DEVELOPMENT OF AUTOMATED VISUAL TRACKING SYSTEM FOR SURGICAL INSTRUMENTS

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ABSTRACT

Surgical instrument processing is crucial for safety, high-quality surgical care but has received a little thought in the medical literature. Typical hospitals have inventories in the tens of thousands of surgical instruments organized into thousands of instrument sets. The use of these instruments for many procedures per day leads to millions of instrument sets being reprocessed yearly in a single hospital (Blackmore, Bishop, Luker, & Williams, 2013). In this project student are proposing a potential method to provide solution to the problem of errors in the processing of sterile instruments that lead to increased functioning times and costs. Automated Visual Tracking System comprised of a system on which the names and pictures of surgical instruments required for a surgical procedure are selectively displayed for reading the optically readable code mark; and a computer which stores the data about surgical instruments for the surgical procedure. The optically readable code mark on a surgical instrument is read by the reader and inputted into the computer, by which the read and inputted surgical instruments are consecutively identified on a screen, and finally the preparation of surgical instrument sets can be prepared. Development of Visual Tracking System for Surgical Instrument is to help to minimize problems that may arise in tracking instruments and to make the management become more efficient. Detection system equipment can then be used to set up a database of information about where each piece of equipment is in the right location. In particular, readers are actively or passively can provide information concerning the completeness of whether the detection system center or remotely via the electrical wiring of the existing or via a network or other system that can carry any information (Black, 1999) using a bar code requires labor -intensive steps to visit the facility with one or more mobile scanner.

ABSTRAK

Pemprosesan instrumen pembedahan adalah penting untuk keselamatan, penjagaan pembedahan yang berkualiti tinggi tetapi telah menerima perhatian yang sedikit dalam kesusasteraan perubatan. Hospital biasa mempunyai inventori dalam puluhan ribu alat pembedahan yang dianjurkan ke beribu-ribu set instrumen. Penggunaan instrumen ini mempunyai banyak prosedur dimana sehari membawa kepada berjuta-juta set instrumen yang diproses semula setiap tahun di sesebuah hospital (Blackmore, Bishop, Luker, & Williams, 2013). Dalam pprojek ini, pelajar telah mencadangkan kaedah berpotensi untuk menyediakan penyelesaian kepada masalah dalam kesilapan pemprosesan instrumen steril yang membawa kepada fungsi masa dan kos. Automatik Sistem Pengesanan Visual terdiri daripada satu sistem di mana nama-nama dan gambar peralatan pembedahan yang diperlukan untuk prosedur pembedahan yang terpilih dipaparkan untuk membaca tanda kod optik boleh dibaca; dan komputer yang menyimpan data mengenai instrumen pembedahan untuk prosedur pembedahan. Tanda kod optik boleh dibaca pada instrumen pembedahan dibaca oleh pembaca dan diinput ke dalam komputer. Pembangunan Sistem Tracking Visual untuk Instrumen Pembedahan adalah untuk membantu untuk mengurangkan masalah yang mungkin timbul dalam instrumen pengesanan dan membuat pengurusan menjadi lebih cekap. Satu sistem pengesanan peralatan kemudiannya boleh digunakan untuk menyediakan pangkalan data maklumat mengenai di mana setiap peralatan terletak di lokasi yang betul. Secara khususnya, pembaca secara aktif atau pasif boleh memberi maklumat berhubung dengan kelengkapan sama ada sistem pengesanan pusat atau jauh melalui pendawaian elektrik yang sedia ada atau melalui rangkaian atau sistem lain yang boleh membawa apa-apa maklumat (Black, 1999) penggunaan kod bar memerlukan buruh langkah -intensive untuk melawat kemudahan itu dengan satu atau lebih pengimbas mudah alih.

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First and foremost, I thank Allah S.W.T for the strength in completing my Research Project for this semester 2, 2015/2016. After so many months of hard works in completing this Research Project, it finally comes to a day of expressing my gratitude to a number of people. I would like to extend my highest appreciation and gratitude to the University of Malaya for providing me with a good environment and facilities to complete this project.

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CHAPTER 1: INTRODUCTION

Healthcare setting nowadays, there are hundreds of instrument sets containing thousands of dissimilar types, designs, and sizes of instruments that are used in surgical procedures. As the number and selection of instruments used in surgery has increased throughout the years, so has the cost of these instruments. In addition, surgical cases and the need for a set have contributed to the need to improve the management and control of surgical instruments. The quality of procedures can be better handled and tracked avoiding the need to routinely flash instruments. The volume, high cost of surgical instruments, increased turns, and limited inventory make it necessary that an effectual management system for this asset be in place to give accurate control and timely data.

Development of Automated Visual Tracking System for Surgical Instruments helps to improves clinical outcomes, smooth workflows and optimized surgical instrument tracking and management.

A more receptive, well-organized and precise healthcare supply chain will decrease errors, process time and cost and allow healthcare professionals to provide an even advanced quality of patient care.

Understanding utilization rates allows for optimization of instrument inventory. Measuring quality levels for accuracy and compliance are consistent with the objectives of infection control and risk management.

Due to the design of surgical instruments and their costs, which can amount to tens of thousands of dollars per instrument, instruments cannot be thrown out and repurchased after each surgery (Swanson, 2008). Rather, they must be collected, decontaminated, sterilized and organized into surgical kits in preparation for the subsequently operation.

1.1 Project Background

By taking advantage of bar coding, wireless, and web-enabled capabilities, Automated Visual Tracking System allow us to find and view count sheets, record and emphasize exceptions to instrument sets, and print count sheets and barcode labels, including exception labels. Count sheet management capabilities allow us to edit items and count sheets with version control, and connect count sheets with sole trays. With tray and instrument tracking, we can locate trays using any online computer, track trays and peel packs as they are moved, and track individual instruments.

Sterilization and decontamination management lets us record sterilization contents, load results, and biochemical test information and receive warnings about incorrect sterilization procedures. The case picking feature helps you assign trays to cases and case carts while you capture and verify tasks with barcode scanning.

The proper sterilization of medical devices, surgical instruments, supplies and equipment utilized in direct patient care and surgery is a critical aspect of the modern health care delivery system and directly impacts patient safety. The Association for the Advancement of Medical Instrumentation (AAMI) defines sterilization as: A process designed to remove or destroy all viable forms of microbial life, including bacterial spores, to achieve an acceptable sterility assurance level. Reusable medical devices, including surgical instruments that enter normally sterile tissue or the vascular system require sterilization before each use. Improperly sterilized or contaminated medical devices utilized in patient care can contribute to surgical site infection and pose a serious risk to the patient's safety and welfare and can result in a serious life threatening infection or even death.

The Department of Health of United Kingdom has suggested that the tracking system of standards should be adopt all over the healthcare system. For example, this would include individually marking instruments and trays, patient identification numbers on wristbands and batch numbers on medicines. To support this initiative, the Department of Health has published a policy position backed by an action plan to support both the NHS and the medicines and devices industries in realizing the benefits for patients. (Lawrence, 2011)

A surgical instrument list for the surgical procedure is stored in a computer. The bar code or other symbol is read with a reader and inputted into the computer, by which surgical instrument is compared with the surgical instrument list stored in the computer.

A huge number of surgical instruments are used in hospitals. Particularly in recent times, advances in medical technology have made highly sophisticated surgical operations possible. As a result, the type and number of surgical instruments used for surgical operations has increased greatly as compared with conventional ones. The management and preparation of such a huge number of these surgical instruments requires much labor.

With this configuration, a picture of a set of instruments in accordance with a surgical procedure is displayed on the screen, and the surgical instruments are inputted into the computer by means of the reader. Then, the inputted surgical instruments are identified on the screen, and finally the completion of preparation of surgical instruments is confirmed on the screen. The list of surgical instruments can include linens, disposable supplies, medicines, and large-size machines. They can be incorporated as surgical instruments by the hospital when the system is adopted so as to be displayed as necessary surgical instruments on the screen.

1.2 Problem Statement

The unavailability of the required surgical instruments at the start of a procedure is undesirable. It causes delay and pressure in the operating room (OR), which can direct to additional risks for the patients. Issues with availability of surgical instruments may become visible just before the start of the procedure but are induced earlier in the delivery process. Therefore, efficient and safe supply chain management is essential.(A. C. Guédon et al., 2016).

The goal of this project was to reduce the missing instrument rate by focusing on specific areas identified as root causes of defects that are currently occurring in the Sterile Processing Department. A defect is defined as any surgical kit variation that could result in the kit being unstable and requiring that a new kit be used in an operation. Defects originate from the Sterile Processing Department, but are recorded in the operating room. The most common causes of defects were kits missing instruments. A missing instrument is defined as anytime a required instrument is not located in a kit during the time of an operation. Because missing instruments comprised such a large component of the total defect rate, this project focused specifically on mitigating the causes of missing instruments. The missing instrument rate is measured by the percent of surgeries in which a missing instrument is recorded. The initial missing instrument rate for January - August 2013 stood at 9% and the goal of this study is to reduce the rate by approximately 20%.(Young, 2014).

