MAKERERE UNIVERSITY

AUTOMATED TABLET AND CAPSULE COUNTER

By

GROUP BSE23-18

[EMBEDDED SYSTEMS PROJECT]

DEPARTMENT OF NETWORKS

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

A Project Report Submitted to the School of Computing and Informatics Technology for the Study Leading to a Project in Partial Fulfillment of the Requirements for the Award of the Degree of Bachelor of Science in Software engineering of Makerere University.

Supervisor

Dr. Ntanda Moses

Department of Networks

School of Computing and Informatics Technology, Makerere University

mntanda@gmail.com

+256-41-540628, Fax: +256-41-540620

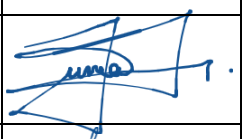
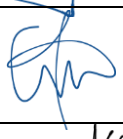
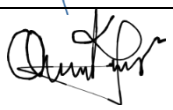
Link to Project Repo and Documents: https://gitlab.cranecloud.io/2023-SE4/bse23-18

Link to project blog site: https://sites.google.com/view/bse23-18/home

June, 2023.

Declaration

We, group BSE23-18, hereby declare that the work presented is original and has never been submitted for an award to any university or institution of higher learning. We can confirm that where we have done consultations either from published material or the works of others, it has been attributed in this report.

#	**Names**	**Registration Number**	**Student Number**	**Signature**
I	Juma Twalib	19/U/13344/PS	1900713344	
2	Queen Rhukhiah Mutoni	19/U/8823/EVE	1900708823	
3	Nyanzi Ashraf	19/U/13235/PS	1900713235	
4	Sharifa Shanklin	19/U/13487/PS	1900713487	

Approval

This project report titled "**Automated Tablets/Capsule counter** " has been submitted for examination with my approval as the supervisor of group BSE23-18.

Dr. Ntanda Moses

Department of Networks

School of Computing and Informatics Technology;

College of Computing and Information Sciences,

Makerere University

Signature: ..... Date: 19/7/23

Supervisor

Dedication

We dedicate the Automated Device and Capsule Counter project to our supervisors, pharmacists, and beloved family and friends with profound gratitude. To our supervisors, thank you for your guidance and patience throughout this journey. Your expertise has shaped our understanding and nurtured our passion for innovation. To the pharmacists, your invaluable contribution in providing us with crucial information throughout the development of the Automated Device and Capsule Counter. And to our family and friends, your unwavering support and belief in our abilities have been our pillars of strength. Together, we have embarked on a mission to revolutionize the pharmaceutical industry and improve patient care. This project stands as a testament to our shared vision, dedication, and the impact of your guidance and support.

Acknowledgements

We dedicate this project, the Automated Device and Capsule Counter, to express our heartfelt gratitude and appreciation to all those who have played a significant role in its success. This project stands as a testament to the collaborative efforts and unwavering support of numerous individuals who have contributed their expertise, guidance, and encouragement along the way.

First and foremost, we extend our deepest thanks to our overall supervisor, whose invaluable guidance has been instrumental in shaping this project. Dr Nsabagwa Mary, your guidance and leadership has propelled us forward, pushing the boundaries of innovation and excellence.

We would also like to express our heartfelt appreciation to our assigned supervisor, Dr Ntanda Moses, for your dedicated mentorship and continuous guidance throughout the course of this project. Your expertise, encouragement, and support have been invaluable, helping us navigate challenges and uncover innovative solutions. We are immensely grateful for your trust in our abilities and your unwavering commitment to our development.

We extend our gratitude to the pharmacists at Mulago hospital, Makerere University hospital, who generously shared their extensive knowledge and insights with us. Your valuable input and expertise have been critical in shaping the design and functionality of the Automated Device and Capsule Counter.

Finally, we express our deepest appreciation to our families and friends, who have supported us throughout this journey. Your unwavering belief and support in our abilities and endless encouragement have been our constant source of inspiration.

To all those mentioned above, and to anyone else who may have contributed to this project, we extend our heartfelt gratitude. It is through your collective efforts that the Automated Device and Capsule Counter is becoming a reality, revolutionizing the pharmaceutical industry and improving patient care. Your commitment, expertise, and support have left an indelible mark on this project and our lives. This dedication is a small token of our gratitude, but it carries with it our sincere appreciation and deepest respect for all those involved.

Thank you all.

Abstract

This report presents a comprehensive design, implementation and manual of an Automated Tablets/Capsule Counter devise designed to count tablets and capsules of various sizes and shapes in light of the challenges that health workers now encounter while dispensing medicine and carrying out stock-taking in pharmacies and hospitals. The Automated Tablets/Capsule Counter will automate the manual counting of tablets and capsules in healthcare facilities, particularly in pharmacies and wards in hospitals.

The automated counting device demonstrated a high level of accuracy, consistently achieving precise counts within a narrow margin of error compared to manual counting across a diverse range of tablet and capsule formulations.

Additionally, the device is meant to demonstrate superior efficiency, completing counts at an average rate of 180 capsules or tablets per minute, significantly outperforming manual counting, which averaged 13 capsules or tablets per minute..

These findings indicate that the Automated Tablets/Capsule Counting device offers a highly accurate, efficient, and reliable solution for health centers. By reducing human error and significantly enhancing counting speed, it has the potential to improve productivity and optimize operational efficiency in healthcare facilities particularly pharmacies and hospitals.

THE SYSTEM DESIGN DOCUMENT

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List Of Figures

INTRODUCTION.

Purpose.

This Software Design Document describes the architecture and system design of an Automated Tablet and Capsule Counting Device. This document will provide a description of the software requirements and specifications to allow software development proceed with an understanding of what will be implemented and how it will be implemented.

The intended audience for this document will include the system developers, system designers, system testers and project managers.

- System developers: The document will help system developers comprehend the system's overall structure, the functionality it will offer and how various components will communicate with one another.
- System designer: This document will act as a blueprint to the system designers while coming up with the actual design of the system.
- System testers: The document will help system testers come up with test cases for the different components that will make up the system to ensure that they work as expected and produce correct results.
- project manager: These will use the document to track project progress and ensure that project goals and objectives are met.

Scope.

We will develop an Automated Tablet and Capsule Counting Device that will count tablets of various sizes and shapes in light of the challenges that health workers now encounter while dispensing medicine and carrying out stock-taking. Currently, counting is done manually where they have to count the tablets or capsules one by one on a counting tray. The Automated Tablet and Capsule Counting Device will automate the manual counting of tablets and capsules in healthcare facilities, particularly in pharmacies and hospitals and it will be able to quickly and efficiently count a number of tablets and capsules.

The goal of creating an Automated Tablet and Capsule Counting Device will be to increase the accuracy and effectiveness of counting capsules and tablets in healthcare facilities.

The objectives of this project will be as written below;

- To improve efficiency and productivity during the counting of tablets and capsules by counting capsules and tablets properly and rapidly with less human intervention thus saving time and minimizing errors.

- To increase the accuracy of counting tablets and capsules with the help of a sensor that will precisely detect and count tablets and capsules accurately thus reducing the risk of errors while dispensing medication.
- To reduce labor costs. The device will be operated by one individual thereby eliminating the need to hire more personales to carry out the manual counting.

The project will provide the following benefits:

- It will provide accurate counting of tablets and capsules hence accurate dispensation of tablets and low risks of errors.
- The Automated tablet and Capsule Counting Device will save time by counting a large number of capsules and tablets in a short period of time.

Overview.

This document is written according to the standards for Software Design Documentation explained in “IEEE Recommended Practice for Software Design Documentation”. This SDD contains eight (8) sections, which include:

- **Introduction**: This provides an overview of the purpose, scope, and organization of this document.
- **System Overview**: It gives a general description of the functionality, context, and design of the automated tablet and capsule counter.
- **System Architecture**: This describes the architectural design of the system, including the decomposition of subsystems and a design rationale.
- **Data Design**: This explains how the information domain of the system is transformed into data structures, including a data description and data dictionary.
- **Component Design**: It takes a closer look at what each component does in a more systematic way, including a summary of algorithms for each function and descriptions of local data.
- **Human Interface Design**: This describes the functionality of the system from the user's perspective including screen images, a discussion of screen objects and actions associated with those objects.
- **Requirements Matrix**: It provides a cross-reference that traces components and data structures to the requirements in the SRS document.
- **Appendices**: This includes any supporting details that could aid in the understanding of the SDD.

Reference Material.

