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## Transforming Library Operation with Robotics

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### Abstract:

*At Singapore public libraries, robots and automatic sorting machines are used to help staff and volunteers with sorting returned books, shelf reading and transportation of library materials. The National Library Board (NLB) has embarked on its robotics journey in 2013 with the introduction of autosorter at the library@Chinatown. Since then, NLB has leveraged on technologies and robotics to re-engineer its library operations and automate many of the labour-intensive and time-consuming tasks.*

*The paper shares how the adoption of robotics and automation technologies has transformed the library operation and improved customer experience at the libraries. The initiatives include autosorters, shelf-reading robots and mobile bookdrop. These innovations have helped to achieve cost savings and simplified workflow for the aging workforce, in addition to bringing convenience to citizens. The operation staff can now take on other higher-value tasks such as engaging patrons and conducting library programmes.*

**Keywords:** Robotics, Automation in libraries

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## 1 INTRODUCTION

Imagine a library without librarians, but you are still able to have everything you need at your fingertips. The NLB is using robots to make that happen.

Singapore has a network of 26 public libraries distributed within an island of about 724 km<sup>2</sup>. At any one day, our libraries receive about 67,000 visitors and process about 89,000 loans. Like many libraries around the world, Singapore libraries have to deal with the challenge of increasing manpower cost, and aging population. It is projected by 2030, 25% of Singapore population will be aged 65 years and above. There is a need for NLB to reduce its reliance on manpower to manage the library operations.

## **2 SMART OPERATION ROADMAP**

In 2015, NLB embarked on a 5-year Libraries of the Future masterplan which aims to transform library services and operations to serve customers better. Guided by the smart operation roadmap, technologies and robotics are introduced to reduce the mundane and routine work, so that library staff can focus on providing higher value work to serve the community. The key transformations include: - Autosorters and shelf-reading robots are deployed at all libraries to handle the more repetitive tasks. This has increased efficiency, reduced human error and lowered the operation cost in the long run. - Operation workflows are simplified and streamlined, resulting in shorter learning curve for staff and volunteers. - Staff no longer station at the library counters, but are empowered to rove within the library to serve patrons as needed. The various automation initiatives have resulted in cost saving of S\$1.9 million annually.

The key automation initiatives rollout in the recent years are:

### **2.1 Shelf-Reading Robot**

The Shelf-reading robot autonomously scans the book shelves after the library closes and detects the RFID tags embedded in the books. The system uses a self-localisation algorithm to analyse the digital data collected against the library's collection database to identify mis-sequenced books, missing books, and books that belong to other libraries. This removes the need for full-library shelf reading as library staff need only attend to the mis-shelved books, which is about 5% of the library collection. Most importantly, it addresses the perennial customer complaint of not able to locate a book in the library. The item locations collected from the daily scan are integrated with the library catalogue. This enables customers to self-help and locate the library books faster without the need to understand the library shelving standards, e.g. the Dewey Decimal Classification system.

### **2.2 Auto-sorter**

The Autosorter processes books returned at the bookdrop and facilitates the automatic sorting of the returned items into bins based on pre-defined categories. Manual intervention is required only for exception items, which is about 1% of the returned items. This has improved productivity, and achieved a high level of accuracy in terms of the returned items being sorted. Using analysis results of past loan records, the autosorter also identifies popular items for library staff to place at "Just Returned" shelves at the entrance of the library so that library users can easily locate them.

## **2.3 Mobile Bookdrop**

When the Tampines Regional Library (TRL) re-opened in August 2017, most patrons preferred to access the library from the secondary entrance which was closer to commercial facilities. This became a point of frustration for patrons as they had to walk the distance the length of a football field to the main library entrance to return their books. An autonomous bookdrop was designed to address the issue. The autonomous robot is able to carry a large volume of items (about 2000 books per day) and transports them back to the sorting room. The system improves productivity and eliminates the need for staff to spend time walking across the library to collect the items. It also enhances workplace safety by reducing the need for staff to carry heavy items across long distances.

## **3 CHALLENGES WITH ROBOT IMPLEMENTATION**

The implementation of robots in libraries has its unique challenges. The lessons learnt in NLB's journey could benefit other libraries that are considering to deploy robotics. A key success factor is to have realistic expectation of the robotics technology. While robots have been widely used in logistics and manufacturing industries, use of robots in retail and service points are still in the preliminary phases.

Below are some lessons learnt from the recent shelf-reading robot implementation:

### **3.1 The quest for perfection**

RFID technology has its limitations - 100% detection is hard to achieve due to the environmental factors, e.g. metallic shelves, reflective book covers, weak tags and irregular shelf configuration that impose navigational challenges. For NLB's implementation, the robot was able to meet the library operation needs with 99% detection accuracy. Libraries should not wait for a perfect solution before considering for deployment.

