# KANTIPUR ENGINEERING COLLEGE

**(Affiliated to Tribhuvan University)**

**Dhapakhel, Lalitpur**


**[Subject Code: EX755]**

**A MAJOR PROJECT FINAL REPORT**

**ON**

# SMART VENDING MACHINE

**Submitted by:**

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**A MAJOR PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR IN ELECTRONIC AND COMMUNICATION ENGINEERING**

**Submitted to:**

**Department of Computer and Electronics Engineering**

**March, 2021**

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# KANTIPUR ENGINEERING COLLEGE
## DEPARTMENT OF COMPUTER AND ELECTRONICS ENGINEERING

# APPROVAL LETTER

The undersigned certify that they have read and recommended to the Institute of Engineering for acceptance, a project report entitled ”Smart Vending Machine” submitted by

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in partial fulfillment for the degree of Bachelor in Electronic and Communication Engineering.

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Date: March 4, 2021

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We would like to record our appreciation to our Head of Department. **Er. Rabindra Khati**, as well as the RTCD for this valuable encouragement for initiating the project. His effort will create the environment and infrastructure to our project. We would like to thank **Er. Sujin Gwachha**, our project head who gave us generously his time and thoughts for selecting our project and discussing the problems and issues that may be encountered during the process of working. we are very much indebted to his support and encouragement for the initial progressing of this project. We would like to thank **Er. Manoj Gyawali**, our project supervisor and mentor who help us throughout the project by providing proper guidance and advises.

Also we would like to express our sincere thanks to our seniors and our teachers for inspiration and generous help and idea in the project.

We would like to express our heartfelt gratitude to all the people who have directly and indirectly helped to initiate this project and we will expect for their support up to the completion of the project.

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# ABSTRACT

Today's vending machines are evolving to be more than just vending machines. With high-definition displays running rich graphics, the ability to interact with the customer, and more, enables continuing innovation to benefit both the customer and virtually everyone in the vending industry. The Smart Vending now offers solution to exceptional shopping experiences to the customers all over the world and has completely changed our typical view towards vending machines of the past.

The main purpose of this project is to create efficient management, interactive and exceptional customer service vending machine. In this approach, we put forward the design of server based(remote) monitoring of system and products' data. According to products data , product's cost, quantity and quality are maintained. When item in vending machine are going to be out of stock, it alerts the owner through server so that owner can restock before in time. A customer has availability of both cash or card as payment method. It makes easier for customer by providing facility to vend multiple items at a time. The ultimate goal is to produce user friendly vending machine to enhance customer purchasing experience as well as easily manageable by a owner.

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# CHAPTER 1
# INTRODUCTION

## 1.1 Background

A vending machine is an automated machine that provides items such as snacks, beverages, cigarettes and lottery tickets to consumers after money, a credit card, or a specially designed card is inserted into the machine.

Traditional vending machine works as when sufficient coin is inserted then customer selects item by using keypads or buttons and item is dropped down to a receiving window. Vending machines exist in many countries, and in more recent times, specialized vending machines that provide less common products compared to traditional vending machine items have been created.

Currently the world is becoming more and more digital and development of smart technologies traditional vending machine is becoming less and less usable or efficient. To improve and reinforce the services of traditional vending machines,this device provides an intelligent solution to facilitate their functions. Along with the coming of the Internet of Things (IoT) age and its increasing prevalence in our daily lives, this project utilizes the principle of IoT. Also it can be easily integrated with additional features such as digital advertising, marketing or consumer gesture recognition, as necessary. In combination with Cloud Platform, it can also provide several additional services, such as central pricing management and real-time sales data analytics.

## 1.2 Problem Statement

As for common vending machine,running out of products is bound to happen in vending machines, especially if you have an infrequent restocking schedule. When there arises any systematic error in machine, the arrival of professionals for repair is very delayed due to lack of information to owner. Traditional vending machine uses only cash or coin payment system.

Our purposed system is capable of mitigating above problems.Product stock, system error, product transaction are analyzed by server based system remotely and are restock and repaired in time without delay. Our system is capable of both cashless and cash payment.

## 1.3 Objective

- To make user friendly vending machine to enhance their purchasing experience.
- To implement server based analysis system so that owner can monitor remotely.
- To produce vending machine which can provide multiple payment option i.e. cash or card.
- To implement multiple items purchasing vending machine at a time.

## 1.4 Features

- Reduce operating costs by knowing exactly what and when to restock.
- Better product offering by identifying top selling items and slow moving ones in real time.
- Adjust product pricing remotely in real-time.
- Reduce machine downtime with real-time alerts.
- Multiple-item vend in one transaction.

## 1.5 Feasibility Analysis

A feasibility study is an analysis of how successfully a project can be implemented, accounting different factors that may affect it. The contents and recommendations of this feasibility study helped us as a sound basis for deciding how to proceed the project. It helped in making decisions such as which software to use for development, hardware combinations, etc.

### 1.5.1 Operational Feasibility

The most of electronics component used in our project are familiar so they can be operated without any difficult problems.There might arise problem while serial communication between Raspberry Pi and Arduino DUE but other else operation are feasible.

### 1.5.2 Economic Feasibility

The most of the components are easily available in local Electronics Market and College. The main components used for the expected system are easily available in local electronics market and inside college and the cost of all the components are reasonably cheap. The project is economically feasible since it can bring a profit if it is sold to the outer market.

### 1.5.3 Technical Feasibility

Our project seems to be technically feasible on its structural development and its hardware requirement, since it uses less number of sensors and other electronic component. By using the limited numbers of sophisticated electronic components we can receive the desired output. The components that is to be used in the project are more of professional compatible than the common user. This project is based on modern technology based hardware components and devices which will be very applicable in future. Based on advanced technology, we have selected hardware components to make this project technically feasible.

# CHAPTER 2
# LITERATURE REVIEW

The earliest known reference to a vending machine is in the work of Hero of Alexandria, an engineer and mathematician in first- century Roman Egypt. His machine accepted a coin and then dispensed holy water. When the coin was deposited, it fell upon a pan attached to a lever. The lever opened a valve which let some water flow out. The pan continued to tilt with the weight of the coin until it fell off, at which point a counterweight snapped the lever up and turned off the valve.

Coin-operated machines that dispensed tobacco were being operated as early as 1615 in the taverns of England. The machines were portable and made of brass. An English bookseller, Richard Carlile, devised a newspaper dispensing machine for the dissemination of banned works in 1822. Simeon Denham was awarded British Patent no. 706 for his stamp dispensing machine in 1867, the first fully automatic vending machine.

The first modern vending machines were developed in England in the early 1880s and dispensed postcards. The Sweetmeat Automatic Delivery Company was founded in 1887 in England as the first company to deal primarily with the installation and maintenance of vending machines. In 1893, Stollwerck, a German chocolate manufacturer, was selling its chocolate in 15,000 vending machines. It set up separate companies in various territories to manufacture vending machines to sell not just chocolate, but cigarettes, matches, chewing gum and soap products.

The first vending machine in the U.S. was built in 1888 by the Thomas Adams Gum Company, selling gum on New York City train platforms. The idea of adding games to these machines as a further incentive to buy came in 1897 when the Pulver Manufacturing Company added small figures, which would move around whenever somebody bought some gum from their machines. This idea spawned a whole new type of mechanical device known as the ”trade stimulators”

In 2017,Abad, Erich P introduced ”Design and Implementation of Paper Vending Machine for Retail of Common Usable Papers for Unstop Students” in International Jour-

nal for Research in Applied Science & Engineering Technology[1].According to this paper, vending machine utilizes a coin-slot machine and will automatically dispense paper of choice by the student depending on the amount inserted.

