need for staff assistance, especially during peak hours. (Library Association of Singapore, 2020).

Unsupervised learning algorithms are rapidly advancing, partly due to new Generative Artificial Intelligence (Gen AI) techniques, which learn from unlabelled datasets by identifying patterns, correlations, or clusters (Feuerriegel *et al.*, 2024). Gen AI has significantly reshaped storytelling and reading experiences. For instance, the StoryGen initiative, developed by NLB and Amazon Web Services, uses Gen AI to create immersive and interactive storytelling experiences. It enriches beloved narratives with fresh perspectives and visualises them through immersive video projections. By bringing scenes to life with AI-generated imagery and exploring alternative genres like sci-fi or

fantasy, StoryGen offers readers a truly engaging and novel experience (National Library Board Singapore, 2024a; Yu, 2024).

Another noteworthy Gen AI initiative is Playbrary, a collaboration between NLB and LePub, which reimagines classic literature as interactive adventure games. Renowned classical titles such as Jane Eyre, Pride and Prejudice, and Frankenstein are revitalised, inviting readers to immerse in digital experiences that blend storytelling with gameplay (National Library Board Singapore, 2024b). This approach preserves literary heritage while blending traditional literature with digital technology, addressing concerns about younger generations' declining interest in traditional reading (Kim, 2024).

### ***New Client Interface***

The final service provision in the AI-LSICF framework is the New Client Interface, which encompasses services such as virtual assistants, chatbox, automated feedback, and intelligent user dashboards. A few studies have been found to showcase AI projects in virtual assistants, chatbox and intelligent user dashboards (Please refer to Table 5).

| Service Types               | Applications/ Projects   | Tasks  | AI techniques   | Countries                        | References  |
|-----------------------------|--|--|---|----------------------------------|---|
| Virtual assistants          | <ul style="list-style-type: none"> <li>• Chatbot</li> <li>• E-Library Data Assistant</li> <li>• Reading Chatbot</li> <li>• BCNPYLIB chatbot</li> </ul> | <ul style="list-style-type: none"> <li>• Virtual support agent to answer enquiries</li> <li>• Analyse users' intentions and sentiments</li> <li>• ChatGPT helps in cataloguing, abstracting &amp; indexing, and content &amp; SEO enhancement</li> </ul> | <ul style="list-style-type: none"> <li>• NLP</li> <li>• Expert Systems</li> </ul> | Singapore; Philippines; Thailand | (Chatchaval, 2024; Mohammed Ali, 2019; Newsbytes.PH, 2023; Suthiprapa and Tuamsuk, 2022; Suwannatee and Suwanyangyuen, 2019; Thalaya and Puritat, 2022) |
| Chat-box                    | <ul style="list-style-type: none"> <li>• ChatBook</li> </ul>   | Interactive chatbox that generates responses based on user inputs, drawing information from NLB's published books and online resources   | <ul style="list-style-type: none"> <li>• NLP</li> <li>• Expert Systems</li> </ul> |                                  | (Stolarchuk, 2023)  |
| Automated feedback          |  |  |   |                                  |   |
| Intelligent user dashboards | Data dashboard   | Analyse user demography and borrowing patterns to plan the locations of new libraries and the collection points  | Predictive Analytics  | Singapore                        | (Nolan, 2022)   |
|                             |  | Analyse user data to guide future strategic directions   | Predictive Analytics  | Singapore                        | (Pang, 2023)  |

| Service Types      | Applications/ Projects   | Tasks  | AI techniques   | Countries                        | References  |
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|                             |  |  |   |           |                    |
|-----------------------------|--|--|---|-----------|--------------------|
|                             |  | enhancement  |   |           |                    |
| Chat-box                    | <ul style="list-style-type: none"> <li>• ChatBook</li> </ul> | Interactive chatbox that generates responses based on user inputs, drawing information from NLB's published books and online resources | <ul style="list-style-type: none"> <li>• NLP</li> <li>• Expert Systems</li> </ul> |           | (Stolarchuk, 2023) |
| Automated feedback          |  |  |   |           |                    |
| Intelligent user dashboards | Data dashboard   | Analyse user demography and borrowing patterns to plan the locations of new libraries and the collection points                        | Predictive Analytics  | Singapore | (Nolan, 2022)      |
|                             |  | Analyse user data to guide future strategic directions   | Predictive Analytics  | Singapore | (Pang, 2023)       |

