Feb 12, 2023

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Subject: ENSC 405W Requirements Specification for CashGrab

Dear Dr. Hegedus,

This letter of transmittal is accompanied by the requirement specification document for our capstone project for ENSC 405W/440. The goal of this project is to address and resolve the issues associated with cash transactions such as employee theft, human error, counterfeit currency, and cross-contamination from interactions with cash.

To accomplish this goal, a point of sale (PoS) device will be developed to automatically process cash payments and thus eliminate the possibility of human error. The validity of the inserted bank notes will be verified by computer vision technology.

The target market for this product are businesses that heavily rely on cash such as retailers in the food truck industry. Through market research and direct interviews with food truck owners, a list of requirements to help guide the design of the product was gathered by the company. The following document outlines the requirements of the overall system, the mechanical system, the electrical system, the software system, as well as the safety and sustainability of the product. In addition, this document provides a timeline indicating the implementation state of each requirement.

The team working on this project consists of students studying computer engineering, systems engineering, and electronics engineering.

Your time investment in reviewing our requirements specification document for CashGrab is appreciated. If you have any questions or concerns regarding the requirements, Dakota Crozier, our Chief Communications Officer, can be contacted via email at dakotac@sfu.ca.

Sincerely,
Jacob Forrest
CEO
Payment Peers

Requirements Specification: CashGrab

Company 07

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Abstract

This document outlines the requirements for Payment Peer's device CashGrab - an autonomous system that can be used to aid the processing of cash transactions. These requirements were developed through interviews conducted with two food truck owners in addition to brainstorming amongst members of the group. Requirements were organized into the following categories: system, mechanical, electrical, software, engineering and government standards, and safety and sustainability. For some of these categories, further organization was done to create sub-categories such as cash transport, security, and display, to name a few. Furthermore, requirement tracing conventions were also added to identify if a requirement needs to be developed during the proof of concept stage (A), engineering prototype (B), or production version (C).

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Glossary

Term	Definition
PoS	A Point of sale (PoS) system is a computerized network used to process transactions and record sales in retail stores and other commercial establishments.
Microcontroller	A microcontroller is a compact computer chip used to control electronic devices and systems.

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1 Introduction

Our company is working on creating an automated PoS system, with cash as an accepted form of payment, for food truck vendors that is affordable, compact, secure, accurate, and convenient to use. This will be implemented using a camera connected to a microcontroller which runs computer vision algorithms to identify the bills inserted by the customer. Mechanical components such as servo motors will be used to create a conveyor for transporting bills from the insertion point to the safety deposit box. Additionally, a display and numbered key pad will be added for staff to set pricing, view the payment transaction, and total cash value.

The food truck industry is a global industry with a market size of $3.93 billion USD and is expected to expand at a compound annual growth rate (CAGR) of 6.8% [1]. However, food truck owners face serious problems that make business operations more difficult. One problem that food truck owners face is cross-contamination through the contact of money and food [2]. From our interview, due to the small area inside food trucks, employees are less likely to wash their hands immediately after handling a cash transaction.

Additionally, food truck owners have to manage loss of profits due to theft and human error. Every year, Canadian businesses lose about $1.4 billion dollars due to employee theft [3]. The average employee steals about $2,500, in cash or goods from their employer before they are caught [3]. This is usually done in small increments, making it more difficult for the employer to detect. Consequently, more than half a million thefts go undetected each year in Canada, although this is likely an underestimate [3].

One solution that businesses have implemented to minimize the effect of employee theft is security cameras. This solution may deter some employees from stealing but some brazen employees are unafraid to steal from the tills believing that no one is watching the cameras [3]. Alternatively, food truck owners can resort to using automated point of sale systems capable of handling cash transactions. Although there are many point of sale solutions already, many of these systems are only capable of accepting credit or debit cards as payment. Systems capable of accepting cash, credit, and debit are often too large to fit inside a food truck and are expensive to purchase.

