LibWalk - The NextGen Library

IIT Mandi - Design Practicum 2018

Group Number 15

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Abstract

LibWalk aims to make any library completely automatic without any check out desk or manual intervention. A first-of-a-kind idea, *LibWalk* attempts to combine the power of modern Face Recognition systems combined with the powerful RFID identification systems to replace check out desks from a library. Just walk-in to the library, take your book, and walk out. You need to do nothing more to get a book. To return a book, just drop in to our return *Book Dropbox* and go away. Our system will unissue the book for you.

As of today the only face recognition based check system in the world is the only Amazon Go store in Seattle. With the world moving fast toward biometrics, it's time we make our library management systems on par with the world.

1 Introduction

LibWalk is a future-proof library concept. This relies on on face recognition based authorization and RFID technology to issue and return books without the need of any check-out counters. This is inspired by the latest concept of Amazon Go store. As a matter of fact library management coupled with face recognition as of today hasn't been implemented anywhere around the world. The world is fast moving towards automation and human-less systems. Libraries have been the way they are for centuries. It's high time we give them a futuristic makeover. LibWalk aims to build a check-out desk-less library. It targets to replace the manual issue and return system with a face recognition based technology, detecting what books a student is taking from the library and issuing it to his name. Additionally we have an automatic book drop-box to return books without any manual interaction with the database.

2 The problem

Todays libraries rely heavily on manpower to issue and return books. This system is slow, less efficient and costly. There is no easy way to find a book if it has been misplaced to a different shelf in the library. Finding a misplaced book would be like replacing a faulty vacuum tube in Eniac!

If an automated system is developed to assist issue and return of books it would make any library a lot faster, more efficient and would save a lot of manpower and hence a lot of money. Even in a relatively small library there would be at least 2-3 people manning the check-out desks. An automated system can save their payroll. For example, our IIT Mandi Central Library has 2 people manning the check-in-check-out desk. On an average these people are paid 20-40k per month. That is on an average 8-10 lacs per year! Thats a lot of saving for a medium sized library.

3 Literature Review

Let's first have a look at few of the existing library management technologies:

3.1 Traditional Method

From centuries libraries around the world have been following the same system to issue books. All the books have a slip attached to them bearing the details of the book. To get the book issued, one has to go to the check-out desk wherein the librarian manually checks the details of the book and logs them into a logger(or a computer). A similar process is followed in case of a book return.

3.2 RFID Library

Today a lot of RFID based library systems are available in the market. These systems primarily put RFID tags into the books. When a person wants to issue a book he needs to pick up a book and then go stand in the check-out queue at the check-out desk. The person manning this desk then manually takes the issuers book and identity card(which may also be RFID or bar code based) and then enters the book and person's data into the system. Some systems further give the facility of self-check-out machines. Using this machine the person has to first put his identity card and then place the books one-by-one to get them issued to his name. Nowadays a few RFID antennas are available which can scan multiple tags at once but are comparatively costlier.

Now let's look at an advanced check out technology:

3.3 Amazon Go

Amazon Go is currently the most advanced check-out system tried out ever over the world. It used advanced computer vision, machine learning and Artificial Intelligence to track the customers inside the store and keep note of what they pick up or keep back from the shelves.

What is Amazon Go

Amazon Go is a new kind of store with no checkout required. We created the world's most advanced shopping technology so you never have to wait in line. With their Just Walk Out Shopping experience, simply use the Amazon Go app to enter the store, take the products you want, and go! No lines, no checkout. (No, seriously.)

How does it work

Amazon Go's checkout-free shopping experience is made possible by the same types of technologies used in self-driving cars: computer vision, sensor fusion, and deep learning. Their Just Walk Out Technology automatically detects when products are taken from or returned to the shelves and keeps track of them in a virtual cart. When you're done shopping, you can just leave the store. Shortly after, they'll send you a receipt and charge your Amazon account.
The ceiling of the store has multiple cameras and store shelves have weight

sensors, to detect which item a customer took. If a customer takes an item off the shelf, it will be added to the person's virtual cart. If a customer places an item back on the shelf, it is "taken out" of the virtual cart.

4 Face recognition

A facial recognition system is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source. There are multiples methods in which facial recognition systems work, but in general, they work by comparing selected facial features from given image with faces within a database.

4.1 Face Recognition Methods

Traditional

Some face recognition algorithms identify facial features by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. These features are then used to search for other images with matching features.

Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face recognition. A probe image is then compared with the face data.

Recognition algorithms can be divided into two main approaches, geometric, which looks at distinguishing features, or photometric, which is a statistical approach that distills an image into values and compares the values with templates

to eliminate variances.