Each project that was completed had the intention of either directly or indirectly supporting this goal. Figure 1-1, shown below, tracks the number of missing instruments per week from August – December 2013.(Young, 2014)

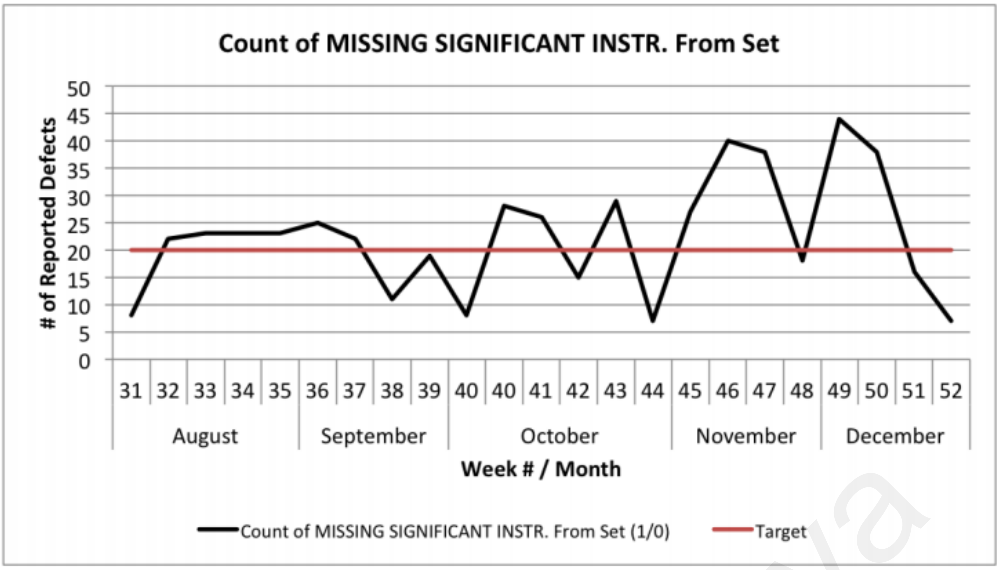


Figure 1-1: Missing Instruments per week at The Academic Medical Center

These data shows that the number of missing instruments processed each week did not change significantly over time. The variance in the number of missing instruments increased over time. It is important to note that this metric is not a direct representation of the missing instrument rate, which takes into account the number of surgeries.

As shown in the root cause analysis, the missing instrument rate is caused by a great number of factors. The next two sections delve deeper into first, able to support the reduction of the missing instrument rate, and second, what major root causes of missing instruments have yet to be addressed.

Lack of inventory was seen to be a problem because kits were sometimes assembled without the full set of instruments. Many times this occurred because a particular instrument either could not be found or did not exist in the inventory of the department. Ensuring that there was enough inventories available to assemble all kits would reduce the missing instrument rate.

1.3 Objectives

The objectives to being achieved are to propose a system called Advanced Surgical Instrument management system that is capable of improving the management in surgical instrument and improves tracking the instruments and checking the inventory within a facility in the hospital.

Hospitals face regular challenges to ensure that the correct instruments are obtainable when and where they are needed. Advanced surgical instrument management software can help to make sure a quality throughout the lifecycle of your instruments and surgical trays. Automated Visual Tracking System for Surgical Instruments can help to improve service to the clinicians and patients, increase staff performance, and lower instrument costs.

1.4 Scope of Project

Scope project in this research project is for developing a web-based system that is capable of detecting the barcode on the instrument tray. It is a preliminary system to be improved upon further in the future.

CHAPTER 2: LITERATURE REVIEW

A previous study has shown that there is a large amount of hazards throughout the entire delivery process of surgical instruments (L. S. Guédon et al., 2015). The unavailability of surgical instruments represented around 40% of equipment-related incidents in the OR (Wubben, 2010) (Weerakkody et al., 2013) Each occasion induce an regular of 12 min of additional work for the OR team and 5 min of delay,(Wubben, 2010) and moreover, it increases the potential for errors in the OR.(Arora et al., 2010) (Tucker, 2004) The importance of having sterilized surgical instruments available on time for each procedure shows the need for a high quality Supply Chain Management.(A. C. Guédon et al., 2016)

In order to analyze the root causes of the missing instrument rate in the Sterile Processing Department (SPD), it was important to know more about the following areas: sterile processing, ergonomics, Lean improvement and case studies of Lean improvement in hospitals. The literature review concludes with a discussion of how work on this project compared to similar sterile processing improvement projects that have been previously undertaken, in other healthcare organizations.

2.1 Sterile Processing Departments and Standards

A surgical kit is a collection of tools that can be used to aid a surgeon in the performance of a surgery (Rozbudd, 2010). A surgical instrument is a specific tool that a surgeon can use in a surgery for a particular purpose. There are thousands of different surgical kits available and each kit may contain hundreds of different instruments.

Furthermore, a single instrument of one size could have many varieties based on which edges are sharp, what direction the blades curve if at all and how much of the tip of the instrument has ridges. Most instruments used in operations are made from stainless steel at operating grade quality. Before being brought to a hospital for use, instruments undergo a passivation process to reduce the likelihood of rust because stainless steel can actually stain. Through repeated sterilization, instruments are oxidized which further passivated them, reducing their likelihood further of rusting (Sloyer, 2012);(Rozbudd, 2010).

Instruments are available in four main finishes: satin, mirror, matte or non-glare (Rozbudd, 2010) Satin and matte instruments are dull to the eye so they do not cause glares in the operating room, but these instruments are more likely to rust. The mirror finish can reflect in surgery and cause distractions for the surgeon, but it is less likely to rust. Non-glare instruments are used specifically in laser surgery where it is important to keep heat concentrated in one specific area.

The work of any sterile processing department begins right away following the transportation of kits used in an operating room case (Sloyer, 2012). Before sterile processing can begin, kits that were used in a surgery must be moved from the operating rooms to the sterile processing department. The instruments are typically sorted and placed into closed containers by members of the operating room staff at the completion of an operation and are then be moved on a covered cart to the sterile processing department.

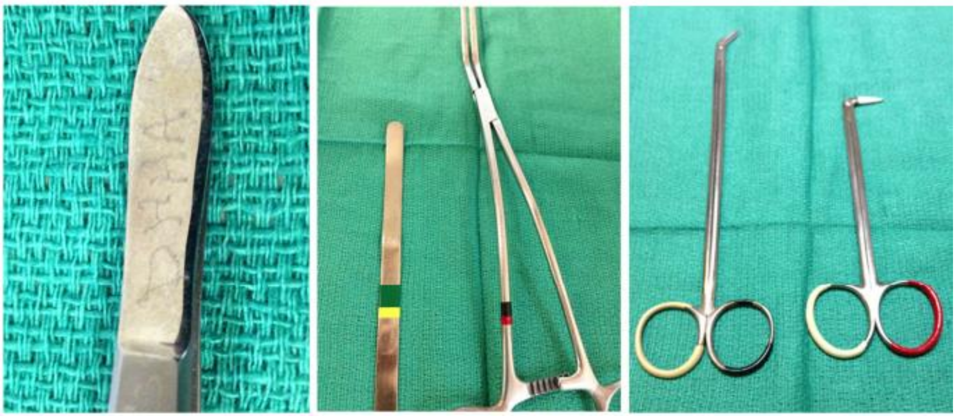
2.2 History

The specialization of surgical practice exponentially increased the amount of instruments a modern surgical center utilizes. It has been calculated that a surgical center maintains at any time several tens of thousands of instruments and that each center on average processes millions of instruments per year.(Blackmore et al., 2013) .

Instruments are transported between surgical suites and sterile processing units and may be shipped to satellite facilities of major institutions. The proper labeling of instruments is essential to identify each tool, to restock instrument sets and to maintain oversight of instrument stock.(Ipaktchi et al., 2013)

Traditionally, instruments have been identified by various engraving and etching techniques Figure 2-1 (a). Given the subtleties of finer surgical instruments and the demand for smooth surfaces, this crude form labeling has been largely abandoned in the last decades in favor of tape labeling or plastic resin dipping of instruments Figure 2-1: (b) and (c). These techniques leave the instrument surface intact and add the benefit of color coding. There are several downsides to this practice which have been in part discussed in literature (Samit & Dodson, 1983).

Any mechanical labeling of an instrument needs to be supervised by a professional surgical technologist to ensure proper label application. The label must withstand the mechanical load of intraoperative utilization as well as the physico-chemical challenges of cleaning and sterilization cycles. In addition to time and resources spent initially labeling the tool, there needs to be continuous maintenance to insure intactness of the label.



(a) (b) (c)

Figure 2-1: Traditional Instrument Marking

2.2.1 Previous Work

Manual instrument management systems are certainly a way to start. In the past it was the only option and these may work for smaller healthcare facilities and surgery centers. However, a manual inventory system takes a considerable amount of time and effort to maintain. Keeping manual logbooks where all processed instrument trays are listed and tracked is time consuming and labor intensive. There is a chance for error. Additionally, retrieving information from a manual system is difficult, as there are volumes of paperwork to look through before data can be complied and analyzed.