- Software Requirements Specification document of the Automated Tablet and Capsule Counting Device.
- Bbiri Applied ICT Centre. (2021, September 18)Shop.[Online]. Available: https://www.bbiri-centre.com . [Accessed between: 28th Feb to 19th April, 2023].

Definitions and Acronyms.

Acronym	Definition
SDD	Software Design Document
SRS	Software Requirements Document
EPROM	Erasable Programmable Read-Only Memory
ATCCD	Automated Tablet/Capsule Counter Device

SYSTEM OVERVIEW.

In hospitals, especially government hospitals, they receive tablets and capsules in containers. These containers have tablets and capsules that are to be dispensed to the patients who have received prescriptions from the doctors. In order to dispense, a healthcare worker needs to manually count the tablets and capsules in reference to the patient's prescription. This process of counting tablets and capsules takes hours and is so tiresome especially when there are very many patients waiting in queue to receive medicine. A healthcare worker may inaccurately count the tablets or capsules which in turn affects the patient’s health. During stock stacking, the same manual technique is also employed.

The Automated Tablet and Capsule Counting Device will provide a solution to the issues mentioned above. It will achieve this counting through a motor that rotates a plate on which the tablets are placed. Once the plate is rotated, the tablets will be pushed into the sensor area where they are detected one by one by a sensor. After the detection of a tablet, the sensor will send a signal to the microcontroller

which will then cumulate the count value and will continuously send the count value to a 4-digit 7-segment display.

SYSTEM ARCHITECTURE.

Architectural Design.

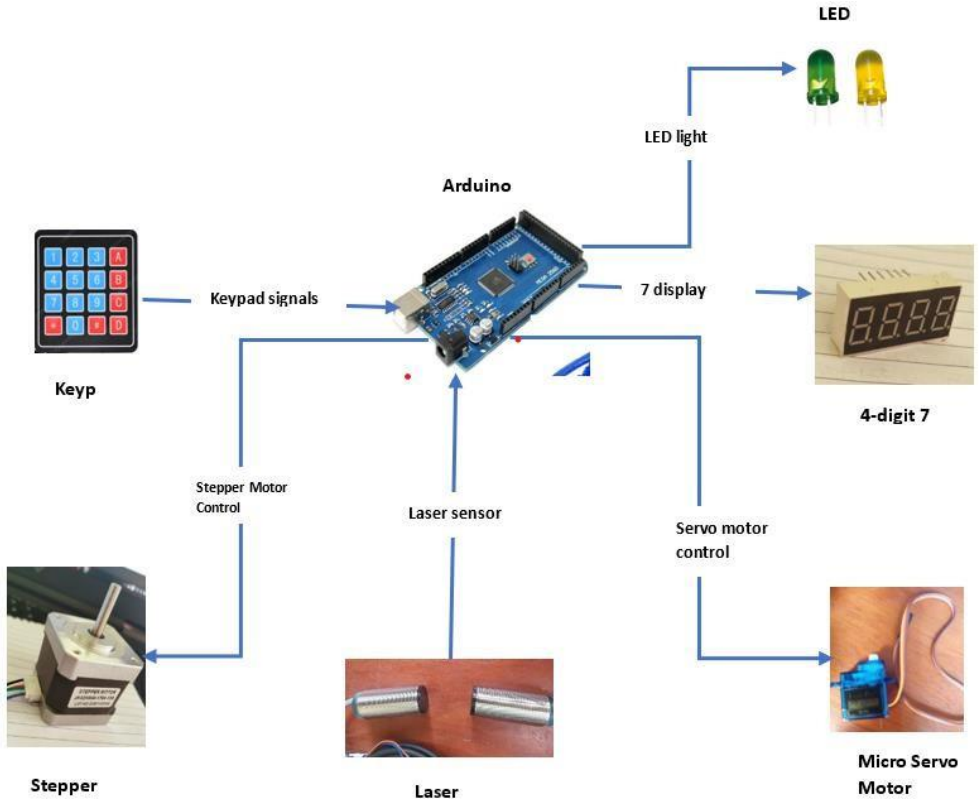

Figure 1: System Architecture

The Stepper Motor

The motor component will consist of a motor and a motor driver circuit.

The stepper motor will rotate a plate on which the tablets and capsules will be released to. The motor will be powerful enough to rotate the plate smoothly and quickly.

Figure 2: This is a Nema 17 Stepper Motor NEMA 17 Stepper Motor.

The driver will be responsible for controlling the speed and direction of the motor and will receive commands from the microcontroller to start and stop the motor.

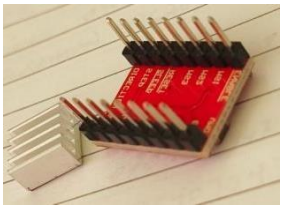

Figure 3: his is an A4988 Nema 17 stepper driver used for controlling the power sent to the motor.

Plate.

The plate is where the tablets and capsules will be poured. The plate will be large enough to hold a significant number of tablets but also fit in the machine. It will be made of a durable material that can withstand repeated use and can easily be cleaned.

The Sensor Component.

The sensor component will consist of a sensor that detects the presence of tablets and capsules in the sensor area. The sensor will communicate with the microcontroller to signal when a tablet or capsule has been detected. The figure below shows the Laser sensor that will be used. The sensor has two parts, the sender end sends laser signals to the receiver end of the sensor. Once a tablet passes, it blocks the signal and the sensor sends sensory signals to the Arduino board.

Figure 4: LASER M18 Cylindrical Photoelectric Sensor.

Micro-controller Component.

The microcontroller component will be responsible for controlling the overall counting process. It communicates with all the other components of the device. That is,

- It will send signals to the motor component, to control when the motor should start or stop and control the speed at which the stepper motor rotates.
- It will receive data signals from the sensor to inform it whether a tablet has been detected.
- It will also send signals to the micro servo motors to open or close the inlet valve and funnel valve.
- It will also receive signals from the keyboard and then process which input is supplied and what action to take.
- It will also send signals to the 4-digit 7-segment display

Figure 5: This is the Arduino Mega, which contains the microcontroller.

The Arduino board will be used for prototyping. It will contain a number of pins via which all the other components of the device will communicate to the microcontroller.

Display Components.

The display component will be responsible for providing feedback to the user about the counting process. It will display the count data in real-time as well as any errors or malfunctions that will occur during the counting process.

The 4-Digit 7-Segment.

This will display the number of tablets or capsules as they will be counted. It will also determine the final count value of the tablets or capsules once counting is done.

Figure 6: This is a 4-digit 7-segment

.

LED indicators.

The LED lights will indicate the mode in which the device is functioning.

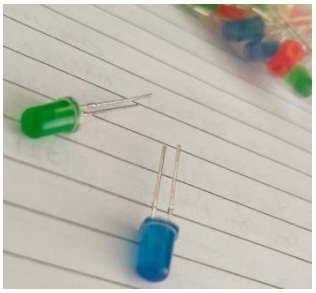

Figure 7: LED light

Keypad.

The keypad will be used to input the number of tablets or capsules to be counted. It will also be used to input the mode of counting, input the start or stop of counting, and will also reset the counter value to zero.

Figure 8: This is a 4 by 4 keypad that will be used for prototyping

Micro Servo Motor

There will be two micro servo motors.

- One will be used to achieve the automatic closing and opening of the inlet valve.
- The other will be used to periodically open the funnel valve.

Figure 9: SG90 Micro Servo Motor.

Power Supply.

The power supply is the component that will provide the power needed to operate the device. It will be designed to be safe, reliable, and efficient. The power supply will also be designed to be easily accessible and replaceable.

Housing.

The housing is the component that will enclose and protect the machine's internal components. It will be designed to be durable, easy to clean, and resistant to damage from environmental factors.

Decomposition Description.

A Context diagram of the Automated Tablet/Capsule counting device

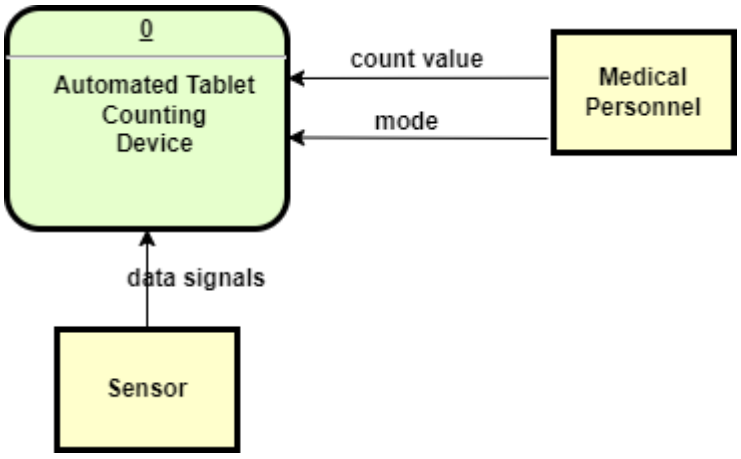

Figure 10: Context Diagram

The automated tablet counting device is divided into four modules, that is, tablet feeding module, motor control module, control module and tablet counting module.