Table 5: AI applications and projects under New Client Interface in Southeast Asian libraries (Source: table by authors based on AI-LSICF)

### Virtual assistants

Chatbots have been used in library services since the 1970s, primarily for answering inquiries, guiding complex tasks, sending notifications, and facilitating resource searches

. Some of the chatbots discussed in the Intelligent reference service section exemplify those focused on reference services. Recent advancements in AI, including Large Language Models (LLMs) like BERT, GPT-4, and T5, have broadened chatbot capabilities, improving their understanding and conversational abilities (Al-Amin et al., 2024; Tay, 2023; Zielinski et al., 2023). Chatbots are now transitioning from retrieval-based models, which match questions to pre-existing answers, to generative models that can comprehend questions and generate responses beyond the databases. This shift enables chatbots to provide services beyond typical library queries.

### Chatbox

With the advancement of Gen AI, chatbots can now enrich the learning experience (Okunlaya *et al.*, 2022) by mimicking book characters or authors and engaging users in unscripted, creative conversations, fostering greater interest and deeper engagement. For example, Playbrary allows users to create new storylines for classic literature (National Library Board Singapore, 2024b). Another pilot project, ChatBook, developed by NLB in 2024, allows users to “debate” or converse with books via WhatsApp or a web application. The chatbot can even respond with unpublished content (Hirdaramani, 2024; National Library Board Singapore, 2024a). While ChatBook has been praised for its innovative and engaging approach to teaching Singapore history, it also faces challenges,

including vague content accuracy, slow response speed and limited content training breadth (Lee, 2024).

Despite these advancements, implementing Gen AI chatbots and virtual assistants presents challenges. Mohammed Ali (2019) noted the significant time, effort and financial costs required to train and maintain chatbots to provide quality answers, as well as the costs associated with "investing in and upgrading" (p. 5) library staff to manage these services effectively. Alongside these operational challenges, there are concerns related to security and ethics. Both Mohammed Ali (2019) and Burkhardt (2018) raised concerns about malicious bots mimicking human behaviours, which could lead to data mining and opinion manipulation. To mitigate these risks, libraries should integrate ethical bot usage into their information literacy programmes.

### *Intelligent user dashboards*

Under the New Client Interface category, AI integration in data analysis is transforming library collection development strategies. At the 18th ASEAN University Network Inter-Library Online (AUNILO) Meeting 2023, Caroline Pang, University Librarian of NTU, highlighted the shift from traditional descriptive analysis to predictive data analysis. This transition enables libraries to gain insights into user behaviours, anticipate emerging trends, and improve operational workflows. By harnessing AI-driven predictive analytics — a method that uncover relationships and patterns within large datasets to forecast future behaviours and events (McCarthy *et al.*, 2022) — libraries can streamline collection development, allocate resources judiciously, and make informed decisions to better serve the evolving needs of their users (Pang, 2023).

Additionally, NLB has been using data analytics to enhance its services. In collaboration with the Singapore Land Authority, NLB applied geo-spatial analytics to understand library user behaviours, such as the distance users are willing to travel to a library. This information is used to plan new library locations and renovation designs. Moreover, NLB regularly conducts surveys to analyse user demographics, activities, and time spent in the library. For example, the REACH Survey investigated why some users do not engage with NLB services, helping the library enhance its offerings and increase visitor engagement (National Library Board Singapore, 2017; Nolan, 2022).