2 System Overview

CashGrab is an automated PoS system designed specifically for cash transactions. In order to eliminate the possibility of human error, malicious activity, or cross-contamination, the system is designed to accept and verify cash transactions without requiring employees to physically handle any money. The CashGrab machine utilizes servo motors to implement a conveyor system that handles the task of transporting cash from the insertion mechanism on the customer interface to the verification hold. Once a banknote has arrived in the verification hold, an internal camera is used to capture images of the banknote. The image data is then processed by a computer vision algorithm to determine its legitimacy. If the banknote is accepted, the microcontroller will send a control signal to the motors to resume transporting the bill to the storage register. In the case that the banknote is rejected, the microcontroller will send a control signal to run the motors in reverse and dispense the bill. The software also stores a record of all transactions which can be retrieved from a web application. Figure 1 depicts the overall system interactions.
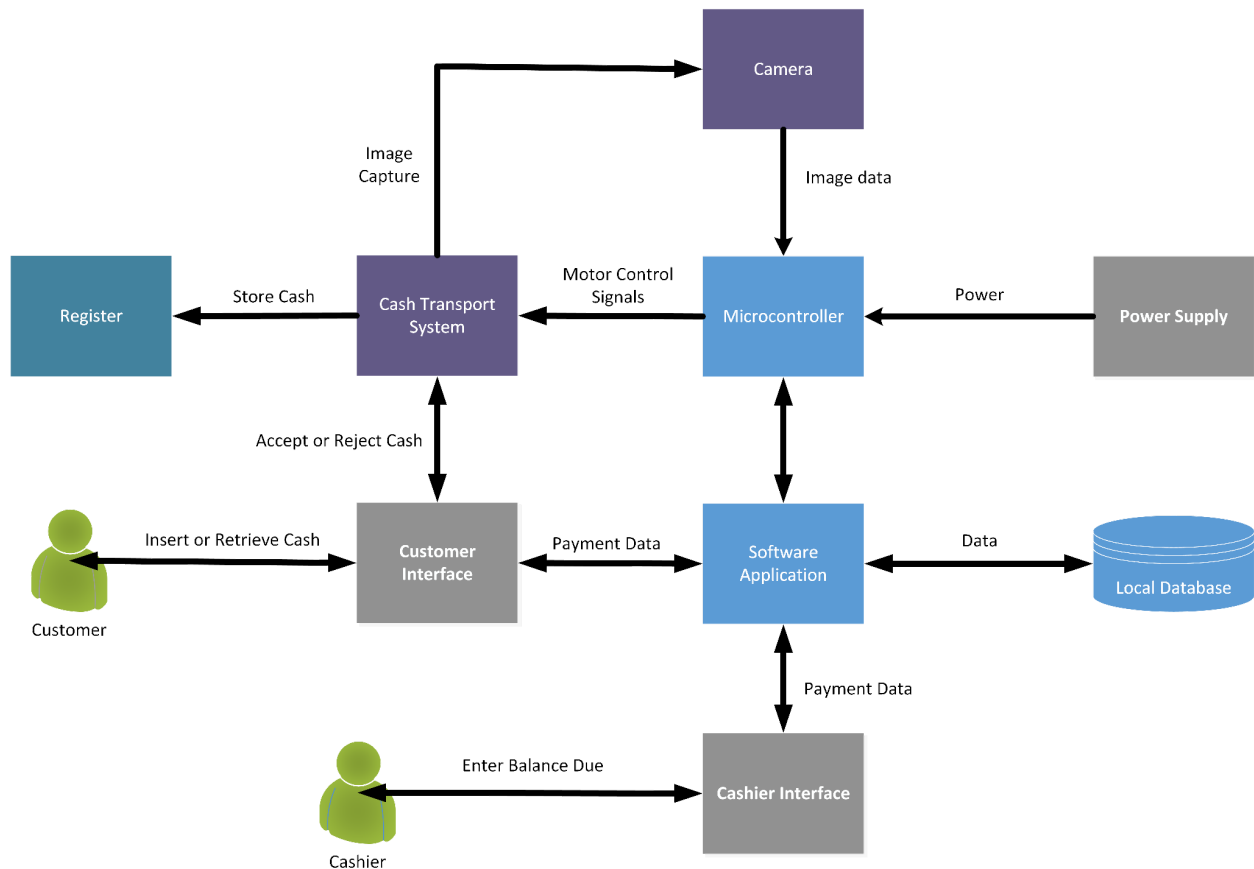
Figure 1 - CashGrab System Block Diagram

To prevent confusion and frustration for customers, the CashGrab interfaces have been designed to be very simple and intuitive. The simple interface reduces transaction friction and makes it easy for employees to process transactions quickly. A simple illustration of the customer-facing interface of the machine is shown in figure 2. The cashier-facing interface is illustrated in figure 3. The transaction price is input using the number key pad shown in figure 4.