Below is a structural decomposition diagram showing the decomposition of the Automated Tablet Counting Device.

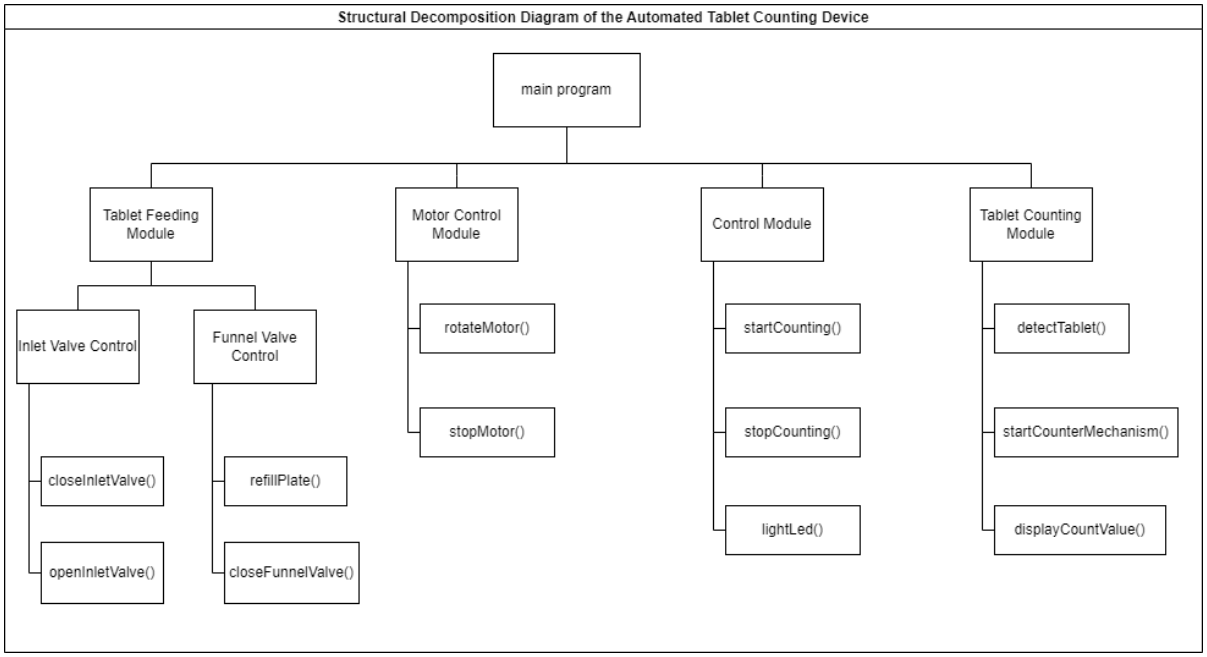

Figure 11: Structural Decomposition Diagram

Main Program.

The main program is the program that will call functions in all the other modules to achieve the complete functionality of the system.

Motor Control Module.

The motor control module will be responsible for controlling the motor that rotates the rotating discs in the tablet and capsule feeding systems. It has functions such as startMotor(), and stopMotor().

Tablet Feeding Module.

The tablet feeding module will be responsible for feeding tablets and capsules into the counting area. It will consist of a funnel, funnel valve, and sensor valve. It will have functions such as openFunnelValve(), closeFunnelValve(), openInlet Valve(), and closeInletValve().

Tablet Counting Module.

The tablet counting module will be responsible for counting the tablets and capsules as they pass through the counting area. It will have functions such as detectTablet(), StartCounterMechanism()

Control Module.

The control module will be responsible for controlling and monitoring the entire device. It will have functions such as startCounting(), stopCounting(), and displayCount().

How They All Work Together.

Each of these modules will have a specific responsibility in the Automated Tablet and Capsule Counting Device. The motor control module will control the motor that will rotate the plate, while the tablet feeding module is handling the loading and release of tablets from the funnel and rotating plate.

The tablet counting module will then detect and count the tablets and capsules that will be passing through the counting area using laser sensors and a counter incremented whenever a tablet is detected. The count value is then displayed on the 4-digit 7-segment display.

The control module will then interact with the user interface which will allow the user to start and stop the counting process and then display the final count.

These modules will work together to achieve the complete functionality of the system alongside the main program that will call each module as needed to automate the counting of tablets and capsules. The modular program structure will allow easy maintenance and scalability, as each module will be updated or replaced without affecting the entire system.

Design Rationale.

The architecture used is a modular architecture in which the system is divided into smaller independent modules that will be developed and tested separately and then will be integrated to form the complete system. This will allow easier maintenance and scalability of the system.

The modular architecture will allow better organization of the code hence making it easier to understand and modify.

DATA DESIGN.

Data Description.

The major data will be the counter value. Upon completion of a counting process, the final counter value will be stored in the systems via EPROM and then retrieved for the next counting. The user may then reset the value to zero.

Data Dictionary.

The following is a data dictionary for the automated tablet and capsule counting device:

Table 1: Data Dictionary

Data	Type	Description
counterValue	Integer	This will be the value of the tablets/capsules so far counted during the counting process.
inputValue	Integer	This will be the number of tablets to be counted. It is input by the user.
isTabletDetected?	boolean	This value will be set or unset depending on whether a table/capsule has been detected by the sensor or not.
Mode	String	It will specify the current mode of counting. It takes the value “batch” or “whole”.

functions

startCounting(inputValue)
startCounterMechanism(counterValue)
stopCounting()
stopButtonPressed()

detectingTablet(

startMotor()

stopMotor()

openInletValve()

closeInletValve()

openFunnelValve()

closeFunnelValve()

refillPlate()

COMPONENT DESIGN.

The Automated Tablet and Capsule Counting Device will consist of several components, namely; A motor that will rotate a disc on which the tablets and capsules to be counted will be placed, a sensor that will detect the tablets and capsules, and a microcontroller that will control the counting process and other parts of the device.

Pseudocode for each function in section 3.2

StartCounting (inputValue, mode, counterValue)

```
refillPlate()
if mode == "whole":
    while !stopButtonPressed():
        startCounterMechanism(counterValue)
     stopCounting()
else:
    if inputValue == 0
         lightLed()
         return
    while !stopButtonPressed()
        while counterValue < inputValue:
            startCounterMechanism()
         stopCounting()
    stopCounting()
```

startCounterMechanism (counterValue)

```
startMotor()
openInletValve()
initialize isTableDetected

while isTableDetected == True:
counterValue++
display counterValue
```

stopCounting()

```
closeInletValve()
stopMotor()
stopRefill()
```

stopButtonPressed()

```
return true;
```

startButtonPressed()

```
return true;
```

detectingTablet()

```
initialize isTabletDetected
if a tablet/capsule is detected by the sensor:
  isTabletDetected = True
else:
  isTabletDetected = false
return isTabletDetected
```

startMotor()

stopMotor()

openInletValve()

closeInletValve()

openFunnelValve()

closeFunnelValve()

refillPlate()

```
initialize startTime = now
while now - startTime < 30000
    openFunnelValve()
closeFunnelValve()
```

stopRefill()

```
closeFunnelValve()
```

Note: the refillPlate() method is called every 10 seconds during counting.

HUMAN INTERFACE DESIGN.

Overview of User Interface.

The Automated Tablet and Capsule Counting Device will be designed to simplify the process of counting and dispensing tablets and capsules. The user interface will be developed to allow easy interaction with the device. The user interface will have the following features;

- **Keypad for inputting values:** The device will be equipped with a keypad that will allow the user to input the number of tablets or capsules to be counted and other special keys that will perform functions such as clearing input, changing mode and starting and stopping the count.
    - **Numeric keys:** These keys will start from 0 to 9.
    - **Start key:** The start key will allow the user to initiate the counting process.
    - **Stop key:** The stop key will allow the user to stop the counting process at any time.
    - **Mode key:** This will be a key that will toggle between batch counting mode and normal counting mode.