While predictive analytics can be a powerful tool for libraries, implementing and maintaining these applications requires specialised knowledge and skills, which may be challenging to acquire. Libraries should have realistic expectations and use these tools with caution. Training models rely on historical data to predict the likelihood of certain events, but they cannot guarantee outcomes, as no model can foresee the future with absolute certainty. Furthermore, if the training data is unbalanced, such as by underrepresenting certain groups, the results may be biased. Ensuring balanced training data and avoiding overfeeding or underfeeding are crucial for effective model design.

## **Impact of emerging AI on library services beyond AI-LSICF framework**

The implementation of AI in library services extends beyond mere integration, significantly altering librarians' roles and responsibilities. As noted by Loh *et al.* (2019), "The shift towards disruptive technologies, artificial intelligence means that students today need ever higher levels of literacy to engage in twenty-first century consumption and work."

This evolving landscape requires librarians to not only adapt to new technologies but also play an active role in fostering AI literacy among users. This may include developing guides, organising workshops, and hosting conferences. Furthermore, the evolving scope of librarians' roles now encompasses new skills such as prompt engineering and understanding AI's ethical implications, reflecting a broader transformation in how library services are delivered and how librarians guide users in leveraging AI tools effectively. (Loh and Lee, 2023; Subaveerapandiyar *et al.*, 2023).

### ***Developing AI literacy resources and programmes***

In Southeast Asia, libraries from public, academic and K-12 institutions -- such as Concordian International School (Thailand), NLB, NTU, NUS, Singapore Institute of Technology (SIT), Singapore University of Technology and Design (SUTD), SMU, and University of Technology Malaysia (UTM) -- are developing library guides or e-books and e-modules on a diverse range of AI topics. These resources cover introductory AI concepts, learning resources, applications across various sectors, ethical considerations, and institutional policies on the responsible use of AI tools. Additionally, some academic libraries, including Khon Kaen University (KKU) Library in Thailand, NIE Library, Swinburne University of Technology (SUT) Library in Malaysia, prioritise digital literacy by offering workshops and one-to-one consultations.

In addition to AI literacy programmes, libraries are actively facilitating consultations workshops and events to integrate AI into research, learning and teaching (Jenkins and Borui, 2024). For example, SMU Library's "Hackathon Generate your L(AI)Library" provides students with opportunities to use large language models to develop innovative programmes for enhancing library services (Ratmelia, 2023). This commitment is



solidifying their role in shaping the future of information access and dissemination (Lund, 2023).

Nevertheless, AI not only introduces new responsibilities for librarians but also offers convenience by automating redundant and repetitive tasks. For example, shelf-reading robots at NLB eliminate the need for staff to manually check mis-shelved items, while auto-sorters automatically handle the sorting of returned books, speeding up reshelving. Additionally, AI-enabled chatbots or virtual assistants, trialled by many academic libraries, can manage a wide range of user inquiries, saving valuable time for reference librarians. These AI initiatives free library staff to focus on personal and career development, as well as more value-added tasks (Harisanty *et al.*, 2022; Liao, 2019; Suthiprapa and Tuamsuk, 2022).

## Discussion

### *AI implementation trend in libraries across Southeast Asia*

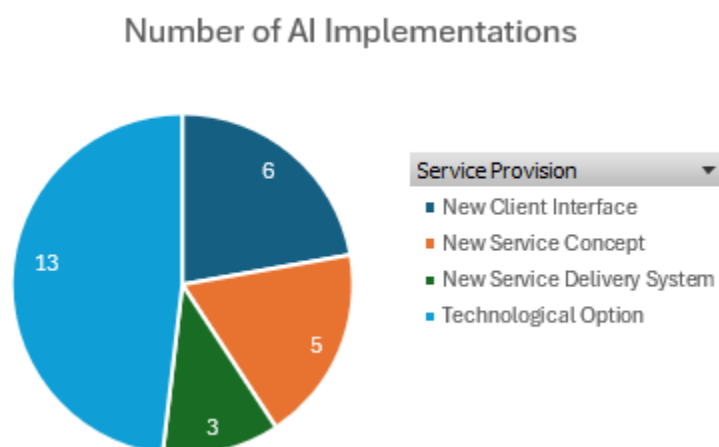


Figure 4: The number of AI implementations under different service provision based on AI-LSICF