Figure 2 - CashGrab Customer Interface

Figure 3 - CashGrab Cashier Interface

Figure 4 - CashGrab Cashier Numeric Key Pad

3 Requirements

The requirements in this document are organized according to the following convention:

Req {Section}.{Requirement Number} {Stage of Development}

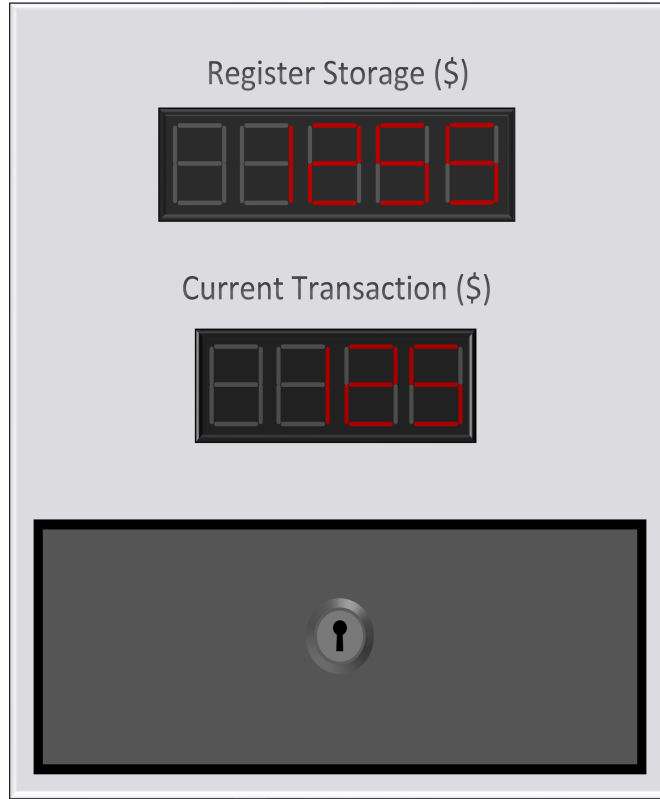| Encoding	Stage of Development
A	Proof-of-concept
B	Engineering Prototype
C	Production Version

Table 1- Development Stage Encoding

The Proof-of-concept requirements will be met by the end of ENSC 405W. The Engineering Prototype requirements will be met by the end of ENSC 440W. The Production Version requirements of the product should all be met by the time it is production.

3.1 Overall System Requirements

The overall system requirements section primarily describes non-technical requirements that our automated PoS system should possess. These requirements describe how the cashier and user interacts with the device, and operating conditions. Overall system requirements were selected with respect to device usability and interfaces.

Requirement ID	Requirement Description
Req 3.1.1 A	The device should be capable of displaying the remaining balance to the customer during a transaction
Req 3.1.2 A	The device should be able to accept and classify Canadian banknotes
Req 3.1.3 B	The device should display the overall, and owing amounts to the cashier
Req 3.1.4 B	The device should provide a keypad for the cashier to input the owed amount
Req 3.1.5 B	The device should display items for sale and their prices
Req 3.1.6 B	The banknotes in the register storage should be unlockable and accessible by the owner

Req 3.1.7 B	The customer interface should provide a cash insertion mechanism
Req 3.1.8 B	The device should have a user-friendly interface that is easy to navigate and understand
Req 3.1.9 C	The device should be powered via electrical outlet
Req 3.1.10 C	The device should operate in temperatures ranging from -20-50℃
Req 3.1.11 C	The device should be durable enough to sustain daily, and long-term use
Req 3.1.12 C	The device should function in an outdoor environment
Req 3.1.13 C	The system should be able to be integrated with other PoS systems

Table 2 - Overall System Requirements

3.2 Mechanical Requirements

3.2.1 Cash Transport System Requirements

Cash transport system requirements were created to ensure that the quality of inserted currency is preserved through usage of the system. These requirements will ensure that any currency that is used in the CashGrab system encounters minimal or no damage, and maintain their usability as legal tender after passing through the system.