- **LED indicators:** The device will have 3 LED light indicators that is to say green, blue and red. The Green LED indicator will light when the mode key is toggled to indicate normal counting mode. The blue LED indicator will light when the mode key is toggled to indicate batch counting mode. The red LED will light incase of an error occurrence during the counting process.
- **4-digit 7-segment display for displaying count value**: This will show the current count value. The display will be bright and clear making it easy to read the count value from a distance.
- **Removable plate for tablets:** The device will have a removable plate on which tablets and capsules are poured for counting. The plate will sit on a motor that will rotate it when counting has started.
- **Removable funnel:** This will hold the tablets or capsules by the use of a valve that will be closed or opened before releasing them onto the rotating plate for counting.

When the user selects a counting mode and inputs the desired number of tablets or capsules, he or she will pour them into the funnel that has a valve which closes and opens to initiate the counting process by pressing the start count button. The motor will then rotate the plate as the tablets/capsule fall through the sensor while being detected and counted. The count value will be displayed on the 4-digit 7-segment display. Once the desired number of tablets or capsules has been counted, the device will stop automatically and the count value will be displayed on the screen.

The automated tablet and capsule device will also provide feedback to the user through visual cues such as an LED indicator and audible cues such as beeps. This feedback will be designed to ensure that the user will be aware of the status of the device and will alert the user about any issues or errors that will have occurred during the operation.

Device Images.

Below is a hand-drawn illustration of the automated tablet and capsule counting device.

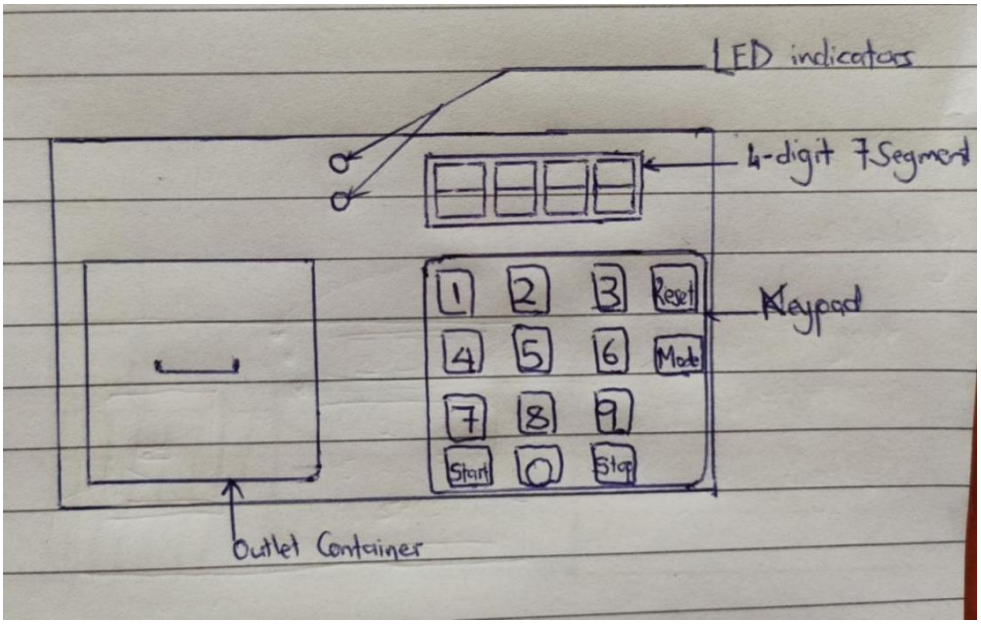

Figure 12:This is a front-view sketch that shows the proposed automated t/c counting device.

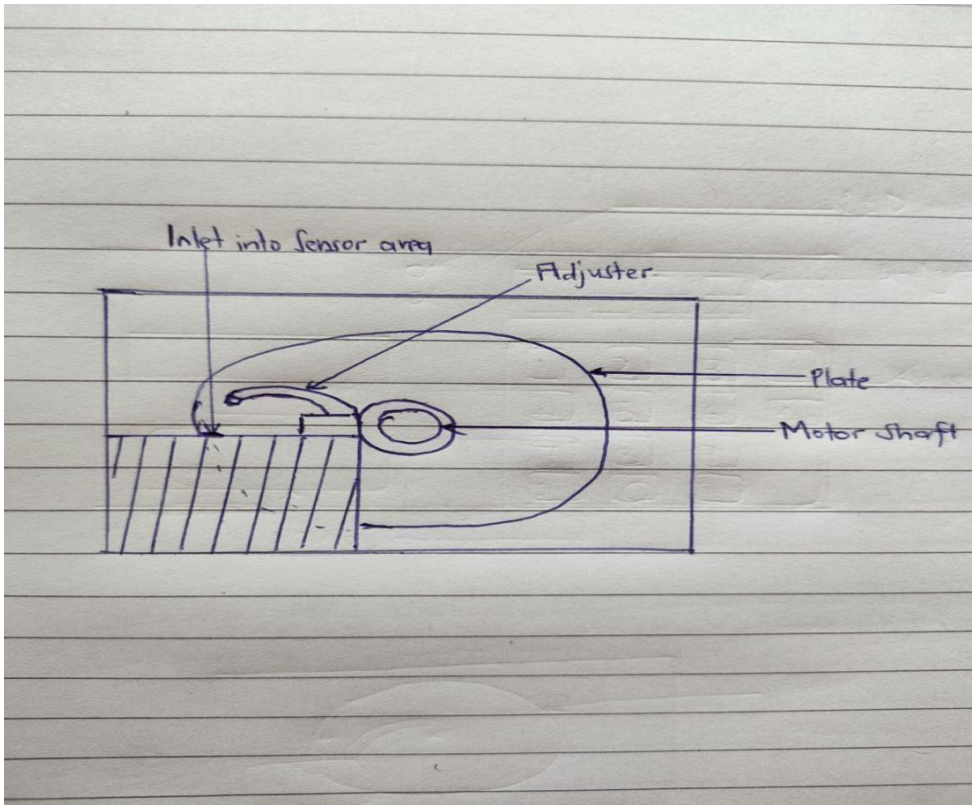

Figure 13:This is a sketch from above showing the plate, motor shaft, and the adjuster.

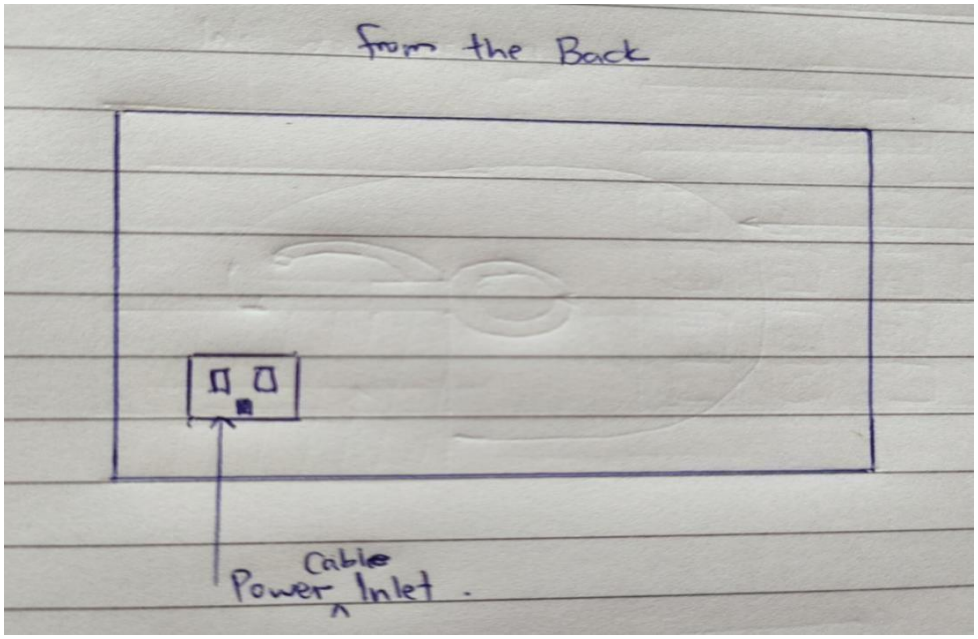

Figure 14: This is a sketch of the device from behind showing the power cable inlet

.

Device Objects and Actions.