When there are many instruments, it is even more difficult to maintain accurate control with the manual system. It is also a challenge to consolidate information from the records to generate needed and valuable reports that are useful to enhance the operation of the department.

Organization and standardization of trays, color-coding, labeling, and instrument count sheets are a few solutions that can help manage the process. There are products currently on the market such as sterilization containers that provide organization and secure containment of surgical instruments. These container systems provide a location for the identification of set name or service, load card information for the sterilization record, and options to customize and standardize sets.

Surgical instrument storage and sterilization systems are identified. These systems, sometimes referred to as surgical instrument trays or surgical instrument kits, normally consist of metal or plastic trays that hold a diversity of general point and procedure specific surgical instruments such as forceps, scissors, clamps, retractors, scalpels and many more.

These trays are brought into the operating room (OR) when preparing for surgery, and also are used as a means to organize, transport and store surgical instruments in a medical facility.

2.2.1.1 Assembly

After the instruments have been cleaned and inspect, they are naturally assembled into sets or trays according to recipe cards that detail commands for assembling each set or tray as shown in figure 2-2.

Figure 2-2: Assembly of surgical instruments into sets

Instruments and other items that are prepared for sterilization must be packaged so that their sterility can be maintained to the point of use. The materials and techniques used for packaging must allow the sterilant to contact the device during the sterilization process as well as to protect the device from contamination during storage and handling before it is used. The time between sterilization and use may range from a few minutes to several weeks to many months. The packaging material selected must also permit the device to be removed aseptically

2.2.1.2 Old Packaging in Sterilizing Process

Place instruments in pouches. Once the instruments sorted, need to place them in sterilized pouches that can go into the autoclave. Use special autoclave pouches designed to withstand the high temperatures of the autoclaves. The pouches have a strip of test tape that changes color when the autoclave process is effective. Take each pile of instruments sorted and place them in as many bags as necessary. (Fulghum, 2012). Results from a survey from visits to several hospitals in Malaysia, 70% of hospital in Malaysia still use pouch packaging and 20% of hospital already use rigid container system.

2.2.1.3 Laboratory operating procedure for surgical sets

A protocol for the microbiological examination of surgical packs was developed according to previous studies.(Widmer, Houston, Bollinger, & Wenzel, 1992), (Webster, Radke, George, Faoagali, & Harris, 2005). A level 1 laminar flow cabinet with high-efficiency particulate air (HEPA)-A filtration in a category 3 area was disinfected before and after examination of packs. Airflow was checked and then allowed to run for 3 min before placing five settle plates at the front, middle and back of the cabinet work surface.

2.2.2 Present Work

A personnel then may load the shipping totes into a vehicle thereby reducing the number of manual operations that must be performed. Before transporting each shipping tote, a barcode shipping label is sometimes prepared that identifies certain information such as the point of origin, the destination, and possibly the contents of the tote, the identification number of each surgical instrument tray contained in the tote. The barcode label allows the tote to be easily and efficiently tracked and entered into inventory at the receiving facility.

Over time, and through ordinary usage, as well as due to rigors of the sterilization process, surgical instruments suffer wear and tear and eventually reach the end of their life cycle. Thus, it is necessary to periodically inspect and maintain records on usage of surgical instruments so that they can be replaced as necessary.

Also, due to the fact that they are constantly moved from the operating room to sterilization, to storage through processing facilities, and back to the operating room, various instruments on a given tray may become lost. Because certain instruments are so specialized that there are no functional substitutes, it also has become necessary to regularly inspect trays for any missing instruments and to readily identify specific instruments that are missing.

Existing methods for performing these necessary functions are overly reliant on costly human interpretation. Also, in some cases, a skilled technician may be required to identify missing instruments.

Different hospitals have different tracking practices ranging from manual systems to automated systems. Some track instruments at tray or group level while others track them at individual instrument level. A number of studies have been done investigating the management of instruments highlighting the following:

Different hospitals have different tracking practices ranging from manual systems to automated systems. Some track instruments at tray or group level while others track them at individual instrument level. Currently very few manufacturers mark instruments for hospitals with a globally unique identifier and those who do often have used proprietary identification systems. A number of hospitals have implemented AIDC-supported systems, with some marking individual instruments. Below are some of the key findings from a recent survey of the systems used for surgical instruments tracking:

2.2.2.1 Need for traceability

It is important that systems are in place to allow sets of surgical instruments to be tracked through decontamination processes in order to ensure that the processes have been carried out effectively. Systems should also be implemented to enable the identification of patients on whom the instrument sets have been used. (Lawrence, 2011)

The introduction and use of sterile services super centers will increase the need for better traceability systems as the services will be out-sourced to third parties who may be handling instruments from different hospitals. A hospital using the decontamination services will need to know that it is getting the same instruments that it sent out for processing.

2.2.2.2 Management of valuable assets

With surgical supplies among the highest expenses in the hospital inventory, accurate instrument tracking is key. Lost instruments can cost a 500-bed hospital an average of over RM100, 000 per year. Problems with instruments are amongst the ten most frequent causes of operating theatre delays. These delays, due to incorrectly assembled or unavailable instrument sets, cost an average of RM5000 per hour.

2.3 Review of History

2.3.1 Surgical instrument identification and traceability

Re-usable instruments go through a cleaning and maintenance lifecycle shown below that can be performed by the hospital, another hospital or specialized third party. In the Malaysia, there is an increase in the use of specialized centers commonly known as super centers.

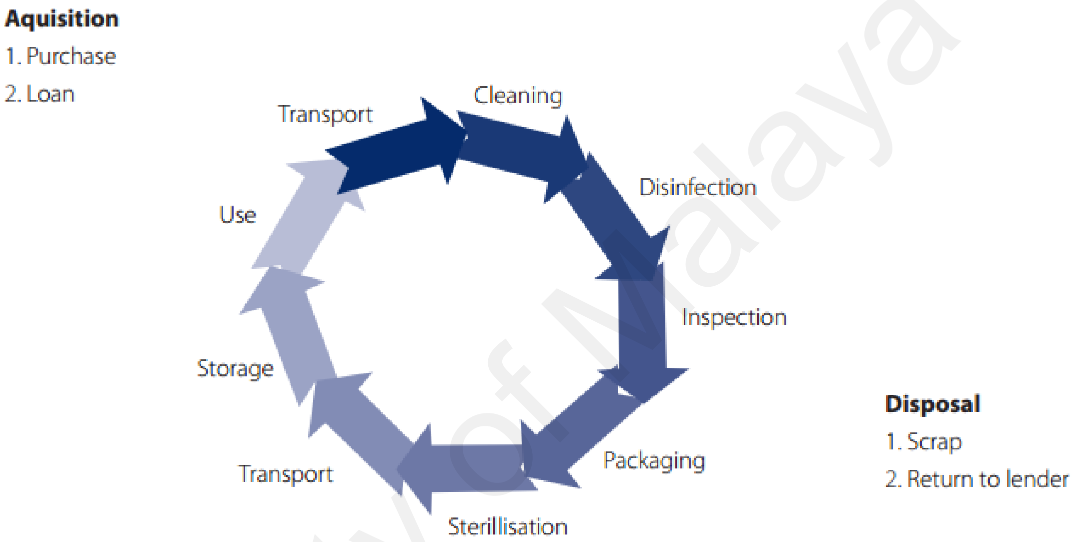


Figure 2-3: Surgical instrument maintenance lifecycle. (Shipp, 1994)

Before a re-usable surgical instrument is used for the first time, it goes through a number of processes including packaging, sterilization, transport, storage and use. During the re-use cycle, it goes through a decontamination process which involves cleaning, disinfection and inspection. This means that there is a need to keep track of where the items are in the decontamination process and to guarantee that the instruments have gone through the correct process.

2.3.2 RFID Tag System

Radio-frequency identification ("RFID") tag systems have been proposed for use in inventory tracking. In such a system, an RFID tag is attached to an object or location, and contains a non-volatile memory for storing information identifying the object or location and electronic circuitry for interacting with an interrogator. RFID tags may be passive or active. In the case of a passive RFID tag, the tag includes circuitry for converting at least a portion of the received RF signals into electrical power needed by the tag for signal processing and transmission.

In a typical conventional system, RFID tags containing information associated with the identities of inventory items to be tracked are attached to the inventory items. An RFID interrogator is used to detect the presence of an RFID tag and read the identification information from the tag. A typical RFID interrogator includes an RF transceiver for transmitting interrogation signals to and receiving response signals from RFID tags, one or more antennae connected to the transceiver, and associated decoders and encoders for reading and Writing the encoded information in the received and transmitted RF signals, respectively.

The interrogator may be a portable device, which can be brought near the tags to be read, or it may be a stationary device, which reads the tags as they are brought to the interrogator, as in the case of tagged library books being returned to a return station that is fitted with an interrogator. RFID tags may also be affixed near a location as a location marker. After detecting both a tag attached to an inventory item and a location marking tag, a processing unit associated with the interrogator may determine that the inventory item is positioned near the tagged location.