Popular recognition algorithms include principal component analysis using eigenfaces, linear discriminant analysis, elastic bunch graph matching using the Fisher-face algorithm, the hidden Markov model, the multi linear subspace learning using tensor representation, and the neuronal motivated dynamic link matching.

3-Dimensional recognition

Three-dimensional face recognition technique uses 3D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin.

Skin texture analysis

Another emerging trend uses the visual details of the skin, as captured in standard digital or scanned images. This technique, called Skin Texture Analysis, turns the unique lines, patterns, and spots apparent in a person's skin into a mathematical space.

Surface Texture Analysis, works much the same way facial recognition does. A picture is taken of a patch of skin, called a skinprint. That patch is then broken up into smaller blocks. Using algorithms to turn the patch into a mathematical, measurable space, the system will then distinguish any lines, pores and the actual skin texture. It can identify differences between identical twins, which is not yet possible using facial recognition software alone.

Thermal cameras

A different form of taking input data for face recognition is by using thermal cameras, by this procedure the cameras will only detect the shape of the head and it will ignore the subject accessories such as glasses, hats, or make up.

4.2 Advantages and disadvantages

One key advantage of a facial recognition system that it is able to person mass identification as it does not require the cooperation of the test subject to work.

However, as compared to other biometric techniques, face recognition may not be most reliable and efficient. Quality measures are very important in facial recognition systems as large degrees of variations are possible in face images. Factors such as illumination, expression, pose and noise during face capture can affect the performance of facial recognition systems.

Face recognition is less effective if facial expressions vary. A big smile can render the system less effective.

Anti facial recognition systems

In January 2013 Japanese researchers from the National Institute of Informatics created 'privacy visor' glasses that use nearly infra-red light to make the face underneath it unrecognisable to face recognition software. The latest version uses a titanium frame, light-reflective material and a mask which uses angles and patterns to disrupt facial recognition technology through both absorbing and bouncing back light sources.In December 2016 a form of anti-CCTV and facial recognition sunglasses called 'reflectacles' were invented by a custom-spectacle-craftsman based in Chicago named Scott Urban. They reflect infra-red and, optionally, visible light which makes the users face a white blur to cameras.

Another method to protect from facial recognition systems are specific haircuts and make-up patterns that prevent the used algorithms to detect a face.

4.3 Python face_recognition Library

face_recognition [**?**] is an open-source face recognition library available for free on github. This library allows us to easily manipulate and recognize faces from images. Built using dlib's state-of-the-art face recognition built with deep learning. The model has an accuracy of 99.38Labeled Faces in the Wild benchmark.

5 RFID

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source (such as a battery) and may operate hundreds of meters from the RFID reader. Unlike a bar code, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method for Automatic Identification and Data Capture (AIDC).

RFID tags are used in many industries, for example, an RFID tag attached to an automobile during production can be used to track its progress through the assembly line; RFID-tagged pharmaceuticals can be tracked through warehouses; and implanting RFID microchips in livestock and pets allows for positive identification of animals.

Since RFID tags can be attached to cash, clothing, and possessions, or implanted in animals and people, the possibility of reading personally-linked information without consent has raised serious privacy concerns. These concerns resulted in standard specifications development addressing privacy and security issues. ISO/IEC 18000 and ISO/IEC 29167 use on-chip cryptography methods for untraceability, tag and reader authentication, and over-the-air privacy. ISO/IEC 20248 specifies a digital signature data structure for RFID and barcodes providing data, source and read method authenticity. This work is done within ISO/IEC JTC 1/SC 31 Automatic identification and data capture tech-

niques. Tags can also be used in shops to expedite checkout, and to prevent theft by customers and employees.

In 2014, the world RFID market was worth USD 8.89 billion, up from USD7.77 billion in 2013 and US$6.96 billion in 2012. This figure includes tags, readers, and software/services for RFID cards, labels, fobs, and all other form factors. The market value is expected to rise to US$18.68 billion by 2026.

5.1 Tags

A radio-frequency identification system uses tags, or labels attached to the objects to be identified. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response. RFID tags can be either passive, active or battery-assisted passive.

5.2 Readers

An Active Reader Passive Tag (ARPT) system has an active reader, which transmits interrogator signals and also receives authentication replies from passive tags.

6 The Solution

Currently a user spends a lot of valuable time just to issue a book from the library. Also stealing of books is a big menace and returning books is a unnecessarily tedious task.

LibWalk is dedicated to optimize the present system. We came up with the idea of creating a system where a user directly gets his books issued bypassing

the check-out counter. Cameras installed on the gate will capture the person's image. Then this image would be passed through a face Recognition algorithms to identify his identity and membership status. In case that the system is unable to recognise the person by face detection, he can get himself registered or use fingerprint based alternative. Each book will contain a passive RFID tag. As soon as the person walk through the gate RFID reader (attached on the sides of the gate) would interact with passive RFID tag and issue the book to the person carrying it.

Our System also offer features of library management. Sometimes books are mistakenly placed on other racks which gives library staff hard time finding the book in the pile of other books. That's where our Library assistant comes to help. RFID readers are attached on all racks of shelves. They are constantly in touch with RFID tags on the books. The current position of any book can be monitored by our system. In case a book is being placed in a wrong rack or shelf a buzzer would buzz.

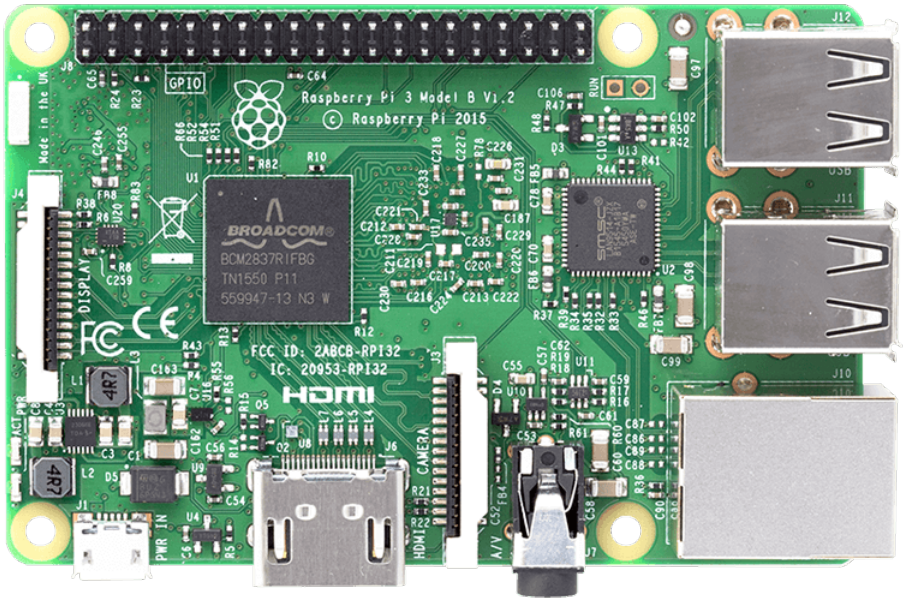
We want the user to be connected with us and get all the information they want in just a matter of click. For this we will created an app called LibGuide. It would give the information like no. of books issued, return date and notification regarding their return. It would update any fine pending. It would show the calender of library, especially indicating the days when library would remain closed and notify the user accordingly.

Return of book is a bigger than needed task manually, taking a unnecessary time and hardwork in sorting and putting them back. We came up with an idea why not to do all this automatically. Instead of returning the book to check-out counter the user would drop those books into the drop-box. Here a RFID technology would again perform its magic and check which book has been returned and if it has been returned on time or not. If there is some delay in returning of the book then the system would calculate the fine and give a notification to the user on the the app. From there a library employee will put the books on the appropriate rack (or maybe the robot of group 14 could do that).

This project is one of its kind. Face-recognition technology is growing rapidly. Currently no library system apply this kind of technology. It would save time of the user and money for library. Apart from this it would also strengthen the library security. This project is a glimpse of how present technology, Artificial Intelligence, computer vision is going to assist humans which seemed just science fiction just a few years back.

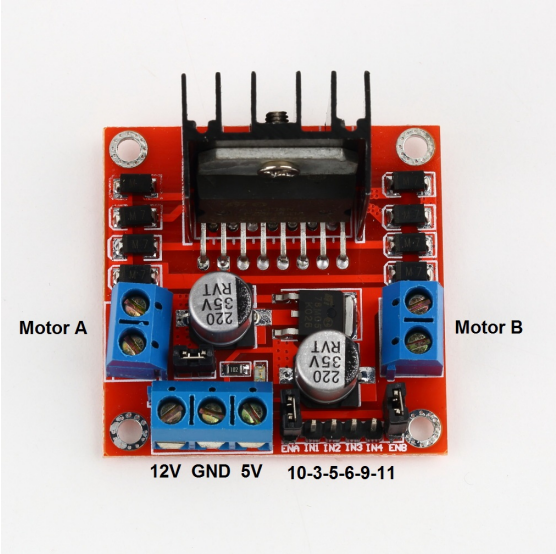
7 Major Components and Modules Used

7.1 Raspberry Pi



The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside its target market for uses such as robotics.

7.2 L298 Motor Driver



The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

7.3 EM18 RFID Reader and Tags

The module radiates 125KHz through its coils and when a 125KHz passive RFID tag is brought into this field it will get energized from this field. These passive RFID tags mostly consist of CMOS IC EM4102 which can get enough power for its working from the field generated by the reader.

Pin No.	Name	Function
1	VCC	5V
2	GND	Ground
3	BEEP	BEEP and LED
4	ANT	No Use
5	ANT	No Use
6	SEL	HIGH selects RS232, LOW selects WEIGAND
7	TX	UART TX, When RS232 is Selected
8	D1	WIEGAND Data 1
9	D0	WIEGAND Data 0

7.4 HC-SR501 Motion Sensor

HC-SR501 is a PIR based motion sensor. A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually this radiation isn't visible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose.

The term passive in this instance refers to the fact that PIR devices do not generate or radiate energy for detection purposes. They work entirely by detecting infrared radiation emitted by or reflected from objects. They do not detect or measure "heat".

8 Designs

Here are the designs of the project:

Figure 1: Blocker for gates - 3D View

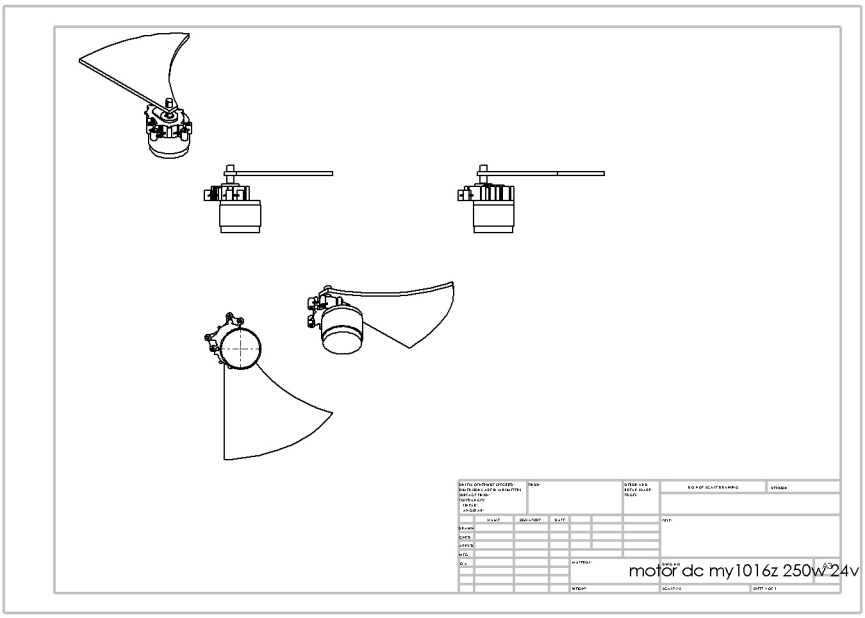


Figure 2: Blocker for gates- 2D Projections

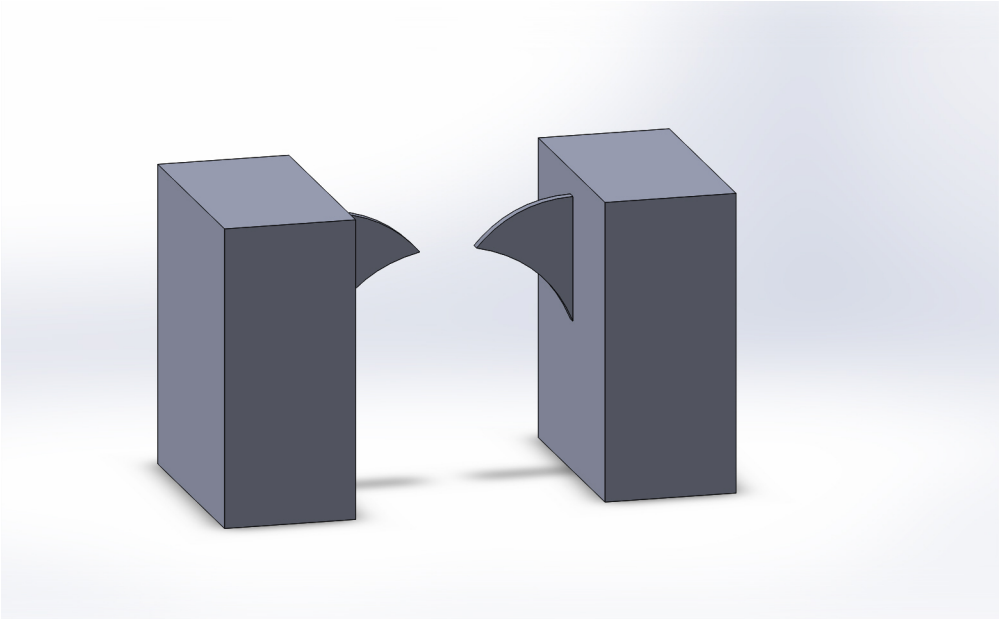


Figure 3: Gates - 3D View

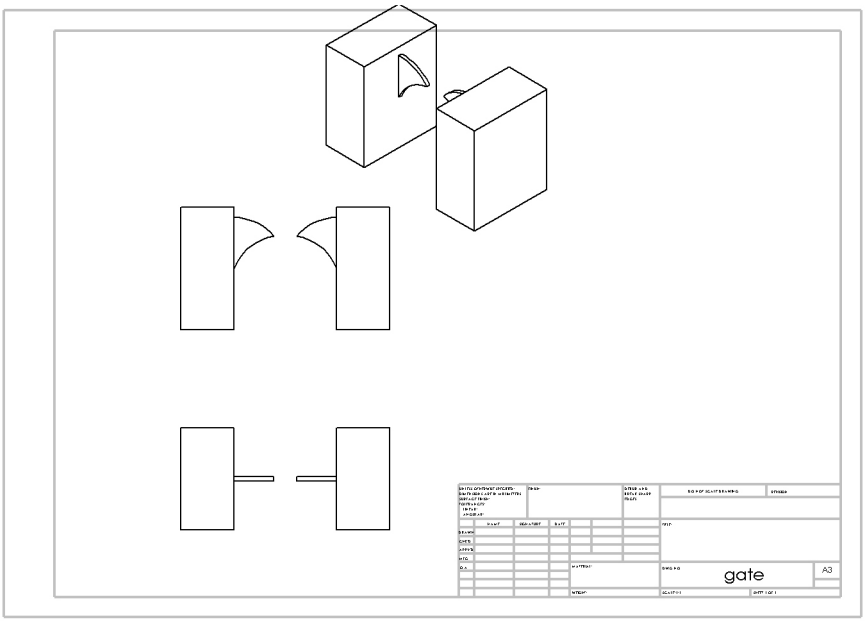


Figure 4: Gates- 2D Projections

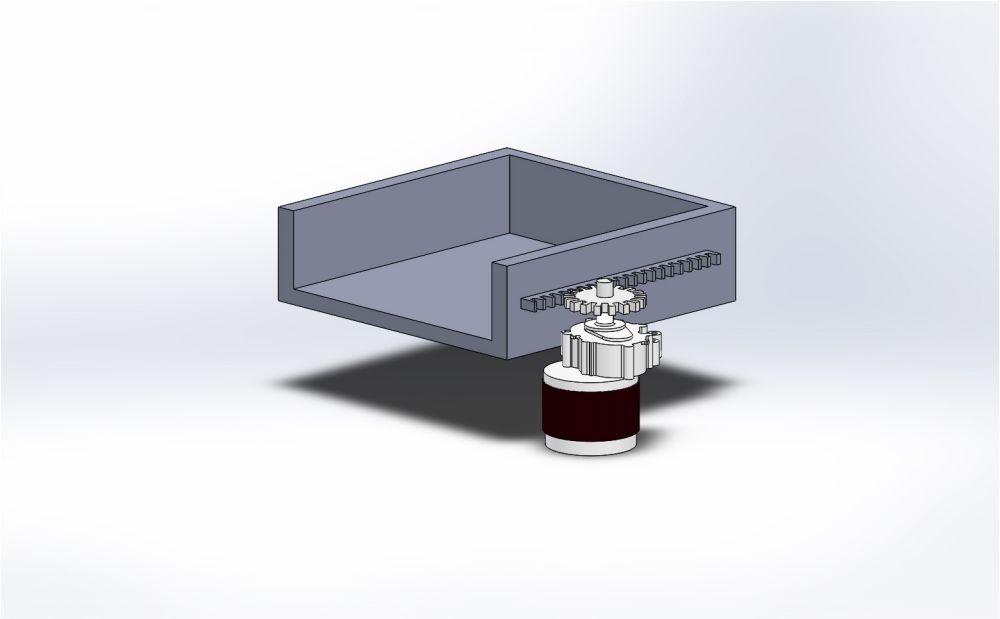


Figure 5: Book collecting movable shelf - 3D View

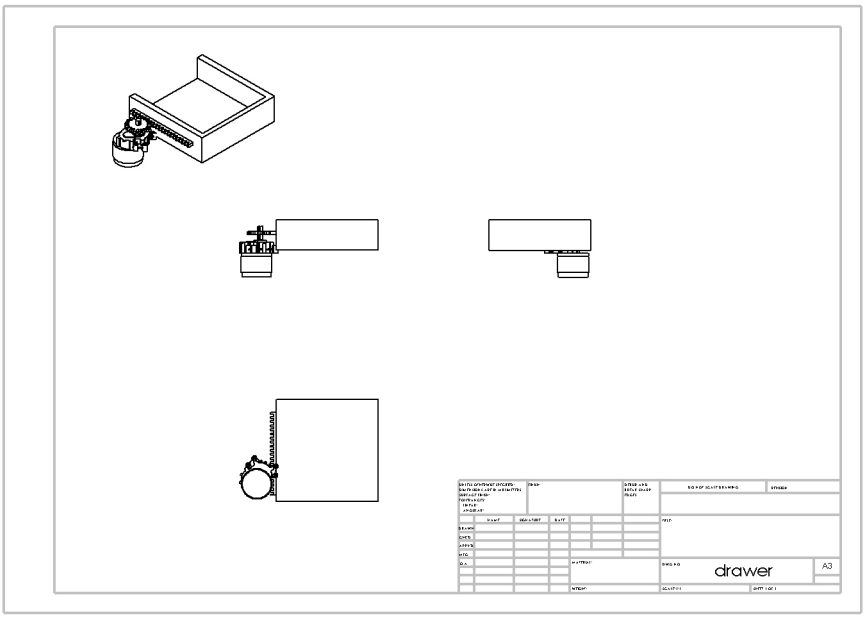


Figure 6: Book collecting movable shelf - 2D Projections

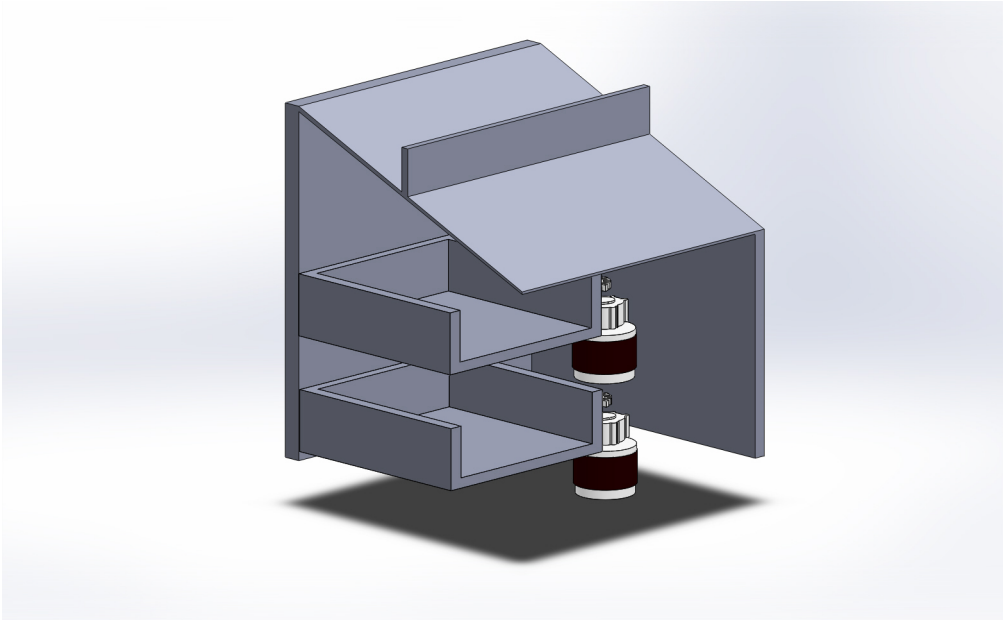


Figure 7: Dropbox - 3D View

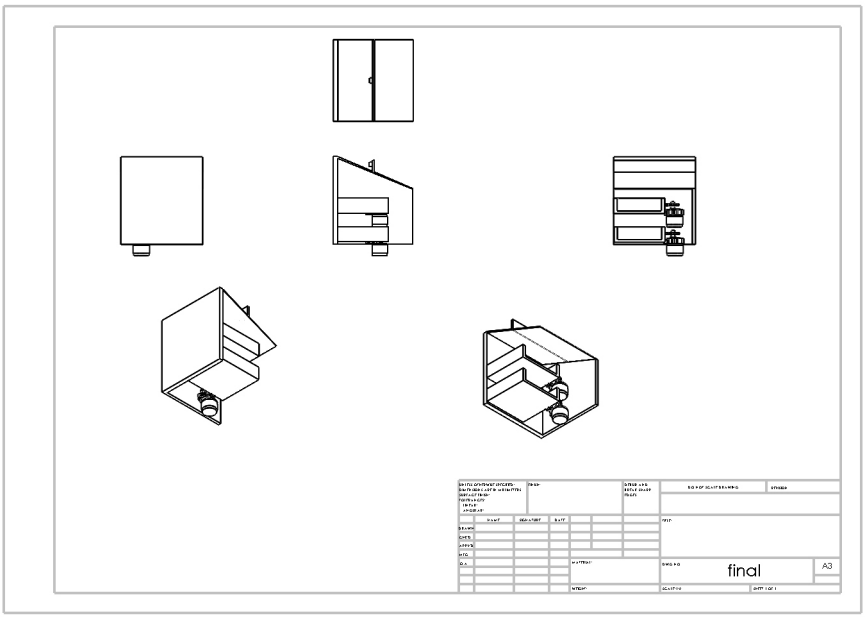


Figure 8: Dropbox - 2D Projections

9 Electronic Circuits

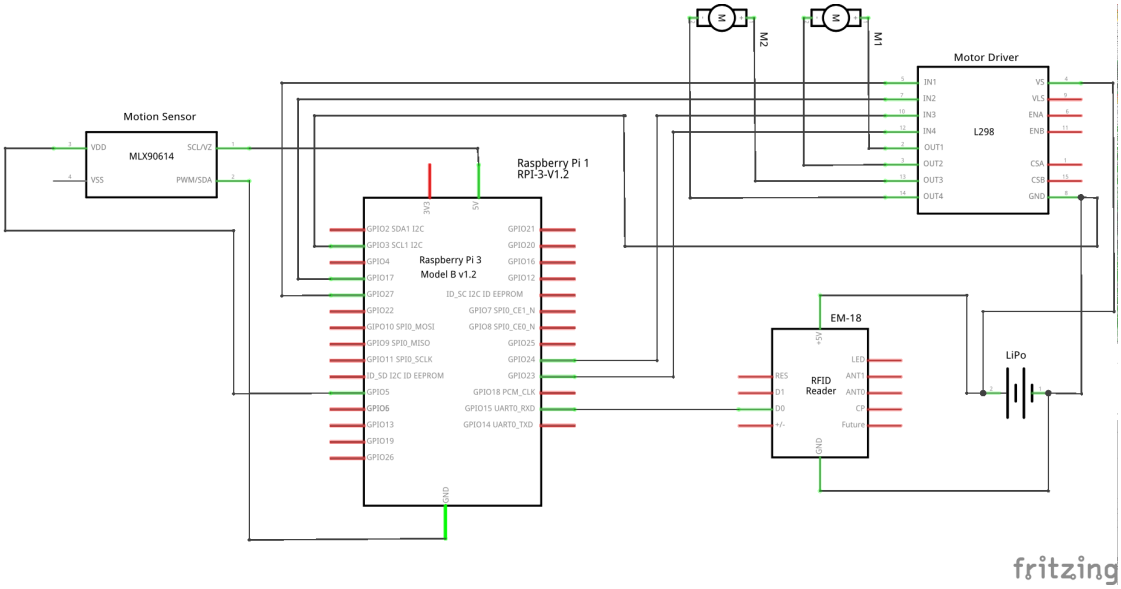


Figure 9: Access control gate - Circuit diagram

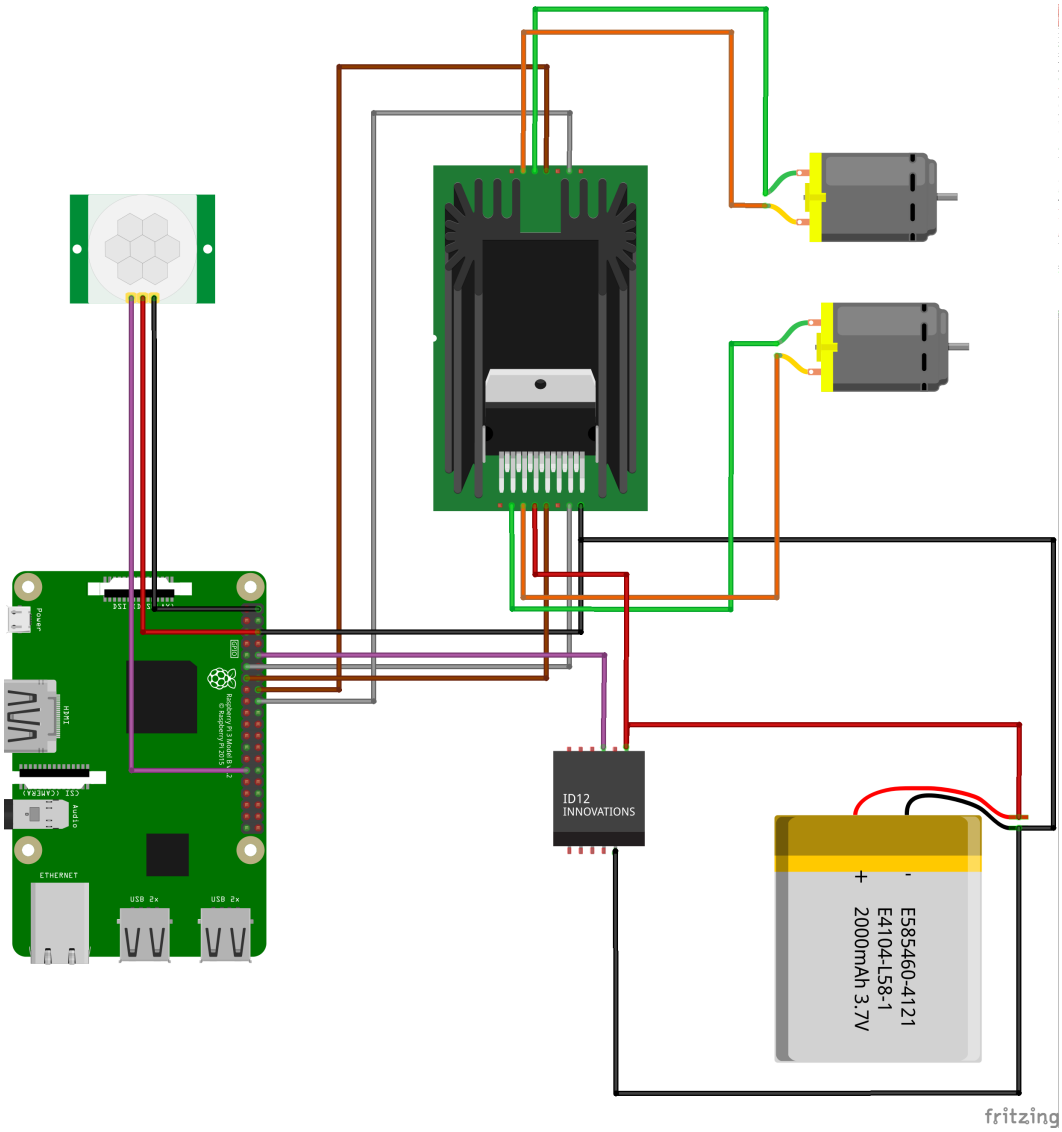


Figure 10: Access control gate - Schematic diagram

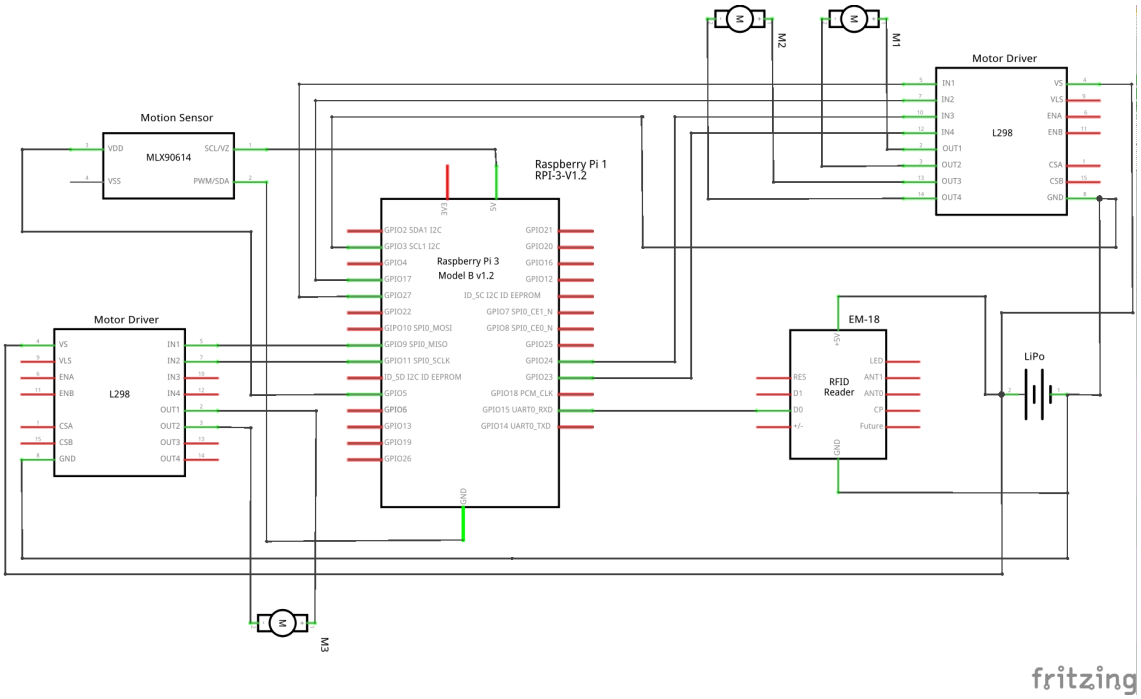


Figure 11: Dropbox - Circuit diagram