The user interface of the Automated Tablet and Capsule Counting Device will include the following screen objects and associated actions:

- **Numeric keypad:** This will allow the user to input the number of tablets or capsules to be counted. The user will be able to use the keypad to clear input or switch between counting modes.
- **4 digit 7-segment display**: This will display the current count value.
- **LED indicators:** They will provide visual feedback to the user indicating the status of the device.
- **Outlet container:** It will collect the already counted tablets.
- **Inlet valve into sensor area:** It will open when the counting of tablets has started and close when the counting of tablets is done

When the user presses the start count button, the device will begin counting the tablets or capsules on the removable plate. The count value will be displayed on the 4-digit 7-segment display and the LED indicator will light up to indicate that counting is in progress. The user can stop the counting process at any time by pressing the stop count button. If an error or issue arises during operation, the device will emit an audible beep and the LED indicator will light to alert the user about the issue.

REQUIREMENTS MATRIX.

Table 2: Requirements Matrix

Functional Requirement	System Component
C-1: The device shall facilitate the holding of tablets or capsules to be counted.	Funnel, plate
C-2: The device shall allow the user to input the number of t/c to count.	Keypad
C-3: The device shall allow the user to start or stop the counting of t/c.	Keypad
C-4: The device shall count the t/c one by one.	Sensor, Motor, Arduino
C-5:The device shall indicate counting completion of the t/c.	4-Digit 7-Segment display
C-7:The device shall automatically release t/c from the funnel onto the container if the container is empty and counting is in progress.	Servo Motor
C-8: The device shall automatically stop counting when the user input value becomes equal to the counter value and the chosen mode is batch counting.	Arduino, inlet valve
C-10: The device shall release the counted t/c into a container.	Arduino, Inlet valve
C-11: The device shall allow the user to reset the counter value to zero.	Keypad, Arduino
C-12: The device shall allow the user to set the counting mode to batch or whole.	Keypad, Arduino
C-13: The device shall display the counter value, user input value, counting mode	4-Digit 7-Segment, Arduino

THE SYSTEM REPORT

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IMPLEMENTATION REPORT

Chapter 1: Introduction

1.1 Background and scope of the project

The development of the Automated Tablets and Capsule Counting device was initiated in response to the growing need for a more efficient and accurate method of counting tablets and capsules in health facilities. Traditional manual counting methods are time-consuming, prone to errors, and often result in inconsistencies.

The scope of this project encompasses the design, development, and implementation of an automated system that can accurately count tablets and capsules. By leveraging on embedded systems and software engineering techniques, the device is meant to not only improve accuracy but also enhance productivity and reduce human error.

1.2 Overview of the document

This document serves as a comprehensive guide to the implementation, testing, and recommendations for the Automated Device and Capsule Counting Device. The document is structured in a logical manner to provide a thorough understanding of the project.

Chapter 1, titled “Introduction”, begins with an introduction that outlines the background, objectives, and scope of the project. This section sets the context for the subsequent chapters and provides a clear understanding of the purpose and significance of the Automated Device and Capsule Counting system.

Chapter 2, titled "System Specifications," delves into the technical details of the system. It provides a comprehensive overview of the system architecture, design principles, and functional requirements. This chapter serves as a foundation for the subsequent development and testing phases, ensuring that the system meets the specified standards and functionality.

Chapter 3, titled "Implementation," provides a detailed account of the development process. It covers the technologies, tools, and methodologies used in building the Automated Device and Capsule Counter system.

Chapter 4, titled "Testing and Validation," focuses on the rigorous testing procedures conducted to ensure the accuracy and reliability of the system. It outlines the test scenarios, methodologies, and criteria used to evaluate the performance of the device. The results of the testing phase are presented, along with an analysis of the system's accuracy rate and areas for improvement.

Chapter 5, titled "Conclusion and Recommendations," summarizes the key findings of the project. It highlights the achievements of the Automated Device and Capsule Counter system. This chapter also identifies areas for improvement and provides recommendations for further research and development to enhance the system's capabilities.

Throughout the document, detailed diagrams, tables, and illustrations are included to enhance the understanding of the system's functionality and design. Additionally, references to relevant research papers, industry standards, and regulations are provided to ensure the system's compliance and alignment with the latest practices. This document aims to provide a comprehensive and exhaustive overview of the Automated Device and Capsule Counter system. It serves as a valuable resource for system developers, testers, end-users, and maintenance personnel, enabling them to understand the system's architecture, functionality, and testing procedures. It also highlights the potential impact of the system on the pharmaceutical industry and recommends further research to improve its accuracy and expand its capabilities.

Chapter 3: Design output

3.1 Implementation (coding and compilation)

Development tools used to implement the system

- **C programming language:** This was the language used to write the code of the system. There were also prewritten libraries that were used such as SevenSeg.h, Stepper.h, and Keypad.h .
- **Arduino Integrated Development Environment(IDE):** This was the IDE used to write, compile, and upload the code to the Arduino Mega 2560 microcontroller prototyping board.
- **Arduino Mega 2560 microcontroller prototyping board:** This is the main controller of the system, it receives input from the sensor, keypad and uses this information to control the motors and the display. It is programmed using C programming language.
- **Breadboard:** This was used in the prototyping phase of the system development. It allows quick and easy connection of the electronic components together without the need of soldering making it easy to test and modify the system during the development process.
- **Jumper wires:** These were used to connect the sensor, motor, keypad, display, and microcontroller together via the breadboard.

Module and integration

Functionality of the individual system components was implemented using C programming language and wiring was done and system was tested.

During the integration phase of the system development, the various system unit code was compiled into a main program and the system components were connected together to form a completed system, the sensor is connected to the microcontroller, which receives input from the sensor and uses this information to control the motor. The motor is connected to the plate on which the tablets and capsules are placed and rotates the plate to count the tablets and capsules. The display module is connected to the microcontroller, which sends data to the display to show the count data in real time. The keypad is also connected to the microcontroller, which receives input from the keypad and uses this information to control the counting process.

Device interfaces

1. The Sensor: The sensor component consists of a laser sensor that detects the presence of tablets and capsules in the sensor area. The sensor communicates with the microcontroller to signal when a tablet or capsule has been detected.

2. Arduino mega 2560: The microcontroller component controls the overall counting process. It communicates with all the other components of the device, including the sensor, motor, and display. The microcontroller receives data signals from the sensor to inform it whether a tablet has been detected. It also sends signals to the motor component to control when the motor should start or stop and control the speed at which the stepper motor rotates. Additionally, it sends signals to the micro servo motors to open or close the inlet valve and funnel valve.

3. Display Components: The display component is responsible for providing feedback to the user about the counting process. It displays the count data in real time as well as any errors or malfunctions that occur during the counting process.

The 4-digit 7-segment display is used to display the number of tablets or capsules as they are counted.

The LED lights indicate the mode in which the device is functioning.

4. The Keypad.

- Inputting the Number of Tablets or Capsules to be Counted: The keypad allows the user to input the number of tablets or capsules to be counted. This information is then used by the microcontroller to control the counting process.
- Inputting the Mode of Counting: The keypad allows the user to select the mode of counting, which can be either batch count mode or whole count mode. In batch mode, the user inputs the number of tablets or capsules to be counted, while in whole count mode, the system counts the tablets and capsules automatically.
- Inputting the Start or Stop of Counting: The keypad allows the user to start or stop the counting process. This information is then used by the microcontroller to control the counting process.
- Resetting the Counter Value to Zero: The keypad allows the user to reset the counter value to zero. This is useful when the user wants to start a new counting process.

5. NEMA 17 Stepper Motor: This motor is responsible for rotating the plate on which the tablets and capsules are placed. The motor is controlled by the microcontroller, which sends signals to start or stop the motor and control the speed at which it rotates. This motor also has a driver that controls the speed and direction of the motor and receives commands from the microcontroller to start and stop the motor.

6. **Tablet Feeding Module:** The tablet feeding module is responsible for feeding the tablets and capsules onto the plate. It consists of an inlet valve and a funnel valve, which are controlled by micro

servo motors. The microcontroller sends signals to the micro servo motors to open or close the inlet valve and funnel valve, allowing tablets and capsules to be fed onto the plate.

7. Power Supply: The power supply provides the necessary power to run the system. The system is designed to run on a 12V DC power supply.

8. Housing: The housing is the component that encloses and protects the machine's internal components. It is designed to be durable, easy to clean, and resistant to damage from environmental factors.

During the implementation process, the code was written in the C programming language using the Arduino IDE. The code was designed to control the various components of the system, including the sensor, microcontroller, and display. The code was tested extensively to ensure that the system was reliable and accurate in detecting and counting tablets and capsules of different sizes, shapes, and colors.

Operating environment of the system:

The Automated Tablet or Capsule Counting Device should operate in a clean dry environment at room temperature.