While these conventional object tracking systems are capable of keeping a record of the inventory items and sometimes their locations, they are not effective for tracking and/or managing the movement of the inventory items. (Francis, McGee, Sainati, Sheehan, & Tong, 2003)

2.3.3 Electromagnetic (EM) Tracking Systems for Tracking Surgical Instruments

For minimally invasive surgical applications, noncontact optical and electromagnetic (EM) tracking systems have been traditionally favored. While both of these approaches provide high-quality pose information, they also tend to be expensive, with costs that can be prohibitive for schools, clinics and hospitals.

EM tracking systems resolve position and/or orientation by sensing the strength and direction of an artificially generated magnetic field. The Aurora (Northern Digital Inc.) and LIBERTY (Polhemus) are commonly used for medical applications. Capable of sub millimeter accuracy and low latency, EM technology has become the gold standard noncontact tracking solution, where accessibility or line-of-sight restrictions render other approaches infeasible. However, for proper operation, the environment must be free from magnetic and ferromagnetic material. Optical trackers operate by detecting fiducially markers (unique features attached to the object to be tracked) in images and relating the position of these markers to the coordinate frame of one or more cameras (typically two).

Some of the more common stereoscopic optical systems used for medical device tracking include the Polaris Spectra by NDI and the MicronTracker 3 by Claron Technology. These systems offer accuracy several times better than EM tracking solutions across a larger operating volume and are immune to EM radiation.

Unfortunately, optical systems tend to be slower and are prone to occlusion. An alternate approach that uses only the endoscopic video feed to track instruments with special markings on the shaft is presented in (Trejos, Lyle, Escoto, Naish, & Patel, 2010). No additional hardware is required for this method making it widely accessible; however, it can also suffer from occlusion and fails completely when the instrument is out of the camera field of view. (Bracken & Naish, 2015)

CHAPTER 3: METHODOLOGY

3.1 Introduction

Each type of surgery requires a certain set of sterile surgical instruments, organized in multiple instrument trays. Specific instruments can also be packed individually. After use in the OR, the instrument trays are sent back to the Central Sterilization Service Department (CSSD). Then the instrument trays go through the sterilization process (which consists of cleaning, disinfection and sterilization) and are delivered back to the OR in a sterile packaging, ready for the next procedure. Instrument trays are usually delivered to the OR directly after sterilization and stored in a dedicated room at the OR complex. Sets of instrument trays specifically needed for each surgery are collected and prepared prior to surgery, mostly by OR personnel. Besides the fact that this entire process of sterilization, delivery and use of surgical instruments is time consuming, it also represents an important aspect of performing safe surgery.

An equipment tracking system can then be used to maintain a database of information on where each piece of equipment is located. Specifically, the readers may actively or passively feed information concerning the equipment to either central or remote tracking systems via the existing electrical Wiring or via other networks or systems capable of carrying such information (Black, 1999) the use of bar codes can require the labor-intensive step of touring the facility with one or more portable scanners.

3.1.1 First Implementation

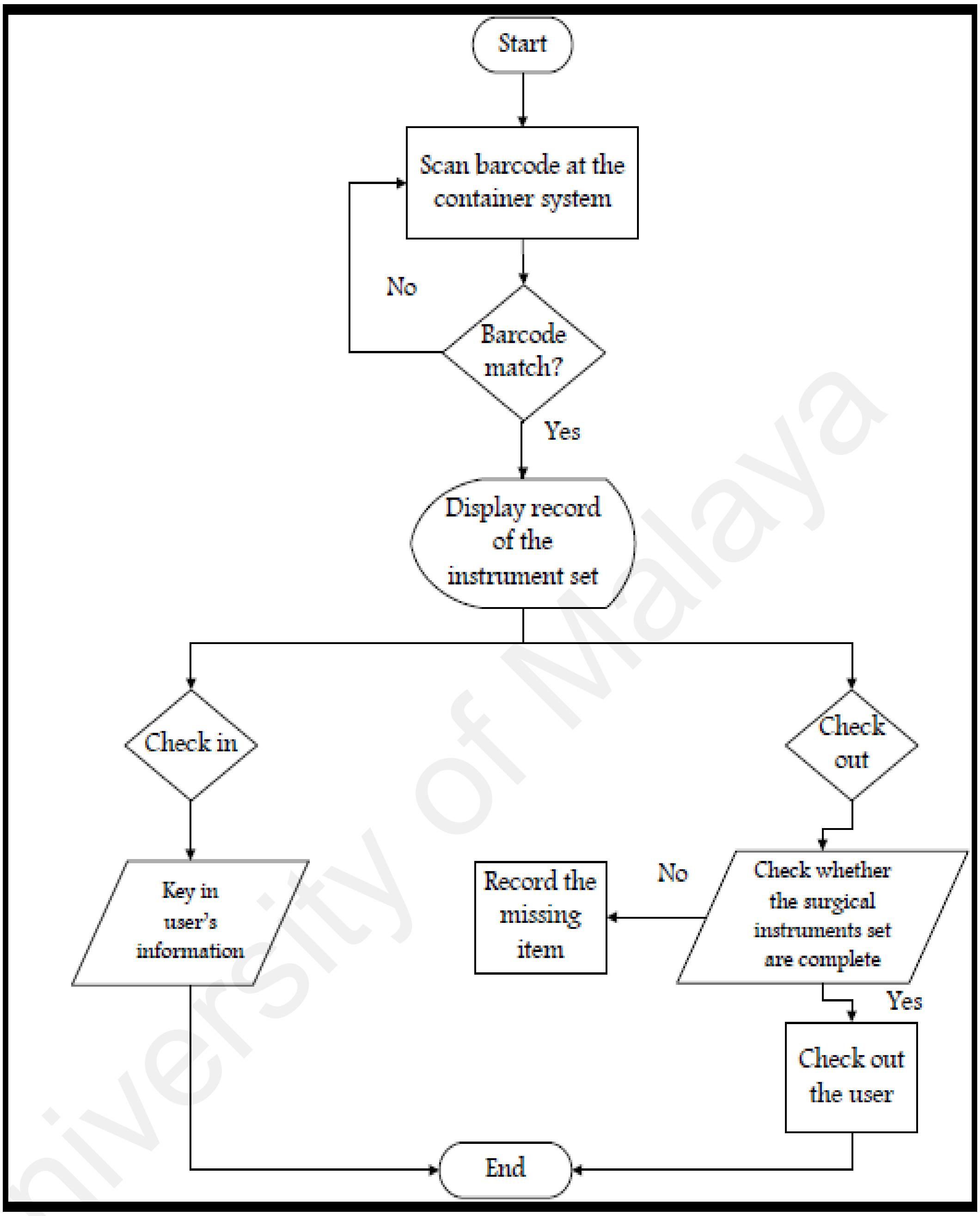


Figure 3-1: Flowchart of project

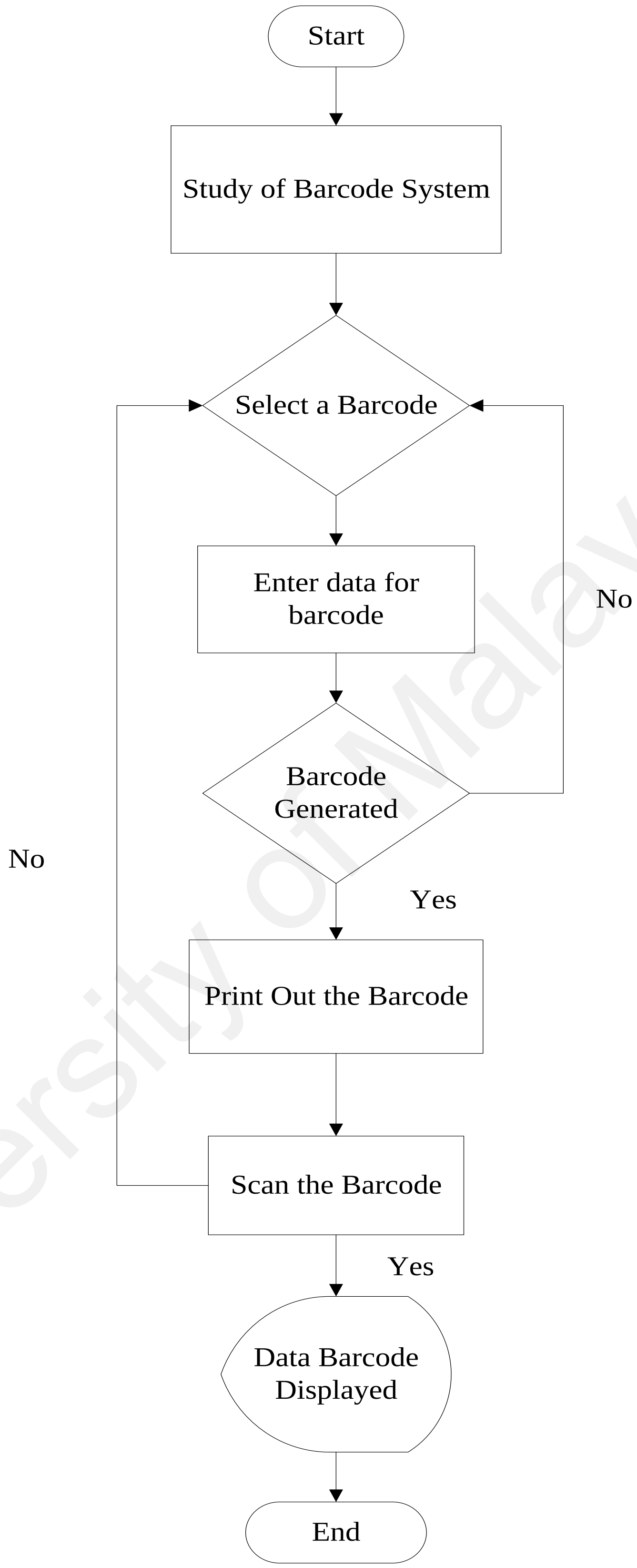
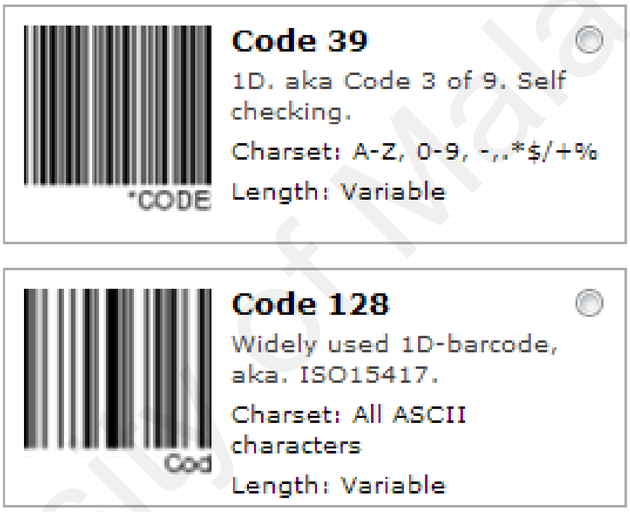