(Source: figure by authors)

In libraries across Southeast Asia, the predominant focus of AI implementation is on Technological Option. This is evidenced by 13 distinct initiatives involving robotics and automation aimed at streamlining library processes to enhance operational efficiency (See Figure 4). Many libraries have adopted robots for tasks such as stocktaking, book returns, and visitor guidance. However, robots with advanced human intelligence capabilities, such as NLP and users' intentions and sentiment analysis, are still in the early stages of development. Currently, most robots are limited to answering simple, preprogrammed questions. Future studies could explore robots equipped with NLP and ML to handle more complex queries effectively. Additionally, RFID technology in the region is mature, with applications including unmanned libraries, mobile bookdrop, auto-sorter, and shelf-reading robots. Integrating RFID with other AI techniques facilitates efficient inventory management, which significantly improves operational efficiency and user experience. It has also paved the way for advanced features like predictive book recommendations and enhanced security protocols, further enriching the library AI ecosystem.

Following closely behind is the Client Interface service provision, with six implementations aimed at enhancing user experiences through AI-driven initiatives such as virtual assistants and chatbots. These implementations highlight libraries' commitment to leveraging AI technologies to better serve their patrons and enhance overall satisfaction with library services. However, these implementations indicate that most libraries are still using retrieval-based or rule-based chatbots and virtual assistants (Abu

Bakar *et al.*, 2019), and are in the early stages of exploring generative-based models. Future exploration may focus on using LLM to train chatbots and virtual assistants.

There is a noticeable lack of AI implementation in the Service Concept within libraries in Southeast Asia. Only five implementations align with the Service Concept objectives of enhancing reference services, all of which utilise concierge robots or chatbots to address reference inquiries. It is worth noting that while these AI implementations are counted under the Service Concept service provision, the use of robots can also be categorised under the Technological Option service provision. This dual categorisation further reinforces the trend of libraries prioritising technological solutions to improve their services.

Lastly, the category with the fewest AI implementations is the Service Delivery System, with only three initiatives, spearheaded by the NUS Library and the Philippine Supreme Court Library. This suggests potential for further exploration and development in this area of library services. These pioneering implementations demonstrate how AI can enhance service delivery, highlighting opportunities for other libraries in the region to adopt innovative approaches through AI integration.

Nevertheless, the scarcity of articles and explorations of intelligent service delivery system features may be partly because many Integrated Library System (ILS) vendors have already implemented similar features, reducing the need for libraries to reinvent the wheel. For instance, Primo VE from Exlibris has the features including a) Resource recommender (Exlibris, 2017); b) AI-enabled Metadata Generator to register three specific MARC fields: Language (041 and 008), Summary (520) and LC subject headings (650) (Rose-Hellmann, 2024); c) Auto Complete feature which offers context-based

suggestions for search strings that are based on top local Primo and CDI queries, as well as data from local Primo institution; d) Digital Adoption Tool that provide users with optimised experiences based on behavioural analytics (Exlibris, 2015, 2022).

Building on the discussion of AI implementation trends in libraries across Southeast Asia, Rogers' Diffusion Theory of Innovation (1962) provides a useful framework for understanding the adoption process. His theory outlines five stages: Knowledge, Persuasion, Decision, Implementation, and Confirmation. Currently, many libraries in the region are in the decision and implementation stages regarding the use of AI technologies in their operations. These libraries generally understand AI technologies and have evaluated the benefits and challenges of integrating AI into their workflows. The synthesised findings indicate that while most libraries have decided to adopt AI and have begun implementing AI-enabled applications, these implementations are not yet comprehensive, with many projects still in the trial stage. This suggests that a consensus on the use of AI across libraries in the region has not yet been reached.