3.4 Documentation

1. Software Requirements Document: This document provides a comprehensive understanding of what the Automated Tablet or Capsule Counting device should do. It outlines all the requirements needed to develop the system.

2. Software Design Document: The Software Design Document provides a detailed description of the system architecture and design. It outlines the design requirements and specifications, and provides a clear understanding of what will be implemented and how it will be implemented. The document is intended for system developers, designers and testers, and serves as a guide for the development and testing of the system.

3. User Manual: The User Manual provides instructions on how to use the Automated Tablet and Capsule Counter system. It includes information on how to set up the system, how to operate the system, and how to troubleshoot. The User Manual is intended for end-users of the system, such as pharmacists and healthcare professionals, and serves as a guide for using the system effectively and efficiently.

The role of these documents to the readers is to provide a clear understanding of the system architecture, design, and functionality. The documents serve as a guide for the development, testing, and maintenance of the system, and provide essential information on how to use, test, and maintain the system effectively and efficiently. The documents are intended for system developers, designers, testers, end-users, and maintenance personnel, and provide the necessary information for each audience to perform their respective roles effectively.

Design details

Table 1: Design Details

Topics	**Design output**	
Good programming practice	Source code is… ☒Modularized ☒Encapsulated ☒Functionally Divided ☒Stictly compiled ☒ Fail-safe (handling errors)	Source code contains… ☒Revision notes ☒Comments ☒Meaningful names ☒Readable source code ☐Printable source code
Dynamic testing	☒All statements have been executed at least once ☒All functions have been executed at least once ☒All case segments have been executed at least once ☒All loops have been executed to their boundaries ☐Some parts were not subject to dynamic test	

Chapter 4: Inspection and testing

4.1 Introduction

Inspection plan and performance

Table 2: Inspection Plan and Performance

Topics	**3.3.1 Inspection plan and performance**	*Date / Initials*
Design output	☒Program coding structure and source code ☒Evidence of good programming practice ☒Design verification and documented reviews ☐ Change-control reviews and reports Comments:	25/05/2023, JT, NA
Documentation	☒System documentation, flow charts, etc. ☒Test results ☒User manuals, On-line help, Notes, etc. ☐ Contents of user manuals approved. Comments:	27/05/2023, SS, QRM

Topics	**3.3.1 Inspection plan and performance**	*Date / Initials*
Software development environment	☒Data Integrity ☐ File Storage ☐ Access rights ☒Code protection ☒Installation kit, replication and distribution Comments:	27/05/2023, NA
Result of inspection	☒Inspection approved Comments:	27/05/2023

4.2 Test plan and performance

4.2.1 Test objectives

The test objectives are as follows:

- To verify the accuracy of tablet and capsule counting.
- To verify the functionality of the user interface, including the keypad, LED indicators, and display.
- To validate the device's ability to handle different tablet shapes, sizes.
- To test the device's error detection and handling capabilities.

4.2.2 Scope and Relevancy of tests

The tests will cover the entire functionality of the automated tablet counting device, focusing on accuracy, user interface, tablet handling, error detection, and device reliability. The testing will be relevant to the intended operational use of the device.

4.2.3 Levels of tests

The testing will include the following levels:

- **Module Test**: Testing individual components and functions of the device.
- **Integration Test**: Verifying the interaction and compatibility between different modules.
- **System Acceptance Test**: Validating the overall performance and compliance with requirements.

4.2.4 Types of tests

The following types of tests will be conducted:

- **Input Testing:** Verifying the correct response to user input from the keypad.
- **Functionality Testing:** Testing the functionality of the device, including counting, mode switching, and error handling.
- **Performance Testing:** Evaluating the device's performance under different operating conditions, such as high volumes or varying lighting conditions.
- **Usability Testing:** Assessing the device's ease of use and user-friendliness.

4.2.5 Sequence of tests

The testing will follow the defined test cases, test procedures, and test data with expected results. Each test case will be executed in a sequential manner, ensuring that all relevant aspects of the device are thoroughly tested.

Keypad input testing

Table 3: Keypad Input Testing

Input Key	Expected output	Actual Output	Result
1	1	1	Passed
2	2	2	Passed
3	3	3	Passed
4	4	4	Passed
5	5	5	Passed
6	6	6	Passed
7	7	7	Passed
8	8	8	Passed
9	9	9	Passed
0	0	0	Passed
R (Reset)	Clears the screen and displays a 0	Clears the screen and displays a 0	Passed
BM (Batch Count Mode)	Blue LED lights.	Blue LED lights	Passed
WM (Whole Count Mode)	Yellow LED lights	Yellow LED lights	Passed
Start	Motor starts	Motor starts	Passed
Stop	Motor stops	Motor stops	passed

Multi-seven segment display

Table 4: Multi-seven segment display

Input Key	Expected output	Actual Output	Result

1	1	1	passed
2	2	2	Passed
3	3	3	Passed
4	4	4	Passed
5	5	5	Passed
6	6	6	Passed
7	7	7	Passed
8	8	8	Passed
9	9	9	Passed
0	0	0	Passed

Batch counting

Table 5: Batch count mode test

Input	**Expected output**	**Actual Ouput**	**Result**
10	10	10	Passed
15	15	15	Passed
20	20	20	Passed
30	30	30	Passed

Normal Counting

Table 6: Whole count mode test

Input	**Expected output**	**Actual Ouput**	**Result**
10	10	10	Passed
15	15	15	Passed
20	20	20	Passed
30	30	30	Passed

4.2.6 Configuration and calculation tests

During the testing phase, specific attention will be given to the configuration and calculation aspects of the automated tablet counting device.

Calculation Accuracy Test:

Develop a set of test cases with known inputs and expected outputs to validate the accuracy of the device's calculations.

Verify that the device correctly counts and displays the number of tablets or capsules based on the poured quantity.

Test the device's ability to handle different tablet sizes, shapes without compromising the counting accuracy.

Batch counting

Input	Expected output	Actual Ouput	Result
10	10	10	Passed
15	15	15	Passed
20	20	20	Passed
30	30	30	Passed

Normal Counting

Input	Expected output	Actual Ouput	Result
10	10	10	Passed
15	15	15	Passed
20	20	20	Passed
30	30	30	Passed

Reliability Verification Test:

Verify that the device's calibration settings can be adjusted or reset as per the manufacturer's instructions.

Ensure that the device maintains its calibration even after power cycles or prolonged usage.

Error Handling Test:

Introduce abnormal or erroneous scenarios, such as invalid input or unexpected environmental conditions, to assess the device's error handling capabilities.

Verify that the device detects and appropriately responds to errors, providing clear feedback to the user through error codes.

By conducting these configuration and calculation tests, we aim to ensure that the automated tablet counting device integrates effectively with the platform and network, performs accurate calculations, maintains calibration integrity, and handles errors efficiently. The test results will help identify any configuration or calculation-related issues and allow for necessary adjustments or improvements to be made.

4.3 Precautions

4.3.1 Anomalous conditions

The following are the potential anomalies that can occur in the device

1. Sensor Malfunction: The sensor responsible for detecting and counting tablets and capsules may experience malfunctions, leading to inaccurate counting or failure to detect certain medications. This can be due to misalignment of the sender and receiver ends of the laser sensor. This could result in incorrect dispensing of medication or inaccurate stock-taking.

2. Motor Failure: The motor that moves the tablets and capsules through the counting process may encounter issues such as jamming or malfunctioning, leading to disruptions in the counting process or inability to count accurately.

3. Communication Errors: Anomalies in the communication between different components of the device, such as the sensor, motor, display, and keypad, could occur. This could result in incorrect data transmission, leading to inaccurate counting or malfunctioning of the device.

4. Software Glitches: Anomalies in the software controlling the automated tablet counting device could lead to unexpected behavior or errors. A high power surge may damage the display(4-digit-multi seven segment), it also may damage the LED lights, and other components of the device. This could include issues with calculation errors, or system crashes.

5. Power Supply Problems: Anomalies related to the power supply, such as voltage fluctuations or power surges, could impact the device's performance and accuracy. This could result in device downtime.

6. Tablet/Capsule Jamming: The device may experience issues with tablets or capsules getting stuck or jammed in the counting mechanism. This could lead to inaccurate counts or even damage to the device if not addressed promptly.

7. Environmental Interference: Anomalies caused by external factors such as electromagnetic interference or ambient lighting conditions could affect the accuracy of the device's sensors, leading to incorrect counting results.

8. Calibration Drift: Over time, the calibration of the device's sensors and components may drift, resulting in deviations from the accurate counting measurements.