Figure 3-2: Flowchart of generating barcode

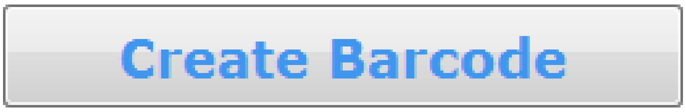
Figure 3-2 shows the flow of generating the barcode. Before the barcode was generated, student has to study about types of barcode and what kind of barcode that suitable used for sterilization. The barcode has been generated by using http://www.barcode-generator.org/. It is very simple program to generate a barcode by following a few steps:

1. Choose what kind of barcode that suitable for the container system. The Code 39 and Code 128 were selected.



2. The data of barcode was entered in the box that provided as shown in figure below. The size or data also can be set whether small, normal, large and very large.

3. The button of "Create Barcode" was pressed to proceed the process of generating the barcode



4. When the input is valid, the result barcode for input data was produced as shown in figure below. The image was save to my computer by right click and save as.

5. The barcode was printed out to test the functionality of the barcode whether the scanner can be detected or not.

6. The barcode was tested by using a LS1203 USB LASER BARCODE and notepad.

7. The scanner was successfully detected the barcode. When it scans the barcode, the output data of barcode will display to notepad.

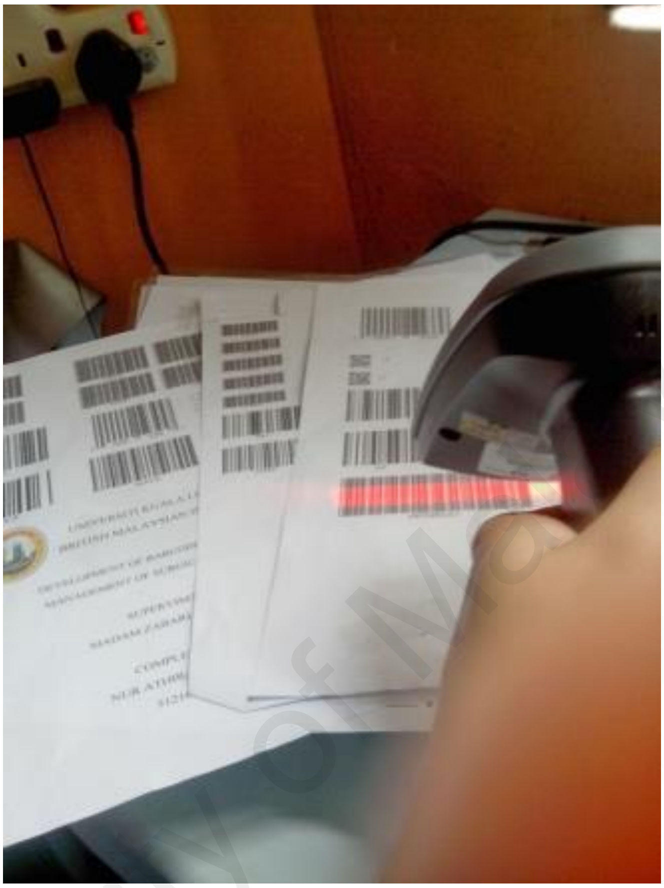


Figure 3-3: Scanner detects the barcode

3.2 Block Diagram

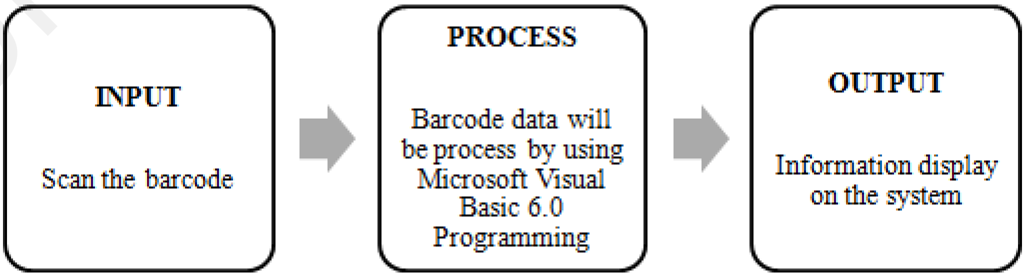


Figure 3-4: Block diagram of research project

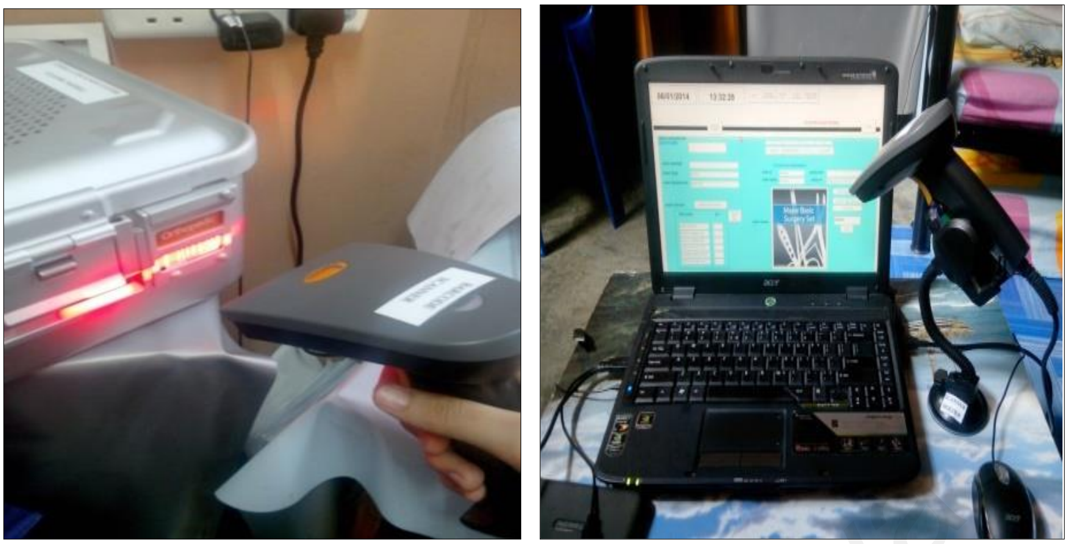


Figure 3-5: Prototype of the tracking system

The block diagram as shown above is the process of the Development of Automated Visual Tracking System for Surgical Instruments. The process of this project was divided into 3 parts which are input, process and output.

For the input part, the barcode at the sterile container system need to be scan by using Argon AS8120 Mid-Range CCD Scanner. Then the Microsoft Visual Basic 6.0 will process the data of barcode that has been generated before. The barcode was generated by using Code 39. This code 39 are already tested and found that it is match to scan and suitable for management.

When the barcode has been scanned, the output will display on the program as shown in figure above. All the information about surgical instruments set will automatically display. So, we just register the name of user, ID and their status whether check in or check out.

3.3 Hardware

3.3.1 Sterile Container System

Figure 3-6: 1/2 Half size of Classic Model

Figure 3-7: 1/1 Full size of Classic Model

The Sterile Container System manufactured according to high quality, level of international standard and workmanship. In dependable position, the containers can be put on top of each other’s without descending over the side as shown in figure.