### ***AI implementation landscape in libraries across Southeast Asia***

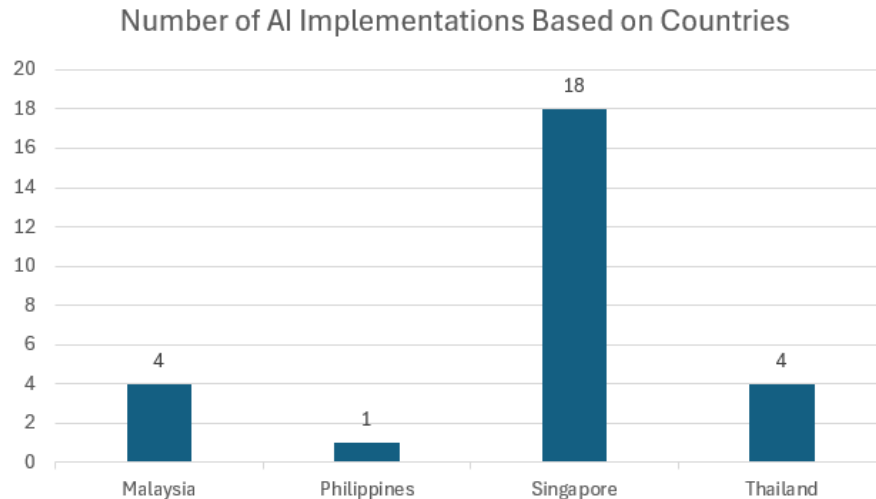


Figure 5: The number of AI implementation based on countries in Southeast Asia (Source: figure by authors)

Four out of the eleven countries in Southeast Asia are actively supporting the enhancement of library services through AI technology. These countries include Singapore, Thailand, Malaysia, and the Philippines. Singapore leads with 18 AI projects, notably with the NLB implementing 9 projects over the last five years (see Figure 5). This effort aligns with its Libraries & Archives Blueprint 2025 (LAB25), which aims to enable Singaporeans to experience and understand technologies such as AI, cloud tech, and virtual reality, providing even tech-savvy individuals with new learning opportunities (National Library Board Singapore, 2021). In Thailand, academic libraries have focused on user interaction and accessibility, with four projects involving robots and chatbots. Libraries in Malaysia have been incorporating facial recognition and robotics to enhance library operations. Meanwhile, the Philippines is still in the exploratory stage with AI-enabled virtual assistants for specialised libraries.

The high number of AI implementations in libraries across these four countries may be attributed to robust government support and well-developed infrastructure (Echedom and Okuonghae, 2021; Subaveerapandiyana, 2023). This is evidenced by the launch of the Singapore National AI Strategy 2.0 (NAIS 2.0), Thailand's National AI Strategy and Action Plan (2022 – 2027), Malaysia's National Artificial Intelligence Roadmap (AI-RMAP), and the Philippines' National AI Strategy Roadmap (AI Thailand, 2023; Department of Trade and Industry, 2021; Smart Nation Singapore, 2023). These strategic plans provide a comprehensive framework with clear objectives, guidelines, and substantial funding opportunities, serving as key catalysts for encouraging libraries to transform their services with AI technology.

While some libraries recognise the challenges posed by AI development for librarians (Trieu, 2023), there is a lack of literature on AI implementation in libraries in Brunei, Vietnam, Myanmar, Cambodia, Laos and Timor-Leste.

### ***Librarians' perceptions of AI in libraries across Southeast Asia***

There are a few studies that examine the perceptions and readiness of librarians and information science (LIS) researchers in Southeast Asia regarding AI. Most of them have a good understanding of AI and agree that it can enhance library management in areas such as data analysis and decision-making. However, barriers to AI adoption remain, including resource constraints, bureaucratic processes, lack of awareness and organisational support, as well as the complexity of managing human resources (Harisanty *et al.*, 2022; de Leon *et al.*, 2024; Subaveerapandiyana, 2023).