Requirement ID	Requirement Description
Req 3.2.1.1 A	The internal mechanisms should not damage bills passing through
Req 3.2.1.2 B	The transport mechanism should not stall
Req 3.2.1.3 B	The insertion point should fit all Canadian banknotes
Req 3.2.1.4 B	The insertion point should restrict the user from forcing multiple bills in at once

Table 3 - Cash Transport System Requirements

3.2.2 Security Requirements

Security requirements were created to ensure that cash deposited by customers are stored in a safe manner. These requirements should make it more difficult for thieves to break into the cash deposit box. Additionally, security measures are added to protect sensitive user transaction data from being leaked.

Requirement ID	Requirement Description
Req 3.2.2.1 B	The cash safe should not break open if the device is dropped
Req 3.2.2.2 B	The cash safe should not be able to be cut into by a blade
Req 3.2.2.3 B	The cash safe should remain locked if power supply cuts out
Req 3.2.2.4 B	The cash safe should not be accessible by the customer
Req 3.2.2.5 C	Confidentiality of transactions history should be maintained
Req 3.2.2.6 C	The device should alarm when the cash register is tampered with

Table 4 - Security Requirements

3.3 Electrical Requirements

The electrical integrity of our system is to be shown in an organized manner by the electrical requirements, which should enable the system to operate at its maximum operating load from any power outlet.

Requirement ID	Requirement Description
Req 3.3.1 A	The device should require minimal electrical load from a 120V supply voltage
Req 3.3.2 C	The control/power board should occupy minimal space in the device

Table 5 - Electrical Requirements

3.4 Software Requirements

3.4.1 Overall Software System Requirements

The overall software system requirements were created to ensure the functionality of cash management, and administrative abilities. The cash management portion of the requirements were added to ensure that the system will provide vital feedback to the customer such as remaining owed amount. The administrative requirements were added to ensure that the manager, or other administrator can perform necessary tasks such as changing the price of goods, and obtaining sale information for recordkeeping purposes.

Requirement ID	Requirement Description
Req 3.4.1.1 A	The system should update the database when total amount of cash deposited changes
Req 3.4.1.2 A	The system should update the database when the count of each denomination changes
Req 3.4.1.3 A	The system should inform the user of the price of product
Req 3.4.1.4 A	The system should calculate the difference between price of product and amount deposited by user
Req 3.4.1.5 B	The system should calculate total price of transaction when there is more than one item
Req 3.4.1.6 B	The system should allow users to login and logout of the system
Req 3.4.1.7 C	The system should provide admin functionality to users based on the permissions specified to the user
Req 3.4.1.8 C	The system should provide functionality to set user permissions
Req 3.4.1.9 C	The system should provide authorized users with functionality add and remove items from the inventory
Req 3.4.1.10 C	The system should provide authorized users with functionality to edit the price of current items
Req 3.4.1.11 C	The system should provide functionality to retrieve transaction information and records

Table 6 - Overall Software System Requirements

3.4.2 Currency Detection Requirements

The currency detection requirements were created to establish the usability and reliability of the system. The currency detection requirements specify that valid inserted currency will be properly detected, regardless of the facing of the inserted currency, valid inserted currency with reasonable but not debilitating damage will also be detected, and invalid bills will not be accepted so customers cannot pay through clearly fraudulent methods. The delay of the currency detection was considered to ensure that the system's latency does not prove a hindrance.

Requirement ID	Requirement Description
Req 3.4.2.1 A	The currency detection software should be able to detect Canadian banknote denominations with high accuracy
Req 3.4.2.2 A	The currency detection software should be able to detect the inserted banknotes independently of the insertion orientation
Req 3.4.2.3 A	The currency detection software should be able to detect and reject non-currency notes
Req 3.4.2.4 B	The currency detection software should be able to correctly detect slightly damaged banknotes
Req 3.4.2.5 C	The currency detection software should be able to detect and reject counterfeit banknotes

Table 7 - Currency Detection Requirements

3.4.3 Web Interface Requirements

The web interface requirements was a section made to clarify the responsibilities of the off board software for the device. The main purpose of the web interface is to facilitate more complex operations of the device such as financial record exporting without needing physical access to the device. This interface will limit cashier access to important operations, such as removing money, further decreasing the risk of theft as only employees with explicit permission will have access.