3.3.2 Security Seal

Figure 3-8: Security Seal with number (Blue)

- The security plastic seals will be broken upon the lock is opened and this action makes it possible to follow up the sterilization process.
- Security seal, made of plastic

3.3.3 Labels

Figure 3-9: For full and half size containers and for small size and special

- Labels paper with indicator.
- Able for full and half size containers
- Able for small size and special containers

3.3.4 Colored identification labels

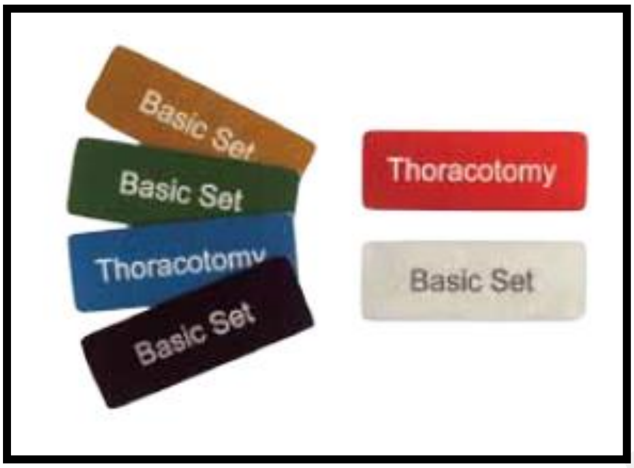


Figure 3-10: Many colors for identification labels

The Colored identification labels which give the description and the department of the sterile item are in changeable features Color fading by effect of Hydrogen Peroxide Gas Plasma on other colors Engraved to your specifications. Maximum16 letters

3.3.5 Filter retainer

Figure 3-11: Example of filter retainer

By means of the locking latches, the holders of the filters enable the filters be changed quickly. The silicon gaskets placed around the inside of the lid, enable the security of the sterilization process.

3.3.6 Silicone Mats

K2-520	275 x 125 mm
K2-529	260 x 180 mm
K2-521	250 x 235 mm
K2-527	230 x 220 mm
K2-523	300 x 300 mm
K2-524	380 x 230 mm
K2-525	440 x 230 mm
K2-528	470 x 230 mm
K2-526	520 x 230 mm

Figure 3-12: Silicon mat and its specification

Enables surgical instruments to be stored without slip and dry well. The silicon mat, for placing the micro instruments

3.3.7 Surgical Instruments

There are a lot of surgical instruments in the hospital but several of surgical instruments have been categorize by set.

Figure 3-13: Half of surgical instruments that were loan from Azym Synergy

3.3.8 Argon AS8120 Mid-Range CCD Scanner

Figure 3-14: Scanner that used in this project

The ArgoxScan can automatically scan barcode at a distance. Simply aim and pull the activate. Code scanning is performed along the center of the light bar emitted from the reading window. This bar must cover the entire code. Successful scanning shall be obtained by leaning the scanner with respect to the barcode to avoid direct reflections that impair the reading performance, especially for 2D barcode.

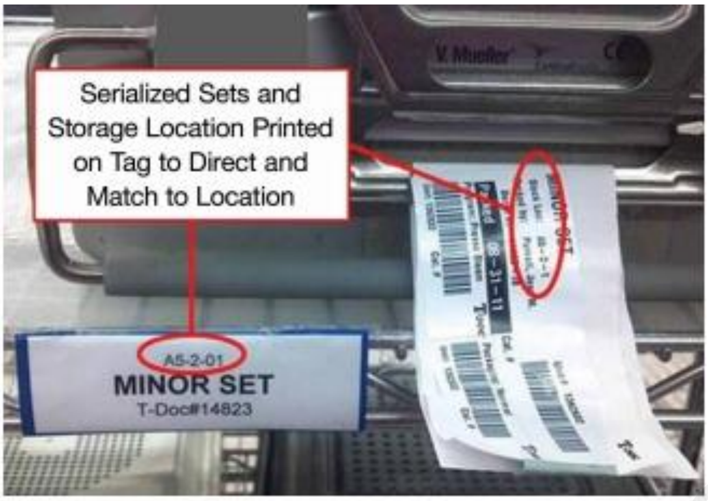


Figure 3-15: Bar code label on instrument sets

3.3.9 Label Printer

Figure 3-16: Printer that use to print the label barcode

Compact, practical, good. W&H offers awide range of accessories for optimization of the sterilization process. Minor extras lead to major results. Work in the practice is easier and your team saves time. The label printer is a quick and easy tool for linking the sterilization cycle with patient records. Dot-matrix printer for printing sterilization cycles on standard paper rolls.

3.4 Software Development

Now with a simple scan of a barcode (labeled or engraved) on the medical instruments or sterile container system allows for total traceability of who has used the equipment, when and where it was taken and when it is due to be replaced. Check-In or Check-Out instrument tracking comes in the standard editions of the software allow for data collection using cabled healthcare attached to PC workstations.

The standard edition of the Microsoft Visual Basic 6.0 software is a complete item database with the ability to use cabled barcode scanners attached to PC workstations. User can enter any inventory item or surgical instrument into the system, and then track by checking them in and out using a cabled barcode scanner. User can easily report on which items are checked out and to whom. Monitor overdue and missing items, track item usage and more.

Microsoft Visual Basic 6.0 includes unlimited computer licenses for compatible computer models. Surgical instrument tracking is made easy using barcodes. Scan or enter the ID of the person checking out an item. Then scan or enter the items they are checking out. When an item is returned, scan the item back in.

Microsoft Visual Basic 6.0 has been choose in the Development of Automated Visual Tracking System for Surgical Instrument because it is very simple software and easy to learn. Visual Basic is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model first released in 1991. Microsoft intends Visual Basic to be relatively easy to learn and use.

Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using Data Access Objects, Remote Data Objects, or ActiveX Data Objects, and creation of ActiveX controls and objects.

A programmer can create an application using the components provided by the Visual Basic program itself. Programs written in Visual Basic can also use the Windows API, but doing so requires external function declarations. Though the program has received criticism for its perceived faults, version 3 of Visual Basic was a commercial success, and many companies offered third party controls greatly extending its functionality.

CHAPTER 4: RESULTS & DISCUSSION

4.1 Introduction

4.1.1 Experimental procedure in industry

In this section, the details process of this project when it applies to the hospital management normally proceeds as follows:

Step one: Collection and transportation of contaminated items

After a medical device has been used, it is usually placed on a collection container which is collected by the sterile services department at agreed times. The items are collected and a link is made to the patient. Containers and trolleys that are used to transport items to and from sterile services also need to be tracked.

Step two: Receipt of contaminated item by Sterile Services Department (SSD)

The department receives items for reprocessing in the designated 'dirty' section of the decontamination area. Staff must check each item and notify the user if any part of the equipment is missing or damaged on receipt.

Step three: Reprocessing

The items are placed in the appropriate container for decontamination. The items are then washed by the washer/disinfector, which also dries the items following the disinfection stage of the automated process. Once the cycle is complete, the machine transfers the cleaned and disinfected medical devices into the production room. Should devices require manual cleaning only, they are cleaned in accordance with the manufacturer's written instructions prior to transfer to the production room.

Step four: Packaging and sterilization

The medical devices are wrapped in medical packaging material and the packaged products sterilized.

Step five: Storage

After sterilization, the products are allowed to cool before being stored or re-issued. A record is kept of items in storage and these items are dispatched on a 'first in first out' basis. The SSD should retain a record within the storage administrative area of items in the store and available for use. A record must be made of the dispatch of any item from this area and stock is issued on a 'first in first out' basis.

Step six: Tracking and tracing

A link needs to be made between the instruments and patients. This traceability to decontamination and sterilized equipment is made by labeling all records/documents that are used in the patient's medical records.