4.3.2 Precautionary steps taken

To circumvent the potential anomalies mentioned earlier, here are some precautions that can be taken:

1. Regular Maintenance: Implementing a regular maintenance schedule to inspect and clean the device, ensuring that all components are in good working condition. This includes cleaning the plate, checking for any obstructions or jammed tablets/capsules, and lubricating moving parts as necessary.

2. Calibration and Testing: Performing regular calibration of the device's sensors and components to ensure accurate counting. This involves verifying the device's measurements against known standards and making adjustments if needed. Additionally, conduct periodic testing to validate the device's performance and accuracy.

3. Environmental Control: Maintaining a controlled environment for the device by protecting it from excessive heat, humidity, dust, and electromagnetic interference. This can be achieved by storing the device in a clean and dry area, away from direct sunlight and sources of electromagnetic interference.

4. User Training: Providing comprehensive training to users on the proper operation of the device by emphasizing the importance of following instructions; entering appropriate input, and handling

tablets and capsules correctly. This can help minimize user input errors and ensure consistent and accurate results.

5. Software/Firmware Updates: Keeping the device's software and firmware up to date by installing the latest updates and patches. This helps address any known software glitches or compatibility issues that could lead to anomalies.

6. Quality Assurance and Testing: Conducting thorough quality assurance testing during the development and manufacturing process to identify and address potential anomalies. This includes rigorous testing of the device's components, software, and overall functionality to ensure reliability and accuracy.

By implementing these precautions, healthcare facilities can minimize the occurrence of anomalies and ensure that the Automated Tablet and Capsule Counter device operates effectively, accurately, and reliably.

Chapter 5: Installation and system acceptance test

5.1 Input files

None

5.2 Supplementary files

None.

5.3 Installation qualification

To ensure the correct installation of the Automated Tablet and Capsule Counting Device, the following steps will be taken:

- Place the Automated Tablet and Capsule Counting Device in the desired location.
- Connect the power cable to a stable power source and ensure that it starts successfully.
- Functional Verification: Perform a functional verification test to ensure that all components of the device are operational, including the numeric keypad, 4-digit 7-segment display, LED indicators, outlet container, and inlet valve. Verify that the device responds appropriately to user inputs and displays accurate count values.

Checklist of the Installation and system acceptance test

Table 7: Checklist of the Installation and System Acceptance Test

Topics	**Installation summary**
Installation method	☒Plug the device in power. Person responsible: Pharmacist or Dispenser.

Installation Procedure Check

Table 8: Installation Procedure Check

Topics	**Installation procedure**	*Date / Initials*
Authorization	☐ Authorization Person responsible: Pharmacist or Dispenser	
Installation test.	☒Tested and approved in a test environment ☐ Tested and approved in actual environment ☐ Completely tested according to test plan ☒Partly tested (known extent of update) Comments:	19/06/2023, JT, NA

Chapter 6: Performance, servicing, maintenance, and phase out.

6.1 Service and Maintenance

Service and maintenance for the Automated Tablet and Capsule Counting Device will be crucial to ensure its continued functionality and accuracy. The device should be regularly serviced and maintained to prevent any issues that may arise during its use. Future updates and modifications may also be necessary to improve the device's performance and address any issues that may arise. In case of any problems, users should be able to contact the manufacturer or supplier for support and problem resolution.

6.2 Performance and Maintenance

Performance and maintenance are critical factors for ensuring the efficient and reliable operation of the automated tablets/capsule counter device. In this phase, we focus on meeting the requirements for service, maintenance, performance, and support to deliver a high-quality product to our clients.

Service Requirements: To provide exceptional service, our device is accompanied by a comprehensive service plan. This plan includes regular inspections, cleaning, and preventative maintenance procedures. By adhering to these guidelines, we can ensure accurate counting and minimize downtime.

Maintenance Requirements: We have established clear maintenance guidelines to optimize the performance and longevity of the device. These guidelines are; sensor efficiency checks, motor efficiency checks, and software updates. By following these guidelines, the device shall have maximum efficiency and minimize the risk of errors.

Performance Requirements: The performance of our automated tablets/capsule counting device is a top priority. We have designed the device to count tablets or capsules accurately and swiftly.

Support Requirements: We understand the importance of providing comprehensive support for the device. Our support services include technical assistance, troubleshooting guidance and software updates.

Incorporating Changes: To stay ahead in the ever-evolving landscape, we recognize the need to incorporate changes into our device. These changes may be driven by technological advancements, customer feedback, or regulatory compliance. We continuously monitor the market and industry trends to identify areas for improvement. By incorporating changes such as new tablet or capsule designs, enhanced counting algorithms to ensure that our device remains at the forefront of innovation.

Software Upgrades: Regular software upgrades are essential to keep our device up-to-date with the latest technologies and performance enhancements. It includes thorough testing, bug fixes, and the addition of new features. These upgrades are designed to enhance the device's functionality and ensure optimal performance.

Performance and maintenance details

Table 9: Perfomance and Maintenance details

Topics	**Performance and maintenance**	*Date / Initials*
Problem / solution	**Problem:** Power supply issues. **Solution:** Regular maintenance and replacement of power cables to prevent faults. Ensure that the power supplied is stable. **Problem:** Slow or Inaccurate counting. **Solution:** Ensuring that the sensor is properly aligned.	**Date:** 01/11/2023 **Initials:** (JT), (NA)
Functional maintenance	If there are any changes in standard required to be met by pharmaceutical devices, the device should be manually updated accordingly.	**Date:** not specific. **Initials:** (SS), (QM) 01/11/2023

Topics	**Performance and maintenance**	*Date / Initials*
Functional expansion and performance improvement	Adding a bluetooth module to send count results to a mobile app in order to achieve automatic record keeping. This is important to keep track counting sessions.	**Date:** 01/07/2023 **Initials:** (JT), (QM), (SS), (NA)

Chapter 7: Conclusion and Recommendations

In conclusion, the development of an automated tablet/capsule counting device has been successfully achieved. The device uses a sensor to detect tables/capsules while being counted. The microcontroller-based system and user interface provide a user-friendly experience for users to input specific parameters and obtain accurate results.

The device was tested using different types of tablets/capsules with varying sizes and shapes, and the results showed an accuracy rate of 100%. However, there are still areas for improvement. The device's performance and maintenance details should be regularly monitored and updated to ensure that it remains compliant with the latest standards and regulations. Additionally, further testing should be conducted to ensure that the device can accurately count and sort a wider range of tablets/capsules.

Based on the findings of this project, it is recommended that further research be conducted to improve the device's accuracy and expand its capabilities. The device has the potential to revolutionize the pharmaceutical industry by providing a more efficient and accurate method of counting tablets/capsules. With further development and improvement, the device could become a valuable asset to the industry.