De Leon et al. (2024) and Harisanty et al. (2022) also highlight several concerns regarding AI implementation in libraries, including the following:

- *Bias and misleading information.* Some librarians have raised concerns about the quality of information generated by AI applications and the potential for bias in the responses. These issues could undermine the reliability of AI-generated information. Similar concerns were highlighted by Mohammed Ali (2019) and Lee (2024), who warned that biases could result in misinformation or skewed data, potentially manipulating public opinion.
- *Reduced human interaction and potentially compromised user experience.* The growing use of robotics to handle some librarians' tasks has raised concerns about reduced interaction between users and librarians. However, what do users really want? Some Filipino librarians have commented that current AI-driven robots have limited functions, and users may feel these bots fail to meet their diverse and dynamic information needs. This could lead to user frustration and a lack of trust in such tools.
- *Data security.* To provide more personalised services, many AI applications need to collect and analyse users' information. This raises concerns about where such data is stored, how it is used, and the potential risks involved. Notably, misuse or breaches of user data could damage the library's and the tool's reputation, erode users' trust, or even result in legal and regulatory consequences.
- *Resistance to change.* The survey by De Leon et al. (2024) reveals significant resistance to AI-enabled applications among Filipino librarians. This resistance may impede the adoption of AI technologies in libraries.

## **Limitations and future research direction**

The insights gained from examining the trends, landscape, and perceptions of AI in libraries across Southeast Asia reveal both significant advancements and notable challenges. Despite the progress detailed in the previous sections, several limitations have emerged, highlighting areas for further research. Addressing these challenges will be crucial for optimising AI implementation in libraries. Future studies should focus on overcoming these limitations and exploring new avenues for research to enhance the effectiveness and integration of AI technologies in library services.

This review has inherent limitations, including a reliance on English-language sources which may exclude initiatives from countries where English is not the primary language. Additionally, focusing only on completed projects, may overlook ongoing initiatives with valuable insights. Addressing these aspects will enhance our understanding and contribute to more comprehensive research on AI integration in libraries.

Additionally, this review uses the AI-LSICF framework to categorise and evaluate AI applications implemented in libraries within Southeast Asia. While the framework is useful for organising a wide range of AI applications, it has certain limitations. Firstly, the framework's service provisions often overlap, creating ambiguity in classification. For example, virtual assistants, used for reference services, could be classified under either the New Client Interface category or the Technological Options category, depending on whether the focus is on their user-facing functions or the underlying technology. This overlap highlights a lack of clear differentiation between functions and technologies, making accurate categorisation challenging and reducing the framework's effectiveness in distinguishing between service provisions.

Secondly, the framework does not fully accommodate the rapid advancements in AI technologies, particularly generative AI and its underlying large language models (LLMs). This limitation makes it challenging to accurately fit new AI initiatives into the existing service provisions of the framework. To address these limitations, future research should develop a more dynamic framework for classifying AI applications based on their specific functions in library services, rather than using broad conceptual categories. This framework should account for advance technologies like Gen AI. Additionally, research should focus on evaluating user satisfaction to assess how effectively AI initiatives meet users' needs and address library challenges .

Currently, there is a lack of studies on the impact and user feedback of AI implementations in library services within Southeast Asia and future research should fill this gap by examining both the effectiveness of these technologies and user satisfaction.

## **Conclusions and recommendations**

In libraries across Southeast Asia, AI initiatives have enhanced user experiences, streamlined operations, and improved efficiency. AI chatbots and virtual assistants offer round-the-clock support, improving information access and user satisfaction, while personalised recommenders aid research by quickly suggesting relevant materials. Technologies such as facial recognition and RFID systems streamline user authentication and automate transactions, boosting convenience. AI-powered robots also contribute by reducing mis-shelved items and offering alternative interactions. Generative AI projects engage users with innovative educational experiences.

According to the AI-LSICF framework, the majority of AI applications over the past five years have concentrated on the Technological Options category, with robotics and RFID systems being the most common. The Client Interface category follows, with virtual assistants and chatbots being developed or explored in the region. Although some projects have proved successful in making libraries more efficient and cost-effective by automating repetitive tasks, managing resources more effectively, and providing more personalised services, a consensus on AI adoption across the region's libraries has yet to be reached.