4.1.2 Result

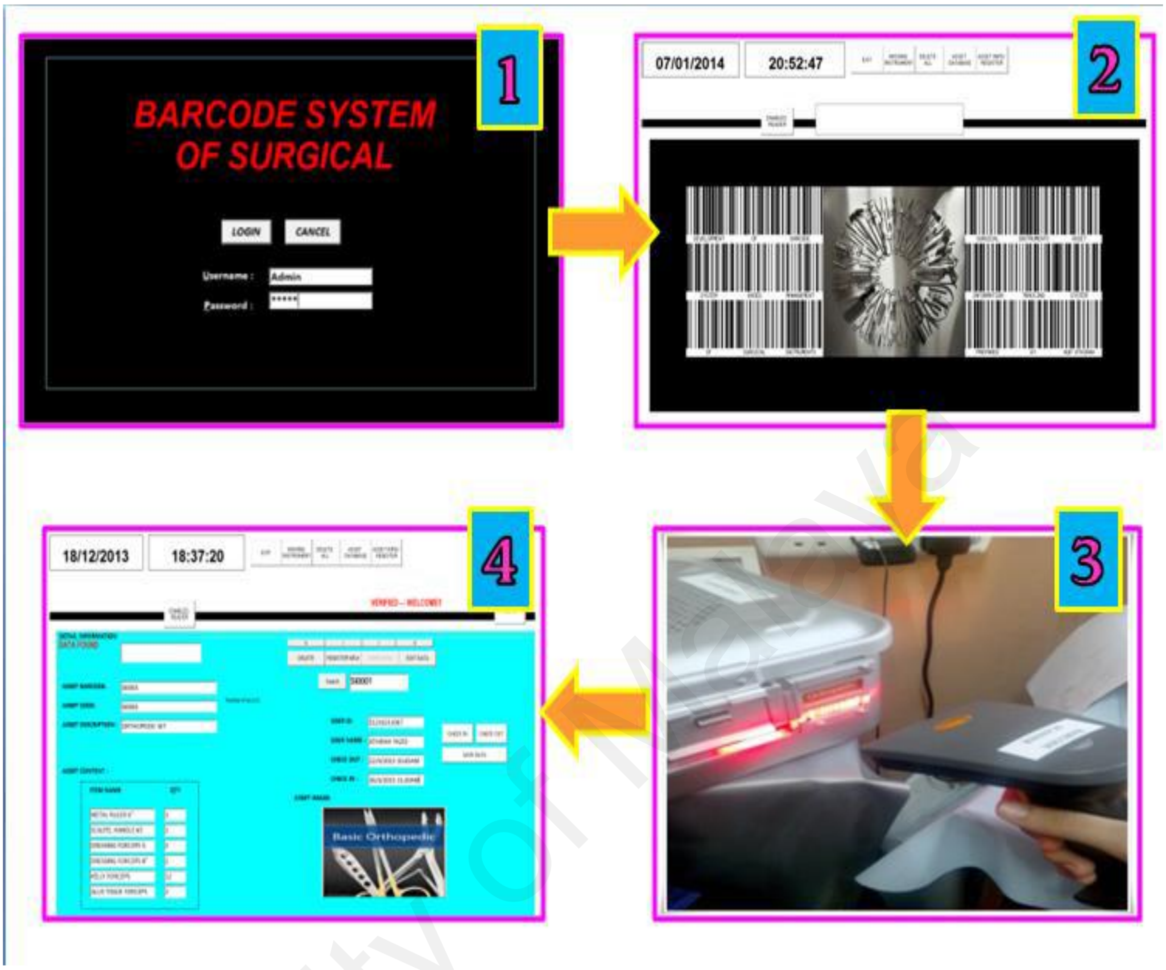


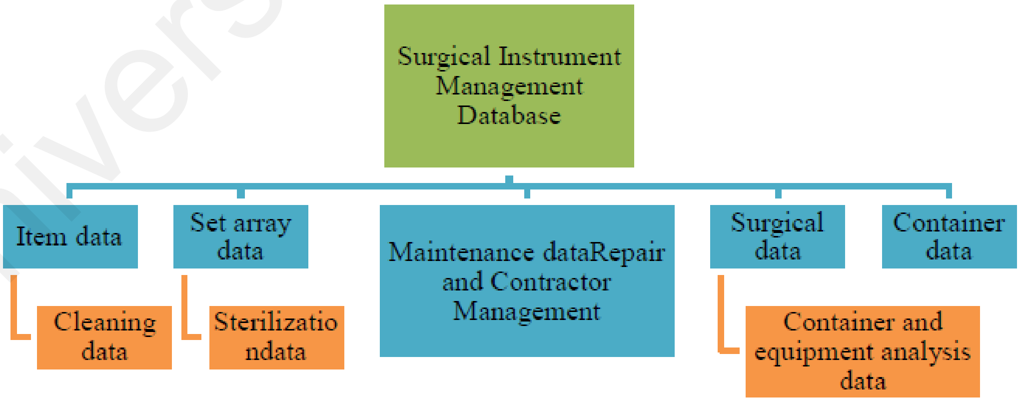
Figure 4-1: Result for overall performance

Figure 4-1 shows the result of for overall performance in Development of Automated Visual Tracking System for Surgical Instruments. The result was including of 2 parts which are hardware and software part. The procedure of this project has been followed successfully. Firstly, the software of Microsoft Visual Basic 6.0 was opened and need to log in. Only respective staff can access to the system with ID and username. Then, it will display the page which we have to scan the barcode by using Argon AS 8120 Mid-Range CCD Scanner. After the barcode was detected, it will display all the information of the surgical instruments sets. The date, time, picture and serial number of the sets are also displayed. So we just register the user n ID in the form that has been provided.

4.2 Summary

From the result and analysis that has observed, this project was successfully functioning and ready to implement in hospital management. Development of Visual Tracking System for Surgical Instrument is to help to minimize problems that may arise in tracking instruments and to make the management become more efficient. This project was function as listed below:

- ✓ Fully integrated control through the network
- ✓ Document preparation and data management
- ✓ Support for set array (Automatic deletion entry with detailed data)
- ✓ Location control of sterilized items
- ✓ Valid terms management for sterilization
- ✓ Control of use and sterilization records
- ✓ Fixed-number control
- ✓ Cooperation in ordering & checking function



CHAPTER 5: CONCLUSION

Automated instrument tracking provides the operating room staff with a dependable and precise record of the status of each surgical item throughout the surgical procedure. Also, it can cut down the time and attempt that is otherwise needed for manual process. Sources of error were recognized, and the system was evaluated under practical surgical conditions.

This project will achieve the entire objective that was state because there is a new invention of management in the hospital. If these technologies are useful to everything used, spent and wasted in the hospital, we can track forward and trace back every care and every event for each patient as a link to records. It should eventually guarantee patient safety and enable cost management in the field of health care.

Computer technology has provided opportunities for improving instrument management. Computerized inventory management systems have the capability to manage and process large volumes of data quickly and provide reports that help the healthcare facility do a better job of managing its surgical instrument inventory.

Although an automated system may need a considerable initial investment, it has proven to be a cost effectual instrument management program. When it comes to inputting data, bar coding is a valuable tool. Inputting data using a barcode system is a definite time saver over manual input as long as the information is recorded at time of use. Barcode trays and a barcode scanner provide improved tracking of instrument sets. Using a tray system that provides a location for labeling as well as the ability to bar code is a clear advantage.

Scanning ensures accuracy of data entry. Instrument sets are scanned at specific workstations in order to know the location and status of any set at any time. Surgical instrument sets can be identified with a bar code label that identifies each set.

Labels can be affixed to inner baskets and outside of containers and to the outside of trays that are wrapped. Computers track the flow of sets through the department and at each stage of the processing department.

5.1 Recommendation / Future Work

Given barcoding's history as a mature reliable technology, bar-coding will continue to be adopted within the healthcare setting to improve the quality of patient care. However, growing attention on radio-frequency identification (RFID) systems are expected to be the future competitor for barcoding. Nevertheless, barcoding will continue to play a prominent role with RFID and will likely collaborate with RFID to form a hybrid system. RFID (Radio frequency Identification) technology is used to detect and uniquely identify each surgical item at various stages during surgery. The use of low frequency RFID enables reliable detection of tags even when soaked in body fluids, in the vicinity of metallic objects such as surgical tools.

Standardization of surgical procedure is essential not only for simplifying workflow in the Sterile Supply Unit (SSU) but also for saving cost in the OR. Outsourcing is very effective as proven in all aspects of hospital management. Freeing surgical nurses from such tasks as cleaning operating rooms and washing surgical instruments enables them to play their own roles in their original field. Where outsourcing of tasks has taken place, outsourced staffs, who work in the SSU, are often not familiar with the tasks. Declining efficiency in the SSU due to outsourcing might affect the entire efficacy of the OR.

Besides that, this project proposal generally also relates to an apparatus and method for implementing radio frequency identification techniques, and more particularly to systems and methods for processing surgical instrument tray shipping totes and control and operating systems for systems for processing surgical instrument tray shipping totes

A bar code is marked directly on the surgical instrument. The bar code to be used on surgical instruments is the two-dimensional GS1 Data Matrix symbol. There are different methods of marking instruments and common methods include dot preening, laser etching, electro-chemical etching, and ink jet marking. Some solution providers offer marking services for hospitals. The main advantage of this kind of service is that the hospital does not need to invest in marking equipment and find qualified people who understand the marking technology and data requirements.

This is especially attractive for hospitals that are only thinking of doing the marking at hospital level as a short term measure and expecting new products to come in already marked by the manufacturer. Laser etching Laser etching, or laser engraving, uses precisely controlled lasers to engrave or mark the bar code on the product. A computer controlling a series of mirrors and lenses focuses the laser to burn or etch the bar code. The process allows a product to be directly and permanently marked but is only suitable for 'laserable' materials.

Dot preening the technology is used to directly mark the material and is particular suitable for solid materials (metals, plastics, wood, etc). It can be used for all the information to be marked on the item (text, date, logo, etc.) as well as the GS1 Data Matrix symbol. A small head, normally made from a very strong material such as tungsten, is computer controlled to make a defined series of identical punch marks in the surface of the substrate.

5.2 Summary

Healthcare facilities typically utilize a manual record-keeping system, or an automated system, to document information. However, all healthcare facilities are not the same. The decision as to which system to utilize, whether manual or automated, is based on several factors, including the size of the facility, the number of surgical instruments, procedures, staff compliance, and the financial resources of the institution. It is important to choose an instrument management system that will best meet the healthcare facility's particular needs. Whatever system is used, it should be efficient, cost-effective, and easy-to-use. It is crucial for the staff to completely understand the system, be trained to use the system, and work together to achieve optimum results.