In 2002,Nicolini,Antonio introduced ”Payment System for Automatic Vending Machines” [2]. According to this paper,it consists of the electronic chip ,capable of identifying the fingerprints of each user of the automatic vending machine, memorizing them in memory cells and subsequently comparing certain electronic scanning points of their memorized image for electronic identification, when checking the residual credit and/or selection of the desired product.

In 1988,Ushikubo, Kohei introduced ”Automatic Vending Vachine”[3].According to this paper,it operates in response to a card inserted by a user. The card contains identification information which is used to access data stored in a memory device regarding the amount of money the user has credited to his account. If the account balance exceeds the purchase price of a desired item, the item is supplied to the user and the amount of the purchase is deducted from his account. A user may increase his account balance at any time by inserting money into the machine. Security is maintained through the use of a security code which the user inputs into the machine after the card is inserted.

In 2018,Wan, Jie and Al-awlaqi, Munassar AAH and Li, MingSong and O’Grady, Michael and Gu, Xiang and Wang, Jin and Cao, Ning introduced ”Wearable IoT enabled real-time health monitoring system” in EURASIP Journal on Wireless Communications and Networking[4]. According to this paper,the WISE (Wearable IoT-cloud-baSed hEalth monitoring system) adopts the BASN (body area sensor network) framework in the support of real-time health monitoring. Several wearable sensors have been embedded. Whilst in WISE, data gathered from the BASN are directly transmitted to the cloud, and a lightweight wearable LCD can be embedded as an alternative solution for quick view of the real-time data.

In 2020,Sanchez, SA and Romero, HJ and Morales, AD introduced ”A review: Comparison of performance metrics of pretrained models for object detection using the TensorFlow framework”[5].This research was focused on a review of the state of the art,

related to the performance of pre-trained models for the detection of objects in order to make a comparison of these algorithms in terms of reliability, ac- curacy, time processed and Problems detected The consulted models are based on the Python programming language, the use of libraries based on TensorFlow, OpenCv and free image databases (Microsoft COCO and PASCAL VOC 2007/2012). These systems are not only focused on the recognition and classification of the objects in the images, but also on the location of the objects within it, drawing a bounding box around the appropriate way. For this research, different pre-trained models were re- viewed for the detection of objects such as R-CNN, R-FCN, SSD (single- shot multibox) and YOLO (You Only Look Once), with different extractors of characteristics such as VGG16, ResNet, Inception, MobileNet.

In 2016,Liu, Wei and Anguelov, Dragomir and Erhan, Dumitru and Szegedy, Christian and Reed, Scott and Fu, Cheng-Yang and Berg, Alexander C introduced ”SSD: Single Shot multibox Detector”[6]. They prsented a method for detecting objects in images using a single deep neural network. Their approach, named SSD, discretizes the output space of bounding boxes into a set of default boxes over different aspect ratios and scales per feature map location. At prediction time, the network generates scores for the presence of each object category in each default box and produces adjustments to the box to better match the object shape. Additionally, the network combines predictions from multiple feature maps with different resolutions to naturally handle objects of various sizes. SSD is simple relative to methods that require object proposals because it completely eliminates proposal generation and subsequent pixel or feature resampling stages and encapsulates all computation in a single network. This makes SSD easy to train and straightforward to integrate into systems that require a detection component.

In 2017,Howard, Andrew G and Zhu, Menglong and Chen, Bo and Kalenichenko, Dmitry and Wang, Weijun and Weyand, Tobias and Andreetto, Marco and Adam, Hartwig published paper on the title ”Mobilenets: Efficient convolutional neural networks for mobile vision applications”[7]. They presented a class of efficient models called MobileNets for mobile and embedded vision applications.They introduced two simple global hyperparameters that efficiently trade off between latency and accuracy. These hyper-parameters allow the model builder to choose the right sized model for

their application based on the constraints of the problem.Then demonstrated the effectiveness of MobileNets across a wide range of applications and use cases including object detection, finegrain classification, face attributes and large scale geo-localization.

At slightly over 5 million nationwide, Japan has the highest density of vending machines worldwide. There is approximately 1 vending machine per every 23 people, according to the Japan Vending Machine Manufacturers Association. Annual sales total more than $60 billion.Japan is a cash-based economy, and the machines are always ready to take coins and 1,000 yen bills (worth around 7 euros or $9.00). And if a customer does not have coins or bills, they can also pay at many machines by scanning their public transportation pass, which deducts the value of the item from the remaining balance on the pass.

Lalitpur city unveils Nepal's first seed vending machine in Dec, 2019. Through the vending machine, farmers can get 36 different varieties of seeds of vegetables and flowers.There are other vending machine for sanitary pad, tea, coffee and so on in Nepal.

# CHAPTER 3
# SYSTEM REQUIREMENTS

## 3.1 Software Requirements

1. Python 3.7.2
2. Arduino IDE
3. Html\CSS
4. Django
5. OpenCV
6. TensorFlow lite
7. TensorFlow object detection API

### 3.1.1 Python 3.7.2

Python is an interpreted, high-level, general purpose programming language created by Guido van Rossum and first released in 1991. Python is dynamically typed and garbage-collected. It supports multiple programming paradigms including procedural, object-oriented, and functional programming. Python is user-friendly and is very easy to learn. It has huge number of libraries which make it suitable for machine learning purposes. We use Python in our project for communicating with server via Raspberry Pi.

### 3.1.2 OpenCv

OpenCV (Open Source Computer Vision Library) is a library of programming functions mainly aimed at real-time computer vision. It mainly focuses on image processing, video capture and analysis including features like face detection and object detection. It also supports the Deep Learning Frameworks TensorFlow, Torch/PyTorch and Caffe. When it integrated with various libraries, such as Numpy, python is capable of processing the OpenCV array structure for analysis. To Identify image pattern and its various features we use vector space and perform mathematical operations on these features.

By using it, one can process images and videos to identify objects, faces, or even handwriting of a human.

**Note:**

Actually, you can use OpenCV to do feature selection to build your input model for TensorFlow. Preprocessing of image (image manipulation) is done with OpenCV before feeding into the model.

### 3.1.3 TensorFlow object detection API

The TensorFlow object detection API is the framework for creating a deep learning network that solves object detection problems. There are already pretrained models in their framework which they refer to as Model Zoo. This includes a collection of pretrained models trained on the COCO dataset, the KITTI dataset, and the Open Images Dataset. These models can be used for inference if we are interested in categories only in this dataset. They are also useful for initializing your models when training on the novel dataset.

**MobileNet:**

The MobileNet model is based on a stream-lined architecture that uses depthwise separable convolutions to build light weight deep neural network. It was designed for mobile and embedded vision application with maximize accuracy while being mindful of the restricted resources for an on-device or embedded application. A standard convolution both filters and combines inputs into a new set of outputs in one step. The depthwise separable convolution splits this into two layers – a separate layer for filtering and a separate layer for combining. This factorization has the effect of drastically reducing computation and model size.

**SSD (Single Shot MultiBox Detector):**

SSD is a supremely effective framework which utilizes small convolution filters to predict object classes and bounding box locations for different aspect ratios and does so across multiple feature maps from the later stages of the network allowing it to aggregate detections at multiple scales. Therefore, by utilizing multiple layers which are of relatively lower input resolution, and using those to generate predictions at different scales, it can provide high accuracy results with faster detection speeds.

**SSD – MobileNet V2**

The SSD architecture is a single convolution network that learns to predict bounding box locations and classify these locations in one pass. Hence, SSD can be trained end-to-end. MobilenetV2 network is used for feature extraction of ship images. The MobilenetV2 network is pre-trained on the Coco dataset, and then fine-tuned on the constructed ship image dataset to save training time and computing resources. In order to verify the accuracy of the SSD_MobilenetV2 algorithm in ship image detection and id0entification, Faster R-CNN_InceptionV2 algorithm was used as a comparison group. Experimental results show that the SSD_MobilenetV2 algorithm has better detection and identification effect on ship images. And the SSD_MobilenetV2 algorithm has better performance in terms of detection speed and NMS(Non-Maximum Suppression), which meets the requirements for rapid detection and identification of ship targets.

### 3.1.4 TensorFlow lite

TensorFlow Lite is an open-source, product ready, cross-platform deep learning framework that converts a pre-trained model in TensorFlow to a special format that can be optimized for speed or storage.The special format model can be deployed on edge devices like mobiles using Android or iOS or Linux based embedded devices like Raspberry Pi or Microcontrollers to make the inference at the Edge.TensorFlow Lite is a set of tools to help developers run TensorFlow models on mobile, embedded, and IoT devices. It enables on-device machine learning inference with low latency and a small binary size.

### 3.1.5 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives

feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port.

It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and another open-source software. This software can be used with any Arduino board. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures.

### 3.1.6 Html\CSS

HTML (the Hypertext Markup Language) and CSS (Cascading Style Sheets) are two of the core technologies for building Web pages. HTML provides the structure of the page, CSS colors, layout, and fonts, for a variety of devices. Along with graphics and scripting, HTML and CSS are the basis of building Web pages and Web Applications.With HTML, authors describe the structure of pages using markup. The elements of the language label pieces of content such as “paragraph,” “list,” “table,” and so on. It allows one to adapt the presentation to different types of devices, such as large screens, small screens, or printers. The separation of HTML from CSS makes it easier to maintain sites, share style sheets across pages, and tailor pages to different environments.

### 3.1.7 Django

Django is a high-level Python Web framework that encourages rapid development and clean, pragmatic design.Django’s primary goal is to ease the creation of complex, database-driven websites. The framework emphasizes reusability and ”pluggability” of components, less code, low coupling, rapid development, and the principle of don’t repeat yourself. Python is used throughout, even for settings files and data models. Django also provides an optional administrative create, read, update and delete interface that is generated dynamically through introspection and configured via admin models.

## 3.2 Hardware Requirements

1. Raspberry PI
2. Raspberry PI Camera
3. Arduino DUE
4. DC Motor
5. L298N Motor Driver
6. LCD Display
7. RFID Module
8. IR sensor
9. NodeMCU
10. Keypad

### 3.2.1 Raspberry PI

**Introduction**

The Raspberry Pi is a computer, and from a connections point of view it doesn't look much different to a normal desktop computer. It has USB ports for connecting a keyboard and mouse, and a video output port for connecting up a display.Because it is more compact and lower cost than a large desktop PC, it becomes possible to use the Raspberry Pi or other small single board computers (SBCs) as they are known, for many scenarios where a desktop or laptop PC would not be feasible.

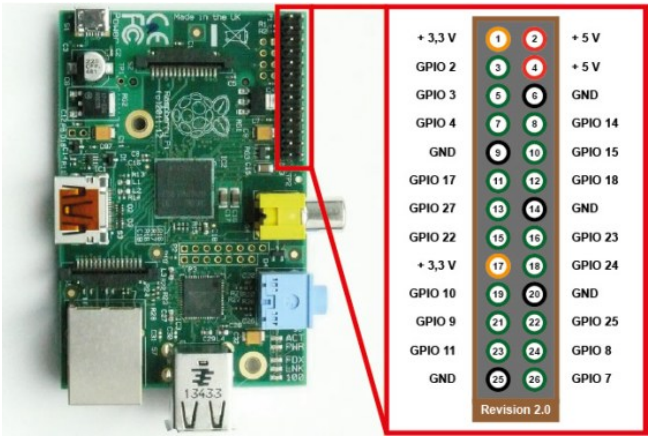


Figure 3.1: Raspberry PI

Often you may want to connect up other ‘things’ to a computer. For example you may wish to use a computer to measure the brightness level and automatically control lights, or to sound an alarm if an intruder is detected.Broken down to more general terms, there is a desire to be able to use a computer to control (also known as to ‘output’) to electronic circuits, and to gain useful information (aka obtain ‘input’) from circuits. This is where the Raspberry Pi and other single board computers excel because one key difference between SBCs and desktop or laptop PCs is that SBCs usually have general purpose input/output (GPIO) capability. This is lacking on larger PCs.

### 3.2.2 Raspberry PI Camera

The Raspberry Pi Camera v2 is a high quality 8 megapixel Sony IMX219 image sensor custom designed add-on board for Raspberry Pi, featuring a fixed focus lens. It’s capable of 3280 x 2464 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. It attaches to Pi by way of one of the small sockets on the board upper surface and uses the dedicated CSi interface, designed especially for interfacing to cameras. The board itself is tiny, at around 25mm x 23mm x 9mm.

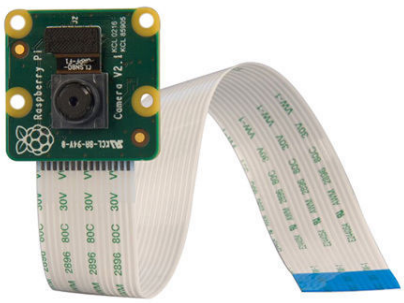


Figure 3.2: Raspberry PI Camera

It connects to Raspberry Pi by way of a short ribbon cable. The high quality Sony IMX219 image sensor itself has a native resolution of 8 megapixel, and has a fixed focus lens on-board. In terms of still images, the camera is capable of 3280 x 2464 pixel static images, and also supports 1080p30, 720p60 and 640x480p90 video.

### 3.2.3 Arduino DUE

#### System Overview

The Arduino Due is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, an USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button.

The board contains everything needed to support the microcontroller; simply connect it to a computer with a micro-USB cable or power it with a AC-to-DC adapter or battery to get started. The Due is compatible with all Arduino shields that work at 3.3V and are compliant with the 1.0 Arduino pinout. The Due follows the 1.0 pinout:

- TWI: SDA and SCL pins that are near to the AREF pin.
- IOREF: allows an attached shield with the proper configuration to adapt to the voltage provided by the board. This enables shield compatibility with a 3.3V board like the Due and AVR-based boards which operate at 5V.
- An unconnected pin, reserved for future use.

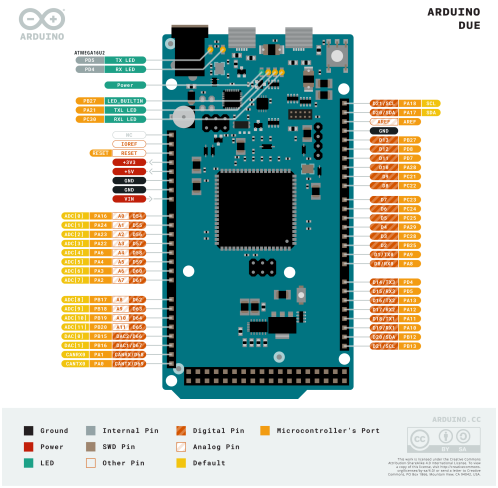


Figure 3.3: Arduino DUE

### 3.2.4 DC Motor

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

Figure 3.4: DC Motor

DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction.We can control the speed of the DC motor by simply controlling the input voltage to the motor and the most common method of doing that is by using PWM signal.