Requirement ID	Requirement Description
Req 3.4.3.1 A	The system should allow authorized users to view the current amount of money stored in the register via web interface
Req 3.4.3.2 B	The web interface should provide offline access device via wired connection
Req 3.4.3.3 B	The web interface should allow authorized users to view the transaction history of device
Req 3.4.3.4 C	The web interface should provide functionality to export financial data and transaction history
Req 3.4.3.5 C	The web interface should allow authorized devices to remotely access the system

Table 8 - Web Interface Requirements

3.5 Engineering and Government Standards

The engineering and government standards section was made to acknowledge the relevant standards and regulation that will be dutifully followed and applied in product design.

Requirement ID	Requirement Description
Req 3.5.1 A	Uphold standards of EGBC code of ethics [4]
Req 3.5.2 A	Do not impose any damage or defacement to legal tender [5]
Req 3.5.3 B	Not accept counterfeit currency as payment and alert authorities if needed [5]
Req 3.5.4 B	Complete all defined essential steps for merchant transactions
Req 3.5.5 C	Proper exporting format of financial records for bookkeeping and audit compliance [6]
Req 3.5.6 C	Ensure device power supply follows External power supplies & Energy Efficiency Regulations [7]

Table 9 - Engineering and Government Standards

3.6 Safety and Sustainability Requirements

Our conception of CashGrab will contain various mechanical and electrical components which will need to be fully enclosed and hidden from users. Our intention is to create a safe device that will protect users from electrical and fire hazards. In addition, our final product will implement safety features such as the suspension of service when internal temperatures rise to unsafe levels.

In terms of sustainability, the composition of our device will use clean and safe materials that will not harm the user or the environment. In addition, to prevent the degradation and discarding of device parts, we will build a robust cover that will protect the internal components of the device. Throughout the different stages and beyond, components such as servos and microcontrollers will be utilized and reused, and components already owned by group members will be sought for recycling and repurposing.

Requirement ID	Requirement Description
Req 3.6.1 B	The product's electronics should be enclosed and electrically shielded to prevent electric shock
Req 3.6.2 B	The electrical and mechanical components should be fully confined within the device
Req 3.6.3 B	The exterior of the device should have blunt edges for user safety
Req 3.6.4 C	The exterior and internal wiring of the device should not be composed of flammable material and should not pose any electrical hazards
Req 3.6.5 C	The device should turn off when the internal temperature rises to unsafe levels
Req 3.6.6 C	The cash slot should be as small as possible to prevent users from accidentally inserting fingers and other objects
Req 3.6.7 C	The device should be composed from safe and harmless materials

Table 10 - Safety and Sustainability Requirements

3.7 System Constraints

Constraint ID	Constraint Description
Con 3.7.1 A	The system should be able to run on a microcontroller, or other comparably specced hardware
Con 3.7.2 A	The system should be able to function with the limited ports provided by a microcontroller
Con 3.7.3 B	The system should be able to detect banknotes regardless of the lighting environment of the device
Con 3.7.4 B	The system should have a latency low enough to not impede transaction speed
Con 3.7.5 B	The device should be small enough to fit on a table
Con 3.7.6 C	The cost to manufacture device should be under $500
Con 3.7.7 C	Total device weight should be under 10kg

Table 11 - System Constraints

4 Conclusion

CashGrab aims to address the following issues associated with cash transactions: employee theft, human error, counterfeit currency, and cross-contamination from interactions with cash. Our product will primarily target the food truck market. At a high level, the requirement specifications have been chosen to accommodate both usability needs of the device, and the specific constraints of food truck businesses.

Specific requirements outline the functionalities of the general system, cash transport components, security concerns, electrical components, general software components, currency detection components, and web interface components. Additionally, the requirements outline compliance with relevant engineering and government standards, and safety and sustainability considerations.

5 Appendix

The Proof of Concept (PoC) deliverables that will presented in the 405W poster presentation are as follows:
- Cash transport system
- Currency counting and counterfeit detection on a laptop
- Device to display relevant information such as remaining cash owed by customer

6 References

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