The objectives of this project were successfully done.

By doing this project, "Development of Automated Visual Tracking System for Surgical Instrument" can increase security of supply: the correct product at the correct time in the right place. It is also can check the inventory of all surgical instruments within the facility by pressing one button besides to minimized logistical costs due to medical errors. The productivity of staff assembling surgical trays is also can be increased.

Last but not least, this project is also contributed to a few benefits in hospital management especially for patient safety.

The multiple requirements for information technology support and a higher level of trust between the CSSD and OR department should be in use into report in order to improve the supply chain management of surgical instruments(A. C. Guédon et al., 2016)

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APPENDIX

APPENDIX A: Datasheet of Hardware Part

1/2 Classic Model	AYGÜN®	Sterile Container Systems

Specificiations / Sizes	Lid (Perforated) / Box (Non-Perforated)	Lid (Perforated) / Box (Perforated)	Safety Lid / Box (Non-Perforated)	Safety Lid / Box (Perforated)
285 X 280 X 100 mm	K6-500 K6-501 K6-502 K6-503 K6-504 K6-505	K6-530 K6-531 K6-532 K6-533 K6-534 K6-535	K6-640 K6-641 K6-642 K6-643 K6-644 K6-645	K6-670 K6-671 K6-672 K6-673 K6-674 K6-675
285 X 280 X 135 mm	K6-506 K6-507 K6-508 K6-509 K6-510 K6-511	K6-536 K6-537 K6-538 K6-539 K6-540 K6-541	K6-646 K6-647 K6-648 K6-649 K6-650 K6-651	K6-676 K6-677 K6-678 K6-679 K6-680 K6-681
285 X 280 X 150 mm	K6-512 K6-513 K6-514 K6-515 K6-516 K6-517	K6-542 K6-543 K6-544 K6-545 K6-546 K6-547	K6-652 K6-653 K6-654 K6-655 K6-656 K6-657	K6-682 K6-683 K6-684 K6-685 K6-686 K6-687
285 X 280 X 200 mm	K6-518 K6-519 K6-520 K6-521 K6-522 K6-523	K6-548 K6-549 K6-550 K6-551 K6-552 K6-553	K6-658 K6-659 K6-660 K6-661 K6-662 K6-663	K6-688 K6-689 K6-690 K6-691 K6-692 K6-693
285 X 280 X 260 mm	K6-524 K6-525 K6-526 K6-527 K6-528 K6-529	K6-554 K6-555 K6-556 K6-557 K6-558 K6-559	K6-664 K6-665 K6-666 K6-667 K6-668 K6-669	K6-694 K6-695 K6-696 K6-697 K6-698 K6-699
Ps: All container measurements cover the outer size of the lids.				

Appendix 1: Sterile Container System (1/2 Half size of Classic Model)

ArgoScan 8110 / 8120		
Specification	Model 8110	Model 8120
Operational		
Light Source	660 nm Visible Red LED	
Optical System	2048 pixel CCD (Charge-coupled device)	
Depth of Scan Field	0-80 mm (CODE 39, PCS=90%, 20mils)	0-150 mm (code 39, PCS=90%, 20mils)
Scanning Width	80 mm at contact	75mm at contact
Scan Speed	50 scans/sec	100 scans/sec
Resolution	4mils, Code39, PCS=90%, on contact 5mils, Code39, PCS=45%, on contact	
Print Contrast	30% or more	
Scanning Angle	Pitch: 60° Skew: 75°	
Decode Capability	Auto-discriminates all standard barcodes; Other symbologies can be ordered optionally	
Beeper Operation	7 tones or no beep	
Indicator	Green led	Blue led
Mechanical		
Length	182 mm	
Width-handle	26 mm	
Width-head	90 mm	
Depth-handle	51 mm	49mm
Depth-head	35 mm	
Weight	155 g	120 g

Appendix 2: Argon As8120 MID-Range CCD Scanner

Read: Format

Start "★"	Data Digits (Variable)	Checksum (Optional)	End "★"

Check-sum verification: The checksum of Code-39 is optional and made as the sum module 43 of the numerical value of the data digits.

Check-sum transmission: By setting Enable, checksum will be transmitted.

Max./Min. code length: Each symbology has own Max./Min. Code Length. They can be set to qualify data entry. If their Max./Min. Code Length is zero, the Global Min./Max. Code Length is in effect. The length is defined as to the actual barcode data length to be sent. Label with length exceeds these limits will be rejected. Make sure that the Minimum length setting is no greater than the Maximum length setting, or otherwise all the labels of the symbology will not be readable. In particular, you can see the same value for both Minimum and Maximum reading length to force the fixed length barcode decoded.

Truncate leading/ending: Refer to Truncate leading/ending of UPCA.

Code ID setting: Refer to Code ID setting of UPCA.

$%+PRO **Program**

Option Bar Code	*Option*	*Alphanumeric Entry*
BAA Read	Disable Enable	00 01 *

Appendix 3: Specification Of Barcode (Code 39)

APPENDIX B: Coding Of Microsoft Visual Basic 6.0

Module 1

```
Public rs As New ADODB.Recordset
Public rsd As New ADODB.Recordset
Public LocEx As String
Public strSearc As String
Public Sub display()
If Not rs.EOF Then
txtNo.Text = Str(rsd(0)) & " " 'Space is appended to avoid error when value is null
txtTitle.Text = rsd(1) & " "
txtAuthor.Text = rsd(2) & " "
txtTranslator.Text = rsd(3) & " " 'as salary is numeric it is converted to string
Cmb.Text = rsd(4) & " "
txtLoc.Text = rsd(5) & " "
txtDate.Text = Str(rsd(6)) & " "
End If
End Sub
Public Sub MoveListBoxItems(lstListToAddTo As ListBox, _
lstListToRemoveFrom As ListBox)
Dim intListX As Integer
For intListX = lstListToRemoveFrom.ListCount - 1 To 0 Step -1
If lstListToRemoveFrom.Selected(intListX) Then
lstListToAddTo.AddItem lstListToRemoveFrom.List(intListX)
lstListToAddTo.ItemData(lstListToAddTo.NewIndex) _
= lstListToRemoveFrom.ItemData(intListX)
lstListToRemoveFrom.RemoveItem intListX
End If
Next
End Sub
```

Frmlogin

```
Option Explicit
Public LoginSucceeded As Boolean
Private Sub cmdCancel_Click()
'set the global var to false
'to denote a failed login
LoginSucceeded = False
Me.Hide
End Sub
Private Sub cmdOK_Click()
'check for correct password
If txtUserName = "Admin" And txtPassword = "12345" Then
'place code to here to pass the
'success to the calling sub
'setting a global var is the easiest
```

```
LoginSucceeded = True
Me.Hide
Form1.Show
Else
MsgBox "Invalid Username and Password, try again!", , "Login"
txtUserName = ""
txtPassword = ""
End If
End Sub
```

Form 1 code

```
Option Explicit
Dim cn As New ADODB.Connection
Dim rscb As New ADODB.Recordset
Dim rcb As New ADODB.Recordset
Dim rsAuthor As New ADODB.Recordset
'-----
Dim rsSubject As New ADODB.Recordset
Dim rcount As New ADODB.Recordset
Dim rdlt As New ADODB.Recordset
Dim rsupd As New ADODB.Recordset
Dim rsbat As New ADODB.Recordset
'report to excell
Dim rst As New ADODB.Recordset
Dim iCols As Integer
Dim oApp As Excel.Application
Dim oWB As Excel.Workbook
Dim strSearch As String
Private Sub Cmb_Click()
End Sub
Private Sub AddTest_Click()
On Error Resume Next
List2.Selected(0) = True
SMSTel.Text = List2.Text
End Sub
Private Sub BtnAdd_Click()
On Error Resume Next
BtnSave.Enabled = True
Call Clear
rs.AddNew
rsd.MoveLast
If Not rs.EOF Then
txtBarcode.Text = Str(rsd(0)) & " " 'Space is appended to avoid error when value is null
End
```

Form 3 code

```
Option Explicit
Dim cn As New ADODB.Connection
Dim rscb As New ADODB.Recordset
Dim rcb As New ADODB.Recordset
Dim rsAuthor As New ADODB.Recordset
'-----
Dim rsSubject As New ADODB.Recordset
Dim rcount As New ADODB.Recordset
Dim rdlt As New ADODB.Recordset
Dim rsupd As New ADODB.Recordset
Dim rsbat As New ADODB.Recordset
'report to excell
Dim rst As New ADODB.Recordset
Dim iCols As Integer
Dim oApp As Excel.Application
Dim oWB As Excel.Workbook
Dim strSearch As String
Private Sub Cmb_Click()
End Sub
Private Sub AddTest_Click()
On Error Resume Next
List2.Selected(0) = True
SMSTel.Text = List2.Text
End Sub
Private Sub BtnAdd_Click()
On Error Resume Next
BtnSave.Enabled = True
Call Clear
rs.AddNew
rsd.MoveLast
If Not rs.EOF Then
txtBarcode.Text = Str(rsd(0)) & " " 'Space is appended to avoid error when value is null
```