APPENDICES

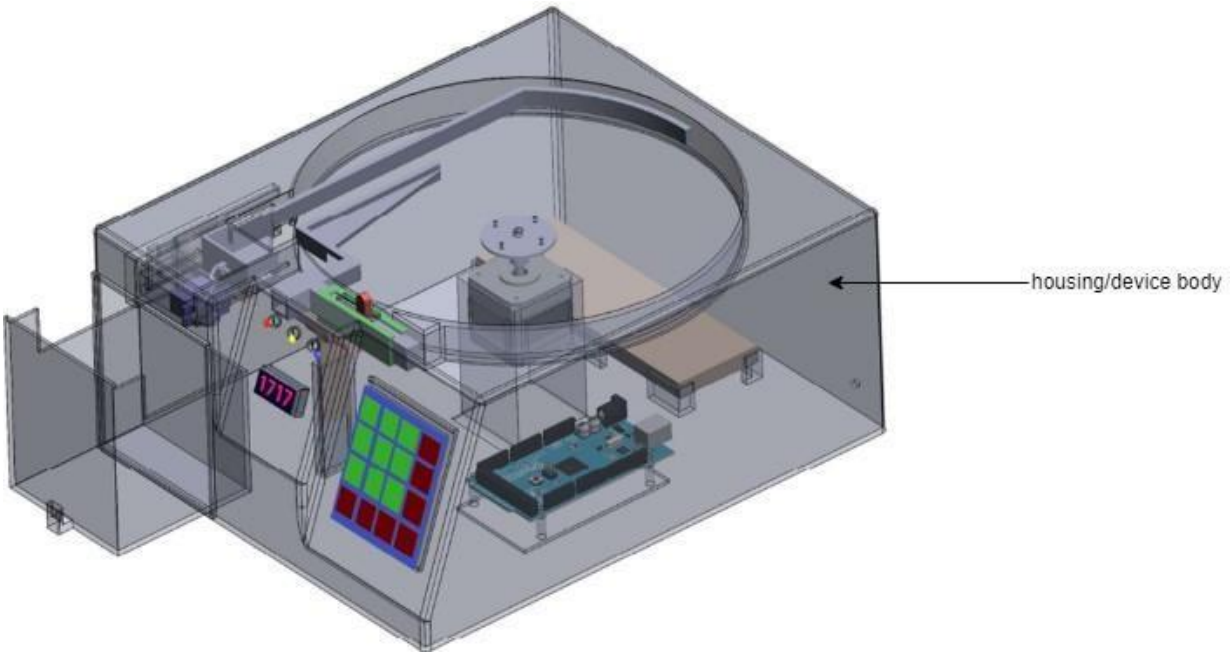

Figure 15: A 3D view of the design modelled in SOLIDWORKS 3D DESIGN TOOL

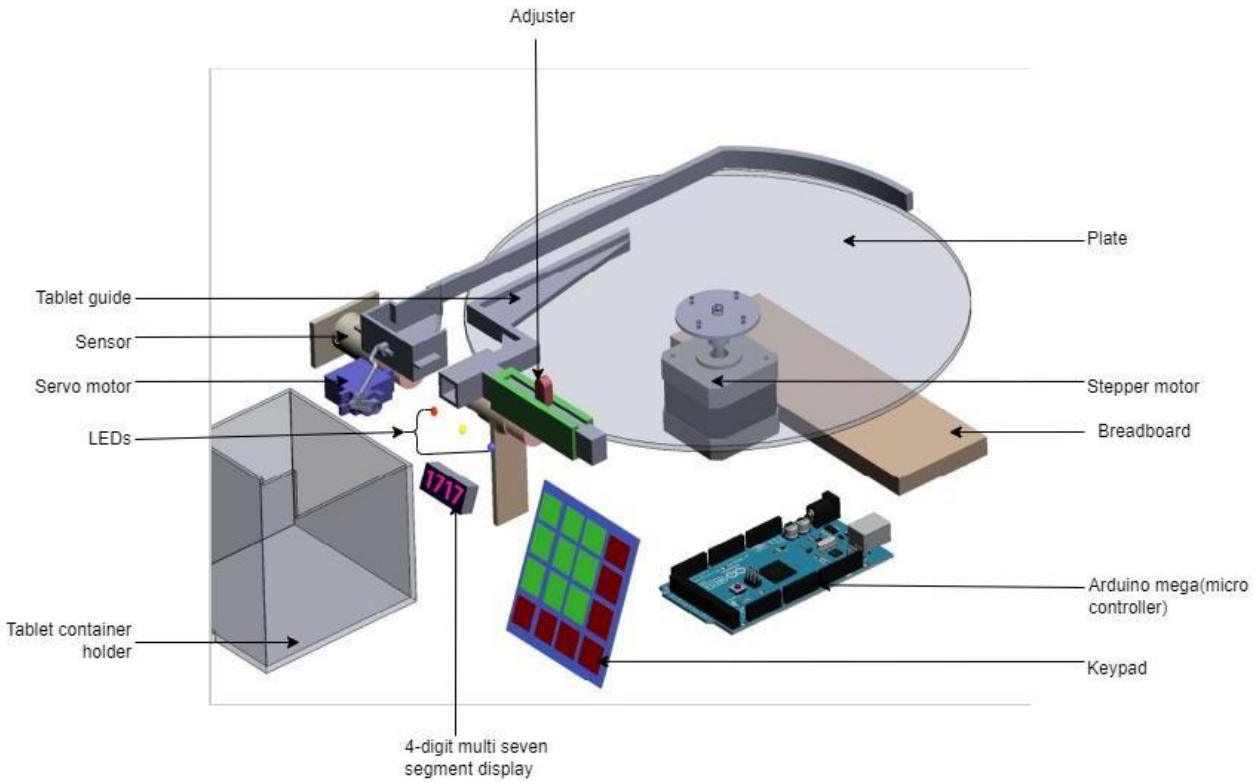

Figure 16: A component view of the 3D design of the ATCCD

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THE USER MANUAL

Table of Contents

USER MANUAL

Introduction

This user manual provides instructions on how to use the automated tablet or capsule counter device. The device is designed to count tablets or capsules automatically, and it can be used in a variety of settings, such as hospitals, clinics, and pharmacies.

Safety Precautions

- Read all instructions before using the device.
- Do not use the device if it is damaged.
- Keep the device out of reach of children.
- Do not use the device near water or other liquids.
- Do not use the device if it is not properly grounded.

Hardware Overview

The automated tablet or capsule counter device consists of the following components:

1. **Keypad**
   Allows users to input numeric values and commands.

Figure 17: Keypad and the LEDs indicating whole mode and batch mode of counting

What each key represents

1) **Numeric Keys:**
   These keys are 1, 2, 3, 4, 5, 6, 7, 8, 9 and 0. They are used to enter in a number of desired tablets that are to be counted.

2) **WM Key:** Once pressed, the device is set into the whole mode state.

3) **Stop Key:** Once pressed, the motor stops rotating, inlet valve is closed and the counting mechanism stopped.

4) **Start:** Once pressed, the counting mechanism is started, regardless of whether the device is in whole mode state or batch mode state.

5) **BM Key:** Once pressed, the device is set into the batch mode state.

6) **Reset Key:** Once pressed, whatever value is on the display is cleared and it the displays shows a zero.

2. **4-Digit multi seven segment display**
   Provides a clear and visible representation of the current count.

3. **Plate**
   The designated area where tablets or capsules are loaded for counting.

4. **Power cable.**
   Connects the ATCCD device to a stable power source for operation.

5. **Drawable tablet container to hold counted tablets.**
   A container specifically designed to hold the tablets or capsules that have been counted.

6. **LED lights**
   The device incorporates LED lights, including a blue light for batch counting mode and a yellow light for whole counting mode.

Figure showing the external components of the device stated above:

Figure 18: The Automated Tablet or Capsule Counter Device

Software Overview

The device is controlled by a software program that is stored in the device's memory. The software program controls all the hardware components of the ATCCD. That is stepper motor, display, servo motor, LEDs, sensor, and allows for the operation of the counting mechanism. It also executes commands entered from the keypad.

How To Use The ATCCD Device

To operate the device effectively, please follow the step-by-step instructions below:

Step 1. Power On Device:
Plug the power cable of the device into power by connecting the power cable to a stable power source.
On powering the ATCCD device, it displays the last count value. This way, if power is cut off unwillingly during the counting mechanism, the user can be able to know how many tablets they counted in the last use of the device.

Step 2. Loading:
Place the tablets or capsules onto the plate of the device.

Step 3. Mode Selection:

Select the counting mode by pressing either the WM Key to count all the tablets placed onto the plate or BM Key to count a desired number of tablets from the ones placed onto the plate. Two modes are available: batch mode and whole mode.
In batch mode, the user specifies the desired count, and the blue LED light indicates that the device is in batch counting mode. The yellow LED light indicates that the device is in whole counting mode.

Step 4. Start count:
Press the "Start Key" to start the counting process or mechanism.

Step 5. Counting Process/Mechanism:
The device utilizes embedded systems to accurately count the tablets or capsules placed onto the plate.

Step 6. Result Display:
During the counting process/mechanism, the device displays a real-time value of the number of tablets counted so far. After the counting process is completed, the device will display the total count of tablets or capsules on its interface.

Step 7. Unloading: Once the counting process is finished, safely remove the counted tablets or capsules from the drawable tablet container.

Troubleshooting

If the device is not working properly, try the following troubleshooting steps:

- Check the power supply. Check to see if the power cable is well plugged in. Check to see if the power supply is stable.
- Clear the count and start over by pressing the Reset Key.
- If the problem persists, contact the manufacturer for assistance.

Maintenance

The device requires minimal maintenance. To clean the device, simply wipe it with a damp cloth. Do not use any harsh chemicals to clean the device.

Specifications

The following are the specifications for the automated tablet or capsule counter device:

- Display: Features a 4-digit Multi-seven segment display.
- Control panel: Consists of a Keypad for entering of commands and user numeric count values.
- Power supply: Requires DC 12V power input.
- Dimensions: 32cm by 25cm by 13cm

Contact Information

For more information, please contact the manufacturer at:

Phone Number: 0779197590 or 0702612673 or 0701415802 or 0756869808
Email Address: jumatee8@gmail.com