### **3.2 Robots replace humans**

It is not a question of robots replace humans, but how humans work alongside robots to complete the tasks. Workflows need to be re-designed to maximise the productivity. For example, the shelf-reading robot has proven to detect misplaced items better than library staff, however, it is unable to pick up the mis-shelved items and put them back to the right shelf. Thus, the robot is deployed to scan the shelves, and hands over to the library staff to act on the mis-shelved items reported by the robot.

### **3.3 All-purpose robots**

Ideally, everyone wants to have a robot that can rove around the library, scan the shelves, re-arrange books, carry out surveillance check and report on abnormal behaviors, or even clean the floor carpet. The robot technology today is built to do one or two tasks well. Thus, it is important to manage stakeholders' expectations on the robot capabilities.

### **3.4 Plug and Play**

Libraries are designed for users, not robots. There is a need to modify the environment to be robot-friendly. Site survey and preparation is crucial to ensure a successful deployment. This includes removal of obstacles in the robot navigation path, reconfiguration of shelves and appropriate positioning of books.

### **3.5 Robots can throw tantrums too**

Robots are best doing what they are programmed to do. NLB has a fair share of strange encounters during the robot deployment. For example, the robot navigation was disrupted by books fallen off the shelves, robot bumping onto glass walls and fell off steps. Robot may need to be enhanced with more proximity sensors and re-programmed to handle new situations or environments. In addition, robots need to be serviced regularly to ensure optimal performance.

## **4 PROCESS AUTOMATION PLAN**

Libraries should first map out their business process automation strategy, and plan the execution in stages. This provides clarity on how the deployment of robots can help to achieve the overall process automation outcomes. Key success factors of robot deployment are:

### **4.1 Strategy**

What problem are you trying to solve? Does it enhance user experience or staff productivity? Only when the problem is clear, then consider what technologies can be applied to solve the problem. In 2014, NLB formed a taskforce to look into the process from book returned until it is placed back to the shelf. After validating with the stakeholders, the project's focus was re-prioritised to reduce the cost of shelving books, instead of looking at improving the efficiency of the current process. This enabled the project team to focus on high-volume, repetitive tasks that are handled manually.

### **4.2 Approach**

While testing out technology-based ideas, NLB employs a rapid prototyping approach called Proof-of-Concept (PoC), through which NLB could safely and economically assess the viability of an idea by developing small-scale projects. By maximizing time and resources within a limited period of time, the PoC approach helped NLB to evaluate the viability of ideas and to minimize the financial risks they might pose. The autosorter was first piloted at library@Chinatown using roller-based conveyer belt system. Since then, an improved system with revised workflow was rollout to subsequent libraries based on the lessons learnt from the initial implementation. For the shelf-reading robot project, there was no viable commercial product when the idea was first conceptualised, Thus, NLB partnered with Institute of Infocomm Research, a Singapore research institution, to develop a Proof-of-Concept. The research engineers eventually formed a startup to commercialise the robot. The initial prototyping enables NLB to refine the solution based on lessons learnt.

### **4.3 Change Management**

Be prepared to re-think process and streamline operations, and most importantly engage the key stakeholders early to ensure a smooth transition to the new workflows. At NLB, the library operation team participated in the initial product trials, and was actively involved in the development of new workflows. The project team also provided on-site training and support during the initial deployment, ensuring even the more elderly staff are able to operate the robot.

## **5 FUTURE PLANS**

Besides autonomous robots, NLB has also embarked on other automation projects, such as Robotic Process Automation (RPA) and conversational chatbots.

RPA are software robots that mimics the activity of a human being in carrying out a task within a process. It is being used to extract daily usage data from subscribed e-resources platforms to provide timely data to inform decision making. Non-IT staff can learn quite quickly how to configure and apply RPA robots.

Chatbots are being deployed to provide real-time, automated responses to online customer queries as well as enquiries on ebooks and library events. The chatbot service uses machine learning and artificial intelligence to simulate a conversation with the user. This enables library users to self-help on simple queries and reduce the manpower required to provide customer service especially during off-peak or library closure hours.

The use of robots has gone a long way to reduce the traditional reliance on manpower. This in turn freed up officers to have their jobs redesigned to be more customer oriented and focus more on services that will benefit NLB's customers. The future workforce will be a blended workforce, not human vs machines.

### **References**

Menkhoff, Thomas and Wirtz, Jochen (2018) National Library Board Singapore: World-Class Service through Innovation and People Centricity.

R. Li, Z. Huang, E. Kurniawan, and C. K. Ho, AuRoSS: an autonomous robotic shelf scanning system, in Proc. of IEEE/RSJ IROS, 2015, pp. 61006105.