Challenges and concerns have also emerged. Both users and librarians are worried about personal data privacy, the reliability of AI applications and their generated content, and the potential reduction in librarian engagement with users. Additionally, the uneven distribution of AI implementations across the region may reflect varying levels of government support and technological infrastructure. Addressing these issues through ongoing evaluation and refinement is crucial to fully realise the benefits of AI in libraries.

Most librarians and LIS researchers in Southeast Asia view AI positively, recognising its potential to enhance library operations, particularly in decision-making and management. However, challenges such as limited funding, insufficient organisational support, and staff reluctance to change hinder broader AI integration in ASEAN libraries.

Based on the synthesised findings, the following recommendations are proposed to ensure a smooth transition for libraries considering the implementing of AI technologies:

- *Assess user feedback and adapt accordingly.* A primary objective of implementing AI technologies in libraries is to enhance user experiences. To ensure this goal is

being achieved and that projects align with users' needs, libraries should collect user feedback through surveys or direct interactions. Regular assessments are crucial, given the rapid pace of AI development, as they enable libraries to adapt to new advancements and respond promptly to evolving user needs.

- *Address users' data privacy concerns.* To address users' data privacy concerns, libraries should implement cybersecurity measures during deployment, including network security, data encryption, and access controls, while also conducting regular security audits. Following deployment, it is crucial to maintain transparency by clearly communicating data privacy, data collection, and access policies. Providing users with the option to opt in or out and obtaining consent prior to data collection will help reduce hesitation in using the services.
- *Training and educating librarians and library users.* Librarians play a vital role in information literacy programmes and must be adept at applying these principles within an increasingly AI-driven information landscape. Libraries should provide services to educate users on AI literacy, including workshops, courses, and guides covering AI concepts, ethical considerations, and practical applications. Concurrently, librarians need to enhance their own AI-related skills to better support users. For instance, NUS Libraries recommend that system librarians acquire skills in ML, mathematical techniques, and relevant software for managing AI-based applications. Instructional librarians should understand AI interfaces and apply information literacy principles in an AI context. Libraries should ensure librarians have access to training and workshops to develop these essential skills (Ng *et al.*, 2024).

- *Effective change management.* The transition to AI-enabled systems in libraries requires a deliberate focus on change management. Some library staff may feel insecure about their job security due to new technologies. Library management should clearly communicate that AI and human roles are complementary rather than interchangeable. For example, while robots can efficiently answer questions based on their training data, they may still require a librarian's expertise for complex queries. Similarly, shelf-reading robots can identify mis-shelved books but cannot return them to the correct locations. The emphasis should be on how humans and AI applications can collaborate to enhance productivity, rather than on fear of replacement. Libraries should also involve staff early in the process to gather their input and feedback, and to demonstrate how new technologies can improve efficiency. These measures will facilitate a smoother transition to new workflows (Liau, 2019).
- *Begin with a small-scale deployment and enhance library collaboration and knowledge sharing.* AI technologies can be expensive, presenting funding challenges for some. Therefore, it is crucial to thoroughly evaluate the value of projects before full-scale deployment. A Proof-of-Concept (PoC) approach is an ideal strategy for piloting AI projects on a small scale, allowing libraries to assess the viability of potential technologies. Liau (2019) noted that many of NLB's robotics projects (e.g., auto-sorters, shelf-reading robots) were initially piloted in a single branch on a small scale, with improved versions rollout to additional libraries based on lessons learnt and feedback from the initial projects. This approach helps libraries optimise the use of time and resources while minimising financial risks.

Additionally, libraries should collaborate on AI initiatives to share knowledge, resources, and best practices. This will not only optimise resource planning but also help libraries navigate the complexities of adopting AI technologies effectively. Regional conferences, workshops, and working committees can facilitate this exchange.

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