#### PWM DC Motor Control

PWM, or pulse width modulation is a technique which allows us to adjust the average value of the voltage that's going to the electronic device by turning on and off the power at a fast rate. The average voltage depends on the duty cycle, or the amount of time the signal is ON versus the amount of time the signal is OFF in a single period of time.

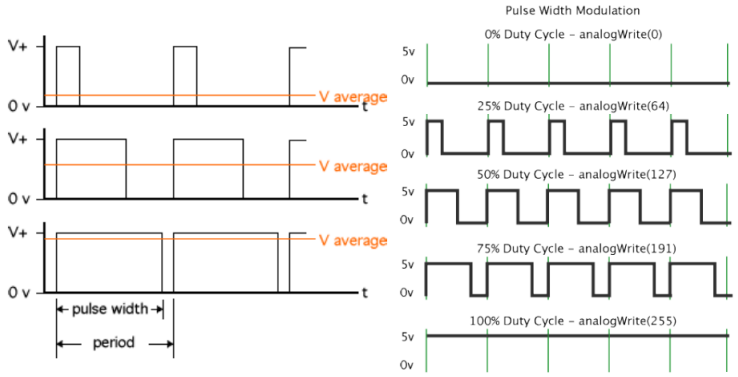


Figure 3.5: PWM Signal

### 3.2.5 L298N Motor Driver

The L298N is a dual H-Bridge motor driver which allows speed and direction control of two DC motors at the same time. The module can drive DC motors that have voltages between 5 and 35V, with a peak current up to 2A.The module has two screw terminal blocks for the motor A and B, and another screw terminal block for the Ground pin, the VCC for motor and a 5V pin which can either be an input or output.The Enable A and Enable B pins are used for enabling and controlling the speed of the motor.

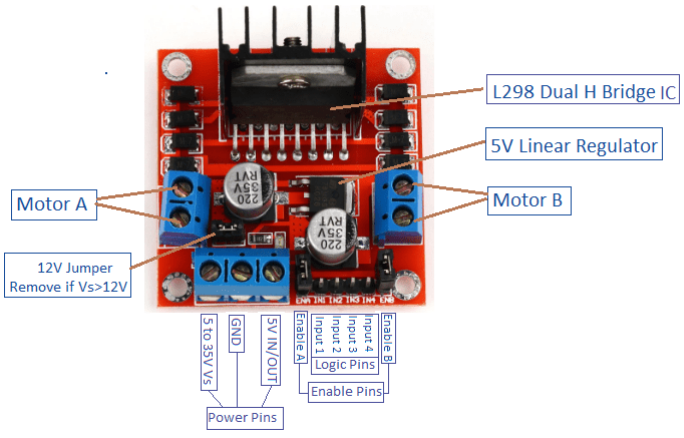


Figure 3.6: L298N Motor Driver

### 3.2.6 LCD Display

An LCD is an electronic display module that uses liquid crystal to produce a visible image. The 16×2 LCD display displays 16 characters per line in 2 such lines.

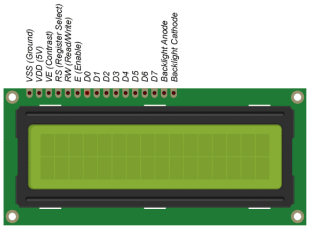


Figure 3.7: LCD Display

The parallel interface consists of the following pins:

- Power Supply pins (Vss/Vcc): Power the LCD
- Contrast pin (Vo): Control the display contrast
- Register Select (RS) pin: Controls where in the LCD's memory you're writing data to
- Read/Write (R/W): Selects reading mode or writing mode
- Enable pin: Enables writing to the registers
- 8 data pins (D0 -D7): The states of these pins (high or low) are the bits that you're writing to a register when you write, or the values you're reading when you read.
- Backlight (Bklt+ and BKlt-) pins: Turn on/off the LED backlight

### 3.2.7 RFID Module

RDM 125KHz card mini-module is designed for reading code from 125KHz card compatible read-only tags and read/write card.

Features:

- Support external antenna
- Maximum effective distance up to 50mm
- Less than 100ms decoding time

Figure 3.8: RFID Module

- UART TTL interface Support EM4100 compatible read only or read/write tags
- Built-in external bi-color LED and buzzer driver
- Small outline design

### 3.2.8 IR Sensor

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. There are two types of infrared sensors: active

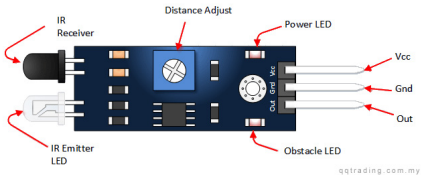


Figure 3.9: IR Sensor

and passive. Active infrared sensors both emit and detect infrared radiation.Passive infrared (PIR) sensors only detect infrared radiation and do not emit it from an LED. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode that is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.

### 3.2.9 NodeMCU

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266

Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module.NodeMCU provides access to the GPIO (General Purpose Input/Output).

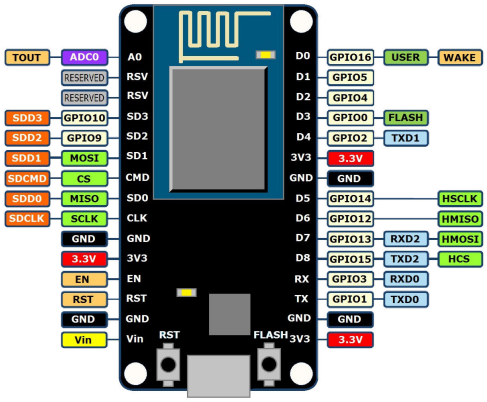


Figure 3.10: NodeMCU

NodeMCU ESP8266 Specifications & Features:

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside your IoT projects

### 3.2.10 Keypad

Keypads allow users to input data while a program is running.The buttons on a keypad are arranged in rows and columns. A 3X4 keypad has 4 rows and 3 columns, and a 4X4 keypad has 4 rows and 4 columns.Beneath each key is a membrane switch. Each switch in a row is connected to the other switches in the row by a conductive trace underneath the pad. Each switch in a column is connected the same way – one side of the switch is connected to all of the other switches in that column by a conductive trace. Each row and column is brought out to a single pin, for a total of 8 pins on a 4X4 keypad.

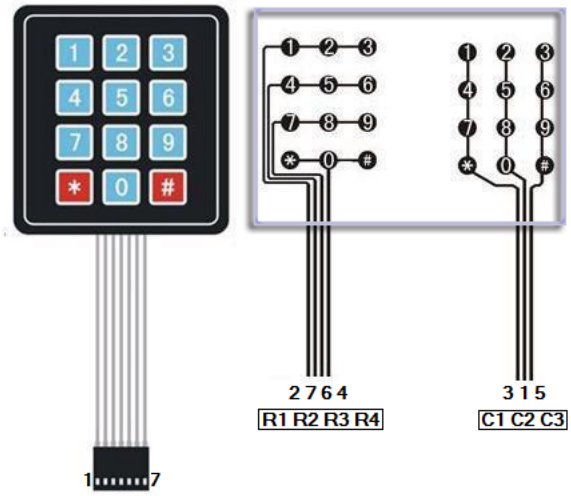


Figure 3.11: Keypad

# CHAPTER 4
# METHODOLOGY

## 4.1 Hardware Development

### 4.1.1 Block diagram

**Vending Machine**

The components of smart vending machine system are connected to each other as shown in below block diagram4.1. LCD display shows items and price of each item in vending machine and user can select,order,add,confirm and cancel order using keypad. Once user orders certain item,those data are saved into the micro-controller(Arduino Due) for further processing. After ordering,bill is displayed on screen asking to confirm the order and move on to payment process. But if order is canceled the LCD display is reset and all the save data in Arduino Due is also deleted.

In LCD screen, remaining amount to be paid is displayed. Payment ca be done either by cash or using RFID card as cashless system. When cash is inserted IR sensor detects it and starts motor to pull cash inside. Simultaneously IR sensor also calculates length of cash to determine inserted cash amount. When whole cash is inserted IR sensor stops motor and Raspberry Pi detects,analyzes and validates inserted cash amount using PI camera. Once cash is paid Raspberry Pi confirms it and sends confirmation to Arduino Due via serial communication. This process is repeated until total amount is paid.For cashless payment system, RFID module checks balance of RFID tag and if it is sufficient it deducts amount from it. But if balance isn't sufficient, the order is canceled automatically and process is reset. Once total amount is paid, the micro-controller controls the motors and drops items in outlet window through which customer can collect their items.

**Server**

NodeMCU is connected to local server. And NodeMCU continuously reads data from server to check whether data is updated in server by owner. And retrieves data from

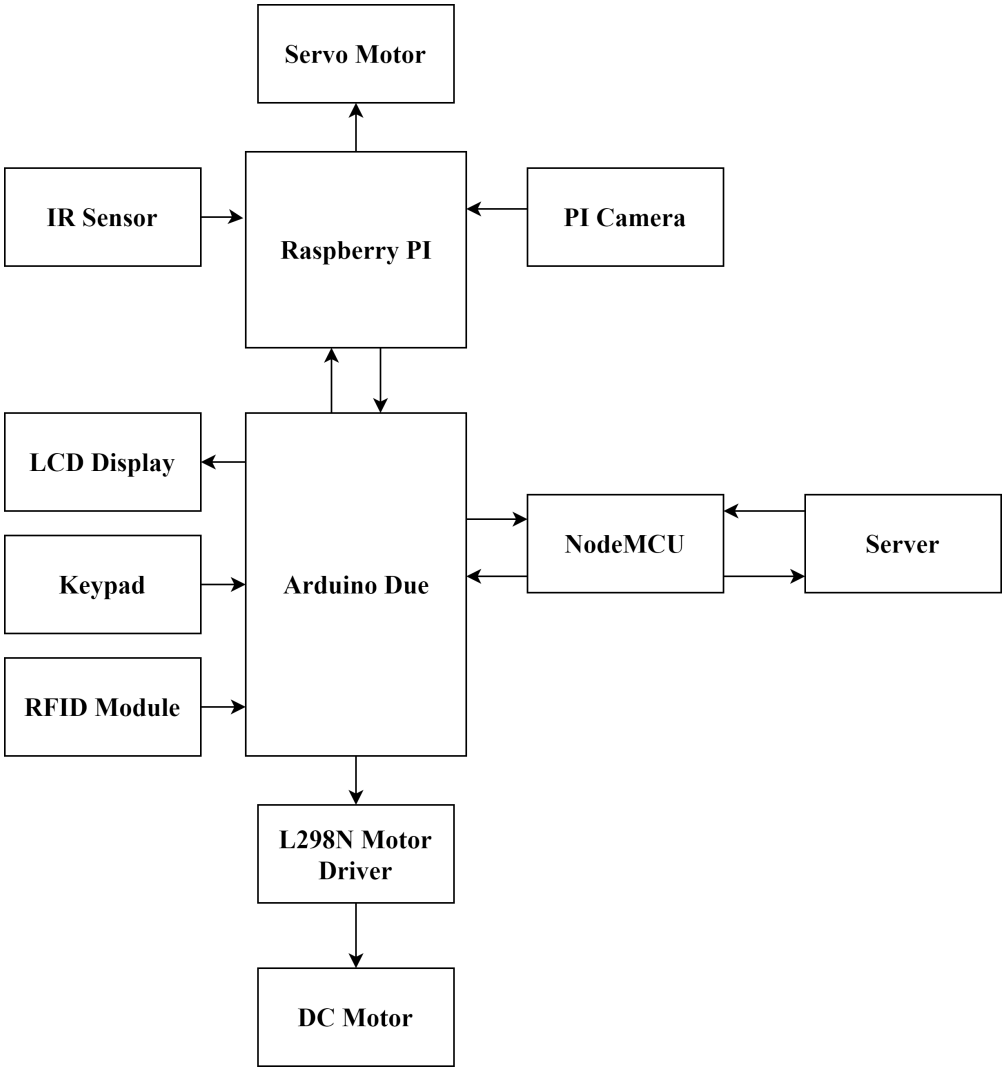


Figure 4.1: Block Diagram of System

server and saves it and sends this data to Arduino Due to display updated value on LCD display. When bill is paid and item is dropped Arduino Due sends ordered items data to NodeMCU via serial communication. This data from Arduino Due is added in local server by using NodeMCU. Owner can monitor system remotely using local server. If item is to be stocked NodeMCU alerts via server and owner can stock item in time.

## 4.2 Software Development

### 4.2.1 Flow Chart

#### Smart Vending Machine Flowchart

Our system is divided into two parts i.e Vending machine and Server. Vending machine system has to major process i.e. taking order process and billing process.

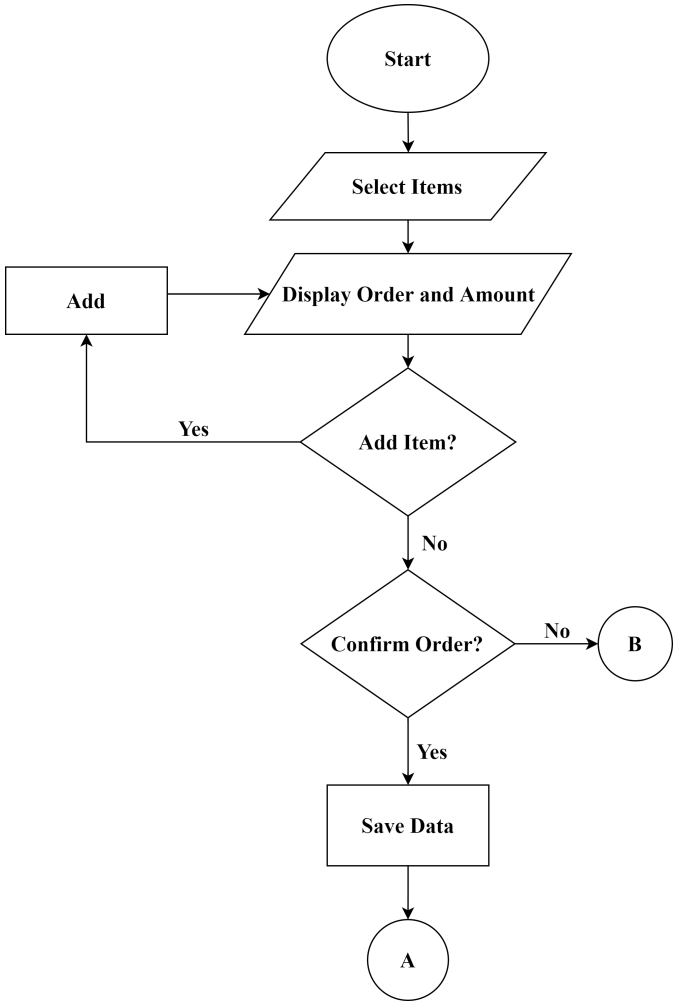


Figure 4.2: Flow Chart of Ordering System

In flowchart 4.2, it shows process for ordering items.On the LCD display, items list with price and quantity are displayed. A customer order item by selecting item using keypad and inputs item amount. A customer can add more items to their order list .Customer can also cancel their order. If customer cancels order than home screen is displayed

on display and saved value are reseted. When they confirm their order, the details of ordered items are saved within Arduino Due.

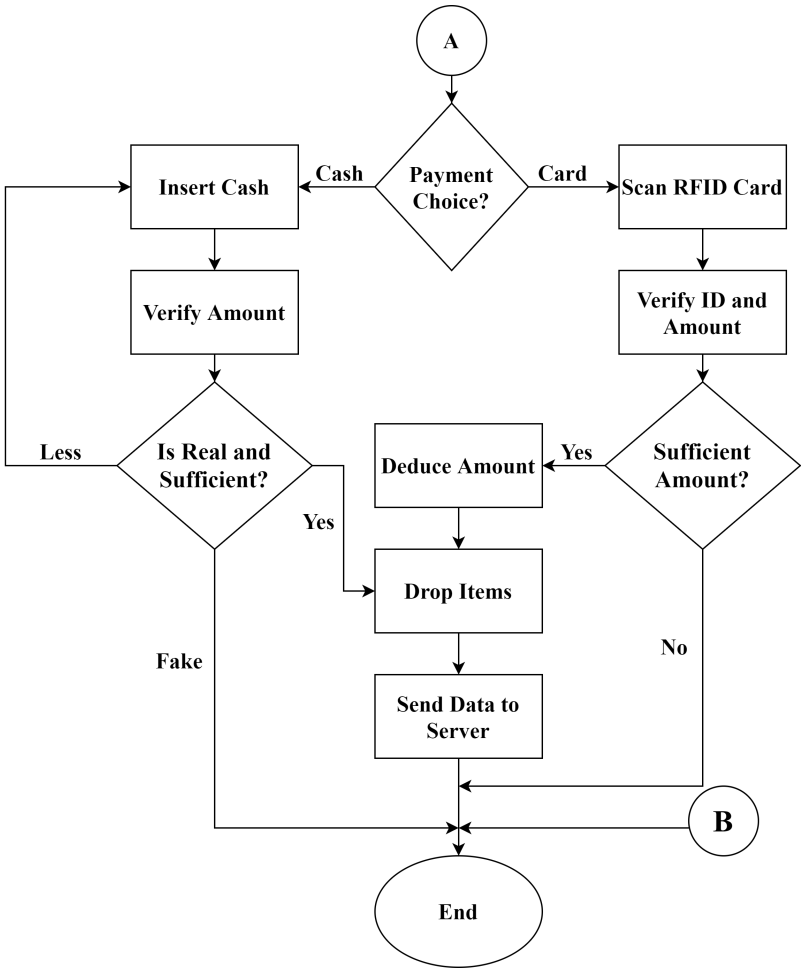


Figure 4.3: Flow Chart of Paying System

In flowchart 4.3, it shows billing process after order is confirmed. Once order is confirmed,system provides options for payment i.e. cash or card. If cash is selected for payment then customer inserts cash. The machine checks presence of cash IR sensor and the validity and amount of cash using Raspberry PI and PI camera for image processing(TensorFlow Object Detection API for image processing). It checks amount is enough or not. If it isn't enough then it asks to insert more cash until enough cash is provided. In case of card, the RFID sensor reads card and verifies its authenticity and amount in it. If there isn't enough balance then system is reset to initial set. But if there is sufficient amount on card then system deduces items amount from it. Once payment is done either by cash or card, system drops ordered items into outlet window for it by customer.

Once whole ordering and billing process is successfully completed, then data of items stored in Arduino Due is send into NodeMCU via serial communication and then into server. However, if process is halt in between either ordering or billing then stored isn't transferred into NodeMCU, they are deleted. Owner can monitor whole transaction remotely and can update price of items remotely through server .When data is updated in server by owner, NodeMCU continuously monitor database so while transaction, updated data will be used. After completion of process system reset to initial state being ready for new order and whole process is repeated for whole new transaction.

**Cash Detection Flowchart**

**Preparing the training data:**

After you labelled your images you will have a respective .xml file for each image. The .xml format is not suitable directly for training our model in Tensorflow, we have to convert the .xml files into .csv and then convert the .csv files into TFRecords.

- convert the .xml files into .csv files
- convert the .csv files into TFRecords
- generate the label map file for the training

**Choosing our pre-trained model And Training:**

Here we choose "SSD_MobileNetv2_quantized" which was previously trained in MS_COCO dataset. The data pool is initailly divided into training and testing group(ratio of 8:2). Then for training, the model individually studies all training data, extracts their correspondingly unique features and uses them as reference to classify the test images. Here MobileNetV2 does all the feature extracting.

**Evaluation of the trained model:**

The evaluation of trained model is done using loss value during it training [i.e. loss is a number indicating how bad the model's prediction was on a single example]. If the model's prediction is perfect, the loss is zero, otherwise, the loss is greater. The goal of training a model is to find a set of weights and biases that have low loss, on average, across all examples. Hence comparing the loss value for every steps of the training

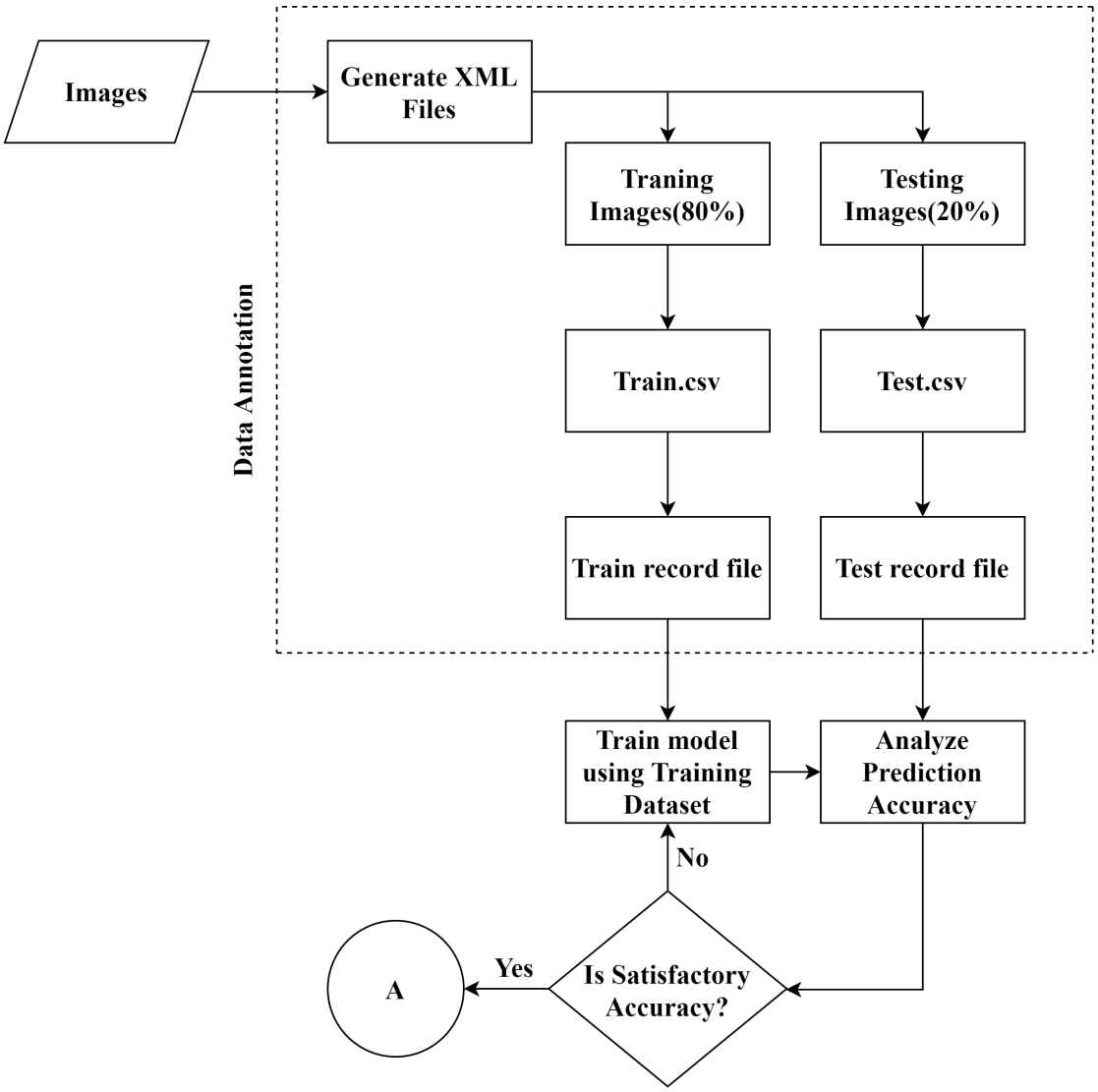


Figure 4.4: Flow Chart of Custom Cash Recognition

phase, we choose to stop training the model at a satisfactory loss value.(Desirable loss value is around $\leq 0.8$)

[NOTE: An epoch indicates the number of passes of the entire training dataset the machine learning algorithm has completed. Epoch is used as a save point during training phase. Example: if you have 2,000 images and use a batch size of 10 an epoch consists of 2,000 images / (10 images / step) = 200 steps.]

**Implementation:**

The trained model is exported to be applied to a raw image for classification. The model then examines, forms bounding boxes and predicts its labels along with a certainty level.

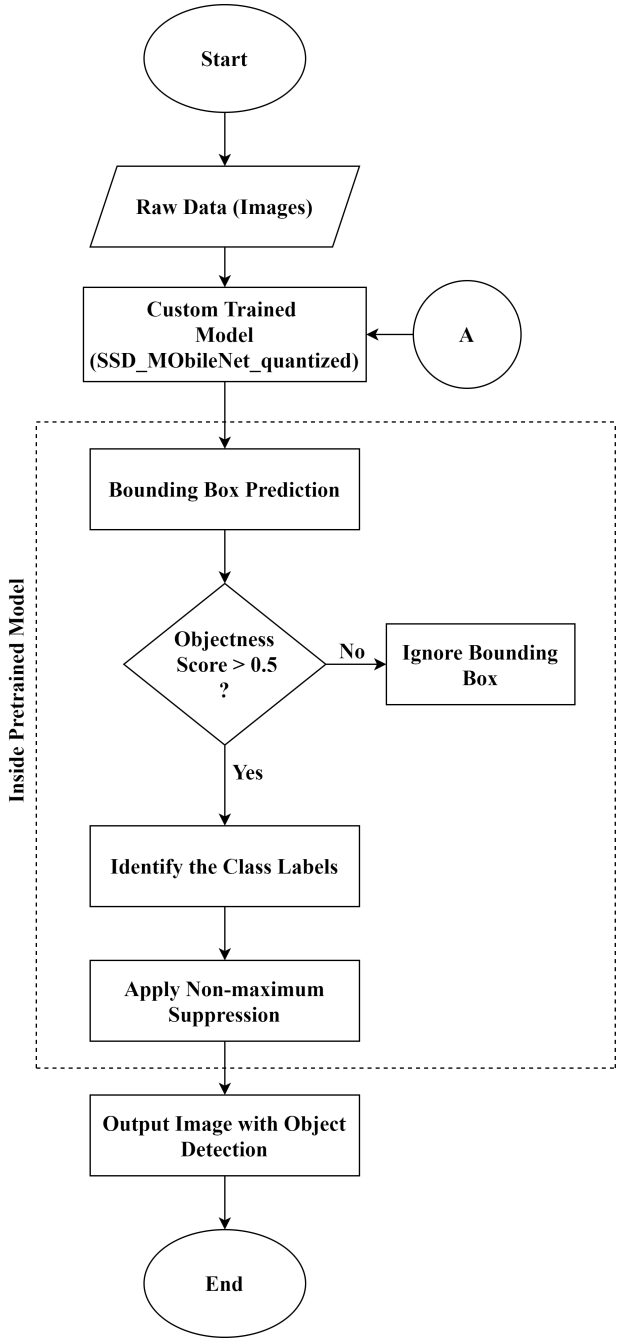


Figure 4.5: Flow Chart of Cash Recognition

# CHAPTER 5
# EPILOGUE

## 5.1 Budget Analysis

| **Equipments** | **Quantity** | **Price(Rs.)** |
|---|---|---|
| Raspberry PI | 1 | 6000 |
| Arduino DUE | 1 | 3500 |
| Raspberry PI Camera | 1 | 1000 |
| DC Motor | 3 | 2000 |
| NodeMCU | 1 | 650 |
| LCD Display | 1 | 700 |
| L298N Motor Driver | 2 | 900 |
| RFID Module | 1 | 300 |
| IR Sensor | 1 | 100 |
| Keypad | 1 | 100 |
| **Total** | | **15500** |

Table 5.1: Cost Estimation

## 5.2 Future Enhancement

- Detection of every types of cash.
- Confirmation of which and how much items are dropped.
- Recommendation system to customer.
- Face recognition of customer.
- Use of both payment at one transaction.

## 5.3 Limitations

- Only detects Rs.5, Rs.10 and Rs.20 cash.
- Sometimes error due to lighting condition for cash detection.
- No confirmation when items are dropped.
- No cash payback system.
- No cancellation of transaction once order is confirmed.

## 5.4 Application

- The sales and purchasing of goods from an automated machine .
- It provides 24 hours sales service.
- Have the flexibility to be placed indoors or outdoors.
- Distribute goods cost effectively.

## 5.5 Result

In our vending machine,list of items with price is displayed in LCD display and ordered is placed by using keypad. For payment, cash is checked and verified by Raspberry PI and IR sensor. For cashless, RFID tag is read, verified and money is deducted. Cash is pulled inside machine by motor which is controlled by Raspberry PI. Ordered items are dropped by rotating motors, Arduino Due as a controller. NodeMCU and local server database are communicated properly and database is updated as per transaction. Also changed value in server database by owner is updated in vending machine remotely via serial communication between NodeMCU and Arduino Due.The evaluation of the trained model is done using loss value during its training [i.e. loss is a number indicating how bad the model's prediction was on a single example]. The loss graph model is shown in Figure 5.1. The confidence level of cash was varying due to camera height and

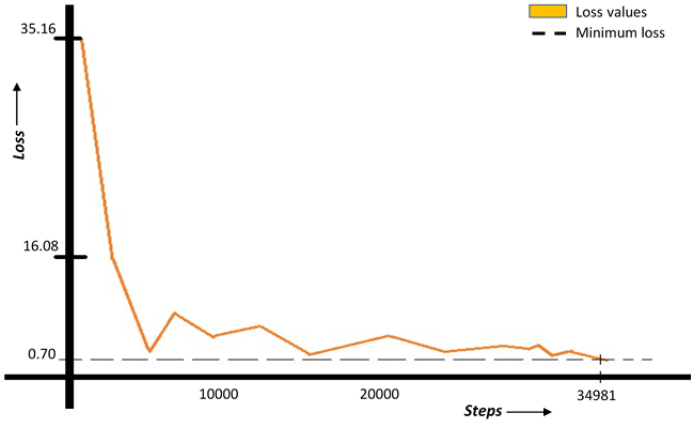


Figure 5.1: Loss Graph of Trained Model

lighting condition. The different confidence level for different amount is shown is listed in tables. Table 5.2, Table 5.3, and Table 5.4 show confidence levels of Rs.5, Rs.10, and Rs.20 correspondingly. From comparing values of these tables, the Pi camera's height was selected to be 10cm and mounted 10cm above the cash tray. The confidence level 0 means no bounding box was formed resulting no cash detected. Also, cash was not detected when there was poor lighting, in such a case flashlight was used.

| | **Cash Visible Portion** | | |
|---|---|---|---|
| **Camera Height** | ***50%*** | ***75%*** | ***100%*** |
| 5 cm | 0 | 0 | 0 |
| 8 cm | 0% | 90% | 94% |
| 10 cm | 87% | 92% | 99% |
| 12 cm | 0% | 0% | 96% |
| 15 cm | 0 | 0 | 0 |

Table 5.2: Confidence Level for Rs.5

| | **Cash Visible Portion** | | |
|---|---|---|---|
| **Camera Height** | ***50%*** | ***75%*** | ***100%*** |
| 5 cm | 0 | 0 | 0 |
| 8 cm | 87% | 90% | 96% |
| 10 cm | 92% | 96% | 99% |
| 12 cm | 90% | 92% | 98% |
| 15 cm | 0 | 0 | 0 |

Table 5.3: Confidence Level for Rs.10

| | **Cash Visible Portion** | | |
|---|---|---|---|
| **Camera Height** | ***50%*** | ***75%*** | ***100%*** |
| 5 cm | 0 | 0 | 0 |
| 8 cm | 90% | 92% | 96% |
| 10 cm | 94% | 96% | 99% |
| 12 cm | 91% | 94% | 97% |
| 15 cm | 0 | 0 | 0 |

Table 5.4: Confidence Level for Rs.20

## 5.6 Conclusion

The Smart Vending Machine put forth key to prodigious exposure to customer all around the world and make to have completely different outlook towards vending machines of back in the days. This Smart Vending Machine is able to transact both cash and cashless. Cash of Rs.5, Rs.10 and Rs.20 are only recognized by this vending machine so customer has to enter only one of this cash. Lighting must be provided to the camera so cash can be detected properly so we used light bulb as source. When the number of item is less than 2, vending machine alerts owner via server to restock it. Then an owner can view list of items and their quantity in server and restock the item which is in less quantity. A customer is able to buy more than one item at one transaction. Also, an owner is able to view the sales data of items. This project is able to meet all the objectives stated before starting it.

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# APPENDIX A

# SNAPSHOTS


Figure i: Snapshot of Cash Recognition

Figure ii: Snapshot of Vending Machine

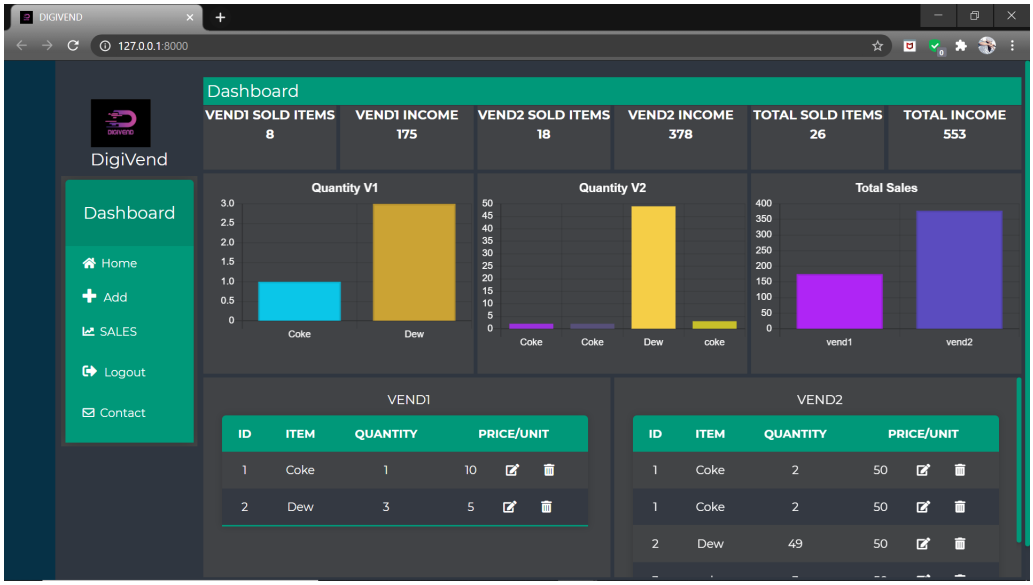


Figure iii: Snapshot of Server

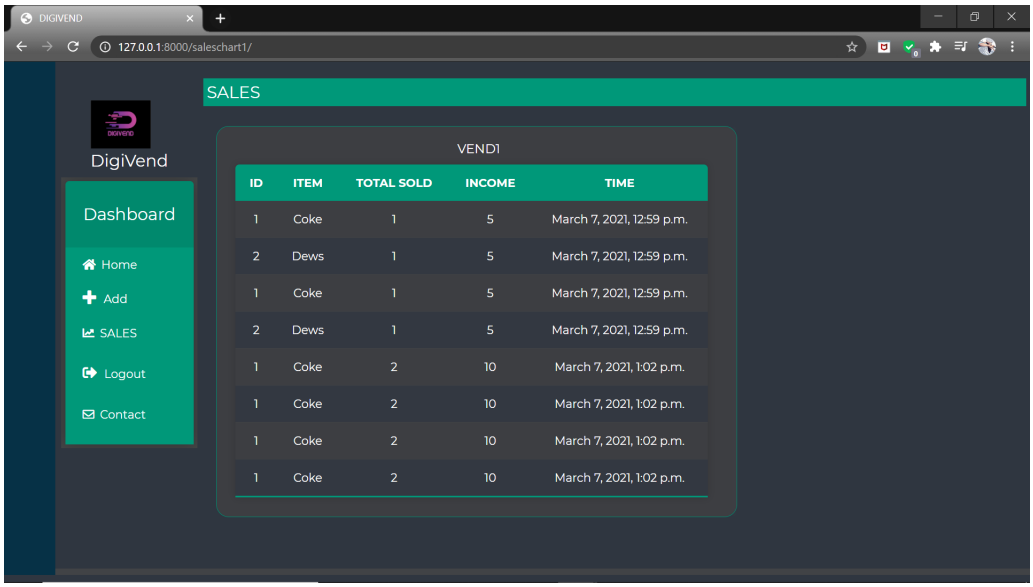


Figure iv: Snapshot of Server Sales Data