SMART TROLLEY

A Project Phase-1 Report

Submitted to the APJ Abdul Kalam Technological University

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Bachelor of Technology

in

Electronics and Communication Engineering

by

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2022 - 23

CERTIFICATE

This is to certify that the report entitled **SMART TROLLEY** submitted by **Akshayraj A** (SPT20EC002), **Navya Das** (SPT20EC008) & **Rushida Nasrin K** (SPT20EC011) to the APJ Abdul Kalam Technological University in partial fulfillment of the B.Tech. degree in Electronics and Communication Engineering is a bonafide record of the project phase-1 work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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DECLARATION

We hereby declare that the project report **SMART TROLLEY** , submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under supervision of Ms. Praseena K, Assistant professor,Electronics and Communication Engineering. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources.

We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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30-11-2022

Abstract

A shopping trolley is a necessary tool for shopping in supermarkets or grocery stores. However there are many struggles faced by customers while using trolley. Like it's hard to push the trolley when it's heavily loaded or it's hard for aged people to push the trolley. Also the customer is needed to stand in a long queue for the bill and payment process. This project introduces a groundbreaking RFID-based Smart Trolley system augmented with human-following capabilities to revolutionize the retail shopping experience. The integration of Radio-Frequency Identification (RFID) technology and advanced sensors enables the development of an intelligent and autonomous shopping companion. This system not only automates the tedious aspects of the shopping process through RFID-based item recognition but also enhances user convenience by incorporating human-following technology.

Acknowledgement

We take this opportunity to express my deepest sense of gratitude and sincere thanks to everyone who helped us to complete this work successfully. We are extremely thankful to our beloved principal Dr.S P SUBRAMANIAN for giving us his consent for this project. We express our sincere thanks to Prof.SUSHMA M, Head of Department, Electronics and Communication Engineering, SREEPATHY INSTITUTE OF MANAGEMENT AND TECHNOLOGY Vavanoor for providing us with all the necessary facilities and support.

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Chapter 1

Introduction

In the past few years, robotic technology has evolved substantially. To aid humans in their work, a robot must be able to recognize and follow them, necessitating the development of robots like the ”SMART TROLLEY” that can interact and co-exist with them. Localizing the items in the surroundings as well as the robot itself is a significant problem in enabling the robot for executing a range of activities in the real-world. A robot need to be sophisticated to track a human through traffic regions, a vibrant atmosphere, and both indoors and out. The project's goal in building a following robot is for it to be able to carry objects alongside humans. It can be utilised in agriculture, construction, airports, and shopping malls. A microcontroller is the overall system's controlling device. The RF signal transmitted by the object can be used by RFID readers to identify the objects. Sensors such as ultrasonic sensors and infrared sensors aid in the recognition and location of objects. The microcontroller is connected to an RFID module and DC motors [1]. The controller is loaded with a programme developed in the Embedded 'C' language to accomplish this operation.

Chapter 2

Literature Review

”SMART TROLLEY” is an innovative solution designed to revolutionize the traditional shopping experience in retail stores and supermarkets.Equipped with advanced technology to offer customers a seamless, convenient, and efficient shopping journey.The trolley is equipped with sensors and cameras that allow it to autonomously follow the customer as they navigate the store. Optimized billing and payment process. Provides customers with real-time pricing information.

2.1 Motion sensors

The most common motion sensors used are IR sensors, proximity sensors and Ultrasonic sensors.

2.1.1 Infrared Sensor (IR)

An infrared (IR) [24] sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. IR sensor has quick response and accurate value for short distance.

2.1.2 Ultrasonic Sensor

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal [10]. It can measure the distance to a wide range of objects regardless of shape,

color or surface texture. They are also able to measure an approaching or receding object.Ultrasonic sensors reflect sound off of objects, so color or transparency have no effect on the sensor's reading. Unlike proximity sensors using light or cameras, dark environments have no effect on an ultrasonic sensor's detection ability. It has an accuracy of about 2mm [8].

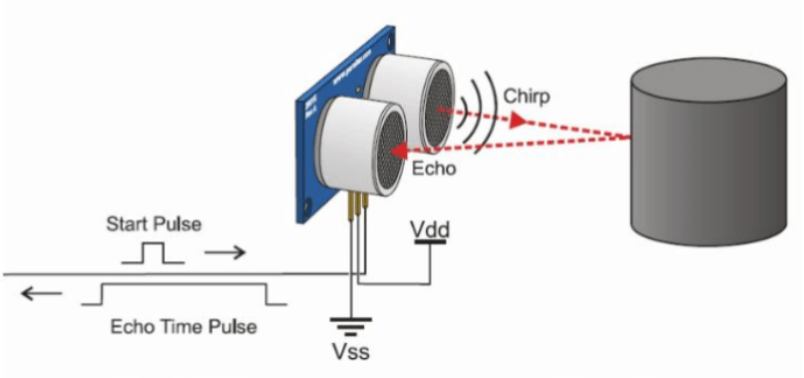

Figure 2.1: Ultrasonic Sensor [31]

2.1.3 Proximity Sensor

A proximity sensor is a device that can detect or sense the approach or presence of nearby objects and for this it does not need physical contact [25]. It is difficult to detect the distance between the sensors and objects accurately and they only detect metallic target.

Column 1	Column 2	Column 3	Column 4
	IR sensor	Ultrasonic sensor	Proximity sensor
Frequency range	300GHZ - 400THZ	25-50KHZ	500HZ - 5KHZ
Distance Range	2 - 80cm	20cm	60mm
Operating Voltage	3.3 - 5v	5v	10 - 30v
Weight	5g	150g	120g
Cost	around 180/-	around 200/-	upto 400/-

Table 2.1: Comparison between IR,ULtrasonic sensor & Proximity sensors

2.2 Product Identification Method

2.2.1 Barcode reader

A barcode is a visual representation of data that is readable by a machine. It uses a pattern of parallel lines of varying widths and spacing to represent numerical or alphanumerical data. The barcode scanner reads the barcode and interprets the information encoded in it, which is then processed by a computer. Barcode reader is usually mounted at the position and requires a light of sight to scan the identification number. Barcode scanner is ineffectual in many applications that instant traceability is needed due to time [3]. Barcode readers do not provide to write/read data in tags memory.

2.2.2 Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) technology uses radio waves to identify people or objects. RFID technology detects objects without any direct contact by using radio waves captured by the reader or antenna. It's tracking ability is faster than barcode. It withstands against of rough situations including humidity,high pressure, dust or extraordinary temperature.It works on electronic product code. Information embedded on microchip attached to antenna (Microchip + Antenna = RFID Tag) leads the information to reader [2]. Reader converts the radio waves impending from tag into digital information which can be displayed on a screen [13].

Column 1	**Column 2**	**Column 3**
	RFID	Bar Code
Rate of reading	More than one tag simutaneously	Single tag at a time
Read/ Write ability	Can read, write and modify	Only read
Line of sight	Not needed	Essential
Durability	High	Low- cannot be read if soiled
Security	High- hard to reproduce	Low- easier to counterfeit

Table 2.2: Comparsion Between RFID & Bar Code Reader

Since RFID system does not require line of sight as it detects the tag using radiowaves , we are using RFID technology for product identification.

2.3 Wireless technology

It reffers to the communication or transmission of data between devices without the need for physical cables or wires. This technology has become an integral part of our daily lives and is used in various applications, ranging from simple tasks like Wi-Fi internet access to more complex systems like mobile communication networks.

2.3.1 Global Positioning System (GPS)

The Global Positioning System (GPS) is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services. It has 100 percentage coverage on earth.But it is difficult to locate object position accurately since it, has a distance error about 30 - 100 meter.Due to its low cost, it's very easy to integrate into other technologies [9].

2.3.2 Wireless Fidelity (Wi-Fi)

Wi-Fi is a wireless networking technology that uses radio waves to provide wireless high-speed Internet access. Wi-Fi is more exposed to attacks by unauthorised users, therefore it poses security risks and have limited coverage area. The cost of installing wifi network is prohibitive. It requires continuous power source. The speed of the network gets decreased when a number of devices are connected .

2.3.3 Bluetooth

Bluetooth is a short-range wireless communication technology which enables devices like smartphones, headphones, and speakers to connect and exchange data over short distances. It is also used for tasks such as file transfer, audio streaming, and connecting peripherals like keyboards and mice [8].

2.3.4 Radio-Frequency Identification(RFID)

RFID uses radio waves to identify and track objects. It is often used in supply chain management, access control systems, and electronic toll collection.This system

Column 1	Column 2	Column 3	Column 4	Column 5
	RFID	Gps	Bluetooth	Wifi
Range	100m	5m	10m	50m
Power consumption	Low	High	Medium	High
Operating frequency	13.56MHZ	50HZ	2.4GHZ	2.4 & 5GHZ
Security problem	Low	High location errors	High	High

Table 2.3: Comparison between Wireless Technologies

consists of two main components, a transponder/tag attached to an object to be identified, and a Transceiver also known as interrogator/Reader. A Reader consists of a Radio Frequency module and an antenna which generates high frequency electromagnetic field. On the other hand, the tag is usually a passive device, meaning it doesn't contain a battery. Instead it contains a microchip that stores and processes information, and an antenna to receive and transmit a signal. To read the information encoded on a tag, it is placed in close proximity to the Reader (does not need to be within direct line-of-sight of the reader). A Reader generates an electromagnetic field which causes electrons to move through the tag's antenna and subsequently power the chip [11]. The powered chip inside the tag then responds by sending its

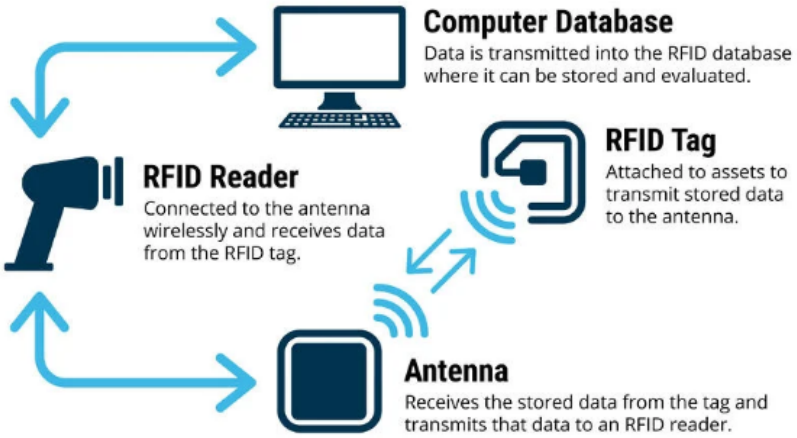

Figure 2.2: Basic RFID System [32]

stored information back to the reader in the form of another radio signal. This is called backscatter. The backscatter, or change in the electromagnetic/RF wave, is detected and interpreted by the reader which then sends the data out to a computer or microcontroller.

2.4 Batteries

2.4.1 Lead-acid batteries

Lead-acid batteries are a type of rechargeable battery that uses a chemical reaction involving lead dioxide and sponge lead to generate electrical energy. These batteries have been in use for over a century and remain widely used for various applications, primarily due to their reliability, relatively low cost, and ability to provide high surge currents.While lead-acid batteries have several advantages, they also pose environmental challenges due to the use of lead, which is a toxic heavy metal [21]. Proper recycling and disposal of lead-acid batteries are essential to prevent environmental contamination. lead-acid batteries continue to be a prevalent and reliable choice for various applications, especially in situations where cost-effectiveness and proven technology are crucial factors. However, in some applications, newer technologies such as lithium-ion batteries are gaining popularity due to their higher energy density and longer cycle life.

2.4.2 Li-ion Battery

The Li-ion battery is currently widely used as one of the main energy sources for electric vehicles due to its advantages of high specific energy, high efficiency and long life [16]. As an important parameter of the Li-ion battery, the capacity, which fades gradually with the cycle progresses, directly determines the endurance mileage of electric vehicles. In addition, the capacity fade rate of a Li-ion battery that is kept inside the battery pack of electric vehicles, being the main parameter for determining battery's cycle life, directly impacts on the consistency of batteries inside the battery pack and the performance of electric vehicles, etc . Therefore, accurately detecting the capacity and fading of a Li-ion battery can ensure its efficient operation, optimized performances and economic manufacturing costs, which is of great significance in the applications, design and manufacturing process of the Li-ion batteries [18].

2.4.3 Nickel-Cadmium Batteries (NiCd)

Nickel-Cadmium batteries are a type of rechargeable battery that uses nickel oxide hydroxide as the positive electrode, cadmium as the negative electrode, and an alkaline electrolyte [17]. These batteries have been widely used for many years in various applications, but they have become less common in recent times due to environmental concerns related to the cadmium content.These batteries are rechargeable, meaning they can be charged and discharged repeatedly. They are often used in applications where frequent charging and discharging are necessary [20].

Column 1	Column 2	Column 3	Column 4
Specification	Lead Acid	Nicd	Li-ion
Energy Density	30-50	45-80	110-160
Power Density	180	150	1800
Self Discharge	Low	Moderate	Very low
Toxicity	Very high	High	Low
Charge Time	8-16 hrs	1-2hrs	1-2hrs

Table 2.4: Comparsion Between Lead,Nicd,Li-ion

2.5 Motors

2.5.1 Stepper Motors

Stepper motors move in discrete steps, where each step corresponds to a specific angular rotation. They are controlled by sending a sequence of pulses to the motor windings.These motors are used in precision applications, such as 3D printers, CNC machines, and robotics.

2.5.2 Brushed DC Motors

Brushed DC motors have a rotating armature and a stationary set of magnets. Brushes and a commutator switch the direction of the current in the windings to keep the motor turning [14]. These motors are used in toys, power tools, and some automotive applications.

2.5.3 Gear DC Motors

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM . The gear assembly helps in increasing the torque and reducing the speed.The gear box therefore functions as a converter of torque and speed. In general, the gear unit slows down the rotational speed of the motor while simultaneously transmitting significantly higher torques than the electric motor alone could provide. DC Geared Motor's overload, start-up, braking torque is large.It is easy to control, DC Reducer Motor is reliable. DC Gear Box Motor's energy consumption is small when adjusting speed.From robotics to automobiles, small and medium sized motoring applications often feature DC gear motors for their wide range of functionality [29]. In order to construct a DC motor, it is essential to establish a magnetic field.

Column 1	**Column 2**	**Column 3**	**Column 4**
	Stepper Motor	Brushed dc motor	Gear dc motor
Maintainace	Low	Required	Low
Controls	precise control	Easy to control	precise & Easy to control
Speed & torque	Low speed	High speed	High torque output
Complexity & Cost	High	Less	Less
Applications(Ex:)	3D printers	power tools	Electric vehicles

Table 2.5: Comparison between motors

2.6 Motor Driver Shields

Motor driver shields are hardware modules designed to interface with microcontrollers like Arduino or Raspberry Pi and provide an easy way to control and drive motors. These shields typically integrate motor driver ICs (Integrated Circuits) and other necessary components to simplify the process of motor control in various projects.

2.6.1 L298N Motor Driver

The L298N Motor Driver is a dual H-bridge integrated circuit commonly used to control the speed and direction of DC motors or stepper motors in electronic projects,

providing a versatile and cost-effective solution for motor control with its built-in diodes, enable/disable pins, and support for a wide range of input voltages [2].

2.6.2 L293D Motor Driver

The L293D Motor Driver [4] is a popular integrated circuit used to control the speed and direction of DC motors or stepper motors in electronic projects, featuring an H-bridge configuration, built-in diodes for protection, and compatibility with microcontrollers for efficient motor control.

Column 1	Column 2	Column 3
	L298N	L293D
Operating Range	46v	4.5 to 36v
Current handling	2A	600 mA
EMF provision	Requires external EMF protection	Internal EMF protection
Output current	2 A/c	650 A/c
Applications	High rpm motors	upto 500 rpm

Table 2.6: Comparison between L298N & L293D

2.7 LCD Display

The LCD (Liquid Crystal Display) 16x2 is a common type of alphanumeric display that consists of 16 columns and 2 rows, allowing it to display up to 16 characters per line and two lines of text. It is widely used in electronic projects for showing information, messages, or data.

2.8 Microcontroller

Microcontrollers are compact, integrated circuits that contain a processor core, memory, and programmable input/output peripherals. They serve as the brain of embedded systems, providing the computational power and control necessary to perform specific tasks in various applications.

2.8.1 Arduino

Arduino is an open-source electronics platform that consists of both hardware and software components. It is designed for individuals, hobbyists, and professionals interested in creating interactive projects and prototypes. Arduino provides a simple and accessible way to build electronic systems and experiment with various sensors, actuators, and other components.At the core of Arduino boards is a microcontroller, typically from the AVR family (e.g., ATmega328 for Arduino Uno). The microcontroller is responsible for executing the code uploaded to the board [25]. Arduino boards can be powered through USB, batteries, or an external power supply. The power source depends on the specific Arduino board and the requirements of the project.The Arduino IDE is a software application that allows users to write, compile, and upload code to the Arduino board [27]. It supports the C/C++ programming language and provides a simple interface for beginners.

2.8.2 Raspberry Pi

The Raspberry Pi is a series of single-board computers developed by the Raspberry Pi Foundation, a UK-based charity organization. These compact, affordable computers are designed to promote computer science education and provide a platform for hobbyists and developers to create a wide range of projects [26].It is equipped with ARM-based processors. The specific model determines the performance, with models ranging from entry-level to more powerful variants.

Column 1	**Column 2**	**Column 3**
	Arduino Uno	Raspberry pi Model B
Price	$30	$35
size	7.6*1.9*6.4 cm	8.6*5.4*1.7 cm
Memory	0.002 MB	512 MB
Clock Speed	16 MHZ	700 MHZ
On board Network	None	1000 wired Ethernet RJ45
Input Voltage	7 to 12V	5v
IDE	Arduino IDE	Scratch,IDLE,anything with linux support
Source Type	Open source	Closed Source

Table 2.7: Comparison between Microcontrollers

Chapter 3

SMART TROLLEY

It is an innovative solution designed to revolutionize the traditional shopping experience in retail stores and supermarkets.Equipped with advanced technology to offer customers a seamless, convenient, and efficient shopping journey.The trolley is equipped with sensors and cameras that allow it to autonomously follow the customer as they navigate the store. Optimized billing and payment process. Provides customers with real-time pricing information.

3.1 Introduction

In the past few years, robotic technology has evolved substantially. To aid humans in their work, a robot must be able to recognize and follow them, necessitating the development of robots like the ”SMART TROLLEY” that can interact and co-exist with them. Localizing the items in the surroundings as well as the robot itself is a significant problem in enabling the robot for executing a range of activities in the real-world. A robot need to be sophisticated to track a human through traffic regions, a vibrant atmosphere, and both indoors and out. The project's goal in building a following robot is for it to be able to carry objects alongside humans. It can be utilised in agriculture, construction, airports, and shopping malls. A microcontroller is the overall system's controlling device. The RF signal transmitted by the object can be used by RFID readers to identify the objects. Sensors such as ultrasonic sensors and infrared sensors aid in the recognition and location of objects. The microcontroller is connected to an RFID module and DC motors. The controller is loaded with a

programme developed in the Arduino IDE software application that allows users to write, compile, and upload code to the Arduino board to accomplish this operation.

3.1.1 Objectives

The goal of our project is to build a Smart Trolley using RFID technology to help customers to reduce the checkout time and to reduce strain while pulling the trolley.It consist of an automatic human following system and auto billing system. The automatic human following system is used to follow the customers with the help of IR and ultrasonic sensor. The automatic billing is done using RFID technology. This project is to improvise the shopping experience and make customers shop conveniently.

3.1.2 Methodology

To develop an RFID-based human-following system and RFID-based automatic billing smart trolley, you can follow these general steps:

Define Project Scope: Clearly outline the objectives, features, and functionalities of both the RFID-based human-following system and the RFID-based automatic billing smart trolley.

RFID Technology Understanding: Gain a solid understanding of RFID technology, including the types of RFID tags, readers, and communication protocols. This is crucial for both human-following and billing aspects.

Hardware Selection: Choose appropriate RFID tags, readers, and other hardware components for both the human-following system and the smart trolley. Consider factors like range, frequency, and compatibility.

Human-Following System:

1. Implement RFID tags for humans to wear.
2. Develop algorithms for the RFID reader to detect and follow the tagged person.
3. Integrate sensors or cameras for more accurate tracking if needed.

Automatic Billing System:

1. Attach RFID tags to products on the smart trolley.

2. Set up RFID readers at the exit of the store.

3. Design a billing system that automatically recognizes the RFID tags on items leaving the store, calculating the total cost.

Communication Protocols: Establish communication protocols between RFID components, ensuring seamless data transfer between the tags, readers, and the central system.

Software Development: -Create an interface for the human-following system to interact with the tracking algorithm.

Build a interface for the billing system, displaying items and total cost.

Integration: Integrate the human-following system and the automatic billing system, ensuring they work harmoniously together.

3.1.3 Block diagram

3.1.4 Human Following System Using RFID,Ultrasonic IR sensors

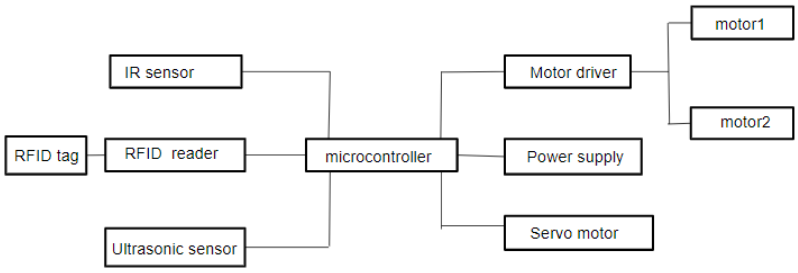

Figure 3.1: Automatic Human Following System

The above given figure shows the block diagram of our project. This concept primarily uses ultrasonic and infrared sensors to track people. Authentication is done with the use of radio frequency identification technology. The RFID process serves as a control key for the robot. The robot can only be controlled by those who have a valid RFID tag. Step 1: The RFID tag acts as the robot's key. The RFID tag's unique identification number is employed as an enable condition for the robot to follow the person in technical terms. The "for and if loops" are used to determine whether to run the code or not. The code instructs the robot to follow the person by using ultrasonic

and infrared sensors after detecting a valid RFID tag. Step 2: The programming to track the human begins to execute after the tag has been detected. To begin, the ultrasonic sensor identifies whether the subject being followed is in front of or behind. If the subject is on either side of the robot, the two infrared sensors identify it and direct it in that direction. Throughout the operation, the infrared and ultrasonic sensors operate together. They identify persons using ultrasonic and infrared technologies and communicate the data to the Arduino. The Arduino acts as a processor, providing information to the motor driver. The generalised system design, which incorporates the controllers with RFID, motors and various sensors and modules.

3.1.5 Automatic Billing System Using RFID Technology

A Radio frequency identification of 125KHZ tag is along with every product in the super-market and mall etc., and the em-18 reader is along with the carrying or moving equipment like trolley. When the customer picks up the product in a mall, the RFID tag along with item scanned by wireless transmission model (EM-18 Reader). Every RFID tag have an individual 12- Digit code [2]. Reference on that 12 Digit code received by Arduino; the product is showing the result on the LCD display with updated amount.

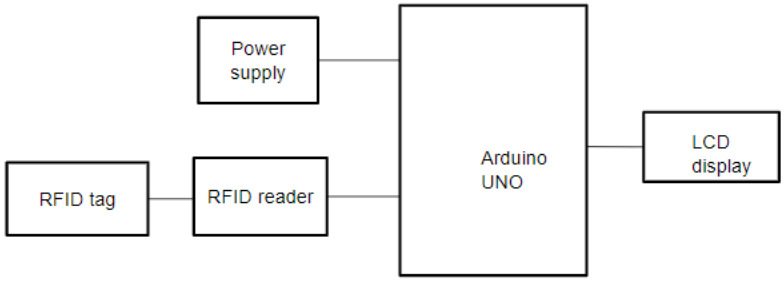

Figure 3.2: Automatic Billing System

As shown in the figure the main controller of this project is Arduino Nano Board where the project code is stored. The Arduino operates all the processes from reading RFID Cards info to storing and calculating prices. The RFID Module that we are using here is the EM-18 Module which operates at a frequency of 125KHz. Apart from the RFID Cards, we need 5-10 RFID cards. These RFID cards are named as different items name like tea, milk, biscuits, oil, etc. The system has a buzzer that turns on when an

RFID is scanned. We are using a 16×2 LCD display for this project. To power the entire circuit, we will use a pair of Lithium-Ion Batteries. Each 3.7V Samsung 18650 connects in series to give a 7.4V Supply. Then the 7.4V is supplied to Vin Pin of Arduino Board. The RFID and LCD module is powered via a 5V pin of Arduino Nano.

3.1.6 Work Plan

Sl. No	Month	Week	Work Proposed	Status
1	September 2023	Week 1-2	project finalization	completed
		Week 3-4	Background research	
2	October 2023	Week 1-2	Literature review	
		Week 3-4	Comparative analysis	
3	November 2023	Week 1-2	Synthesis	
		Week 3-4	Report preparation	
4	December 2023	Week 1-2	Project design	
		Week 3-4	RFID integration	
5	February 2024	Week 1-2	Human following system	
		Week 3-4	Automatic billing system	
6	March 2024	Week 1-2	Integration and testing	
		Week 3-4	Finalization and documentation	

Table 3.1: Work Plan

Chapter 4

Conclusion

The implementation of the ”Human Following and Automatic Billing Smart Trolley” by using the seamlessly integrated RFID technology, provides the system with a precise and efficient billing processes, minimizing errors and enhancing the overall shopping experience.Based on literature survey the finalized technologies include sensors-IR sensor, ultrasonic sensor , product identification method-RFID technology ,wireless technology-RFID, batteries-Li-ion battery, motors-geared dc motor, servo motor, motor driver shield-L298N,microcontroller-Aurduino.By proper use of technology, system makes a human following and automatic billing smart trolley it helps to reduce human strain and checkout time. The incorporation of human-following capabilities adds an extra layer of convenience, allowing shoppers to navigate the store effortlessly.It also helps in optimizing operational workflows, reducing manual efforts, and improving the accuracy of transaction processes.Fostering a more seamless and enjoyable shopping environment for consumers while offering retailers enhanced efficiency and data-driven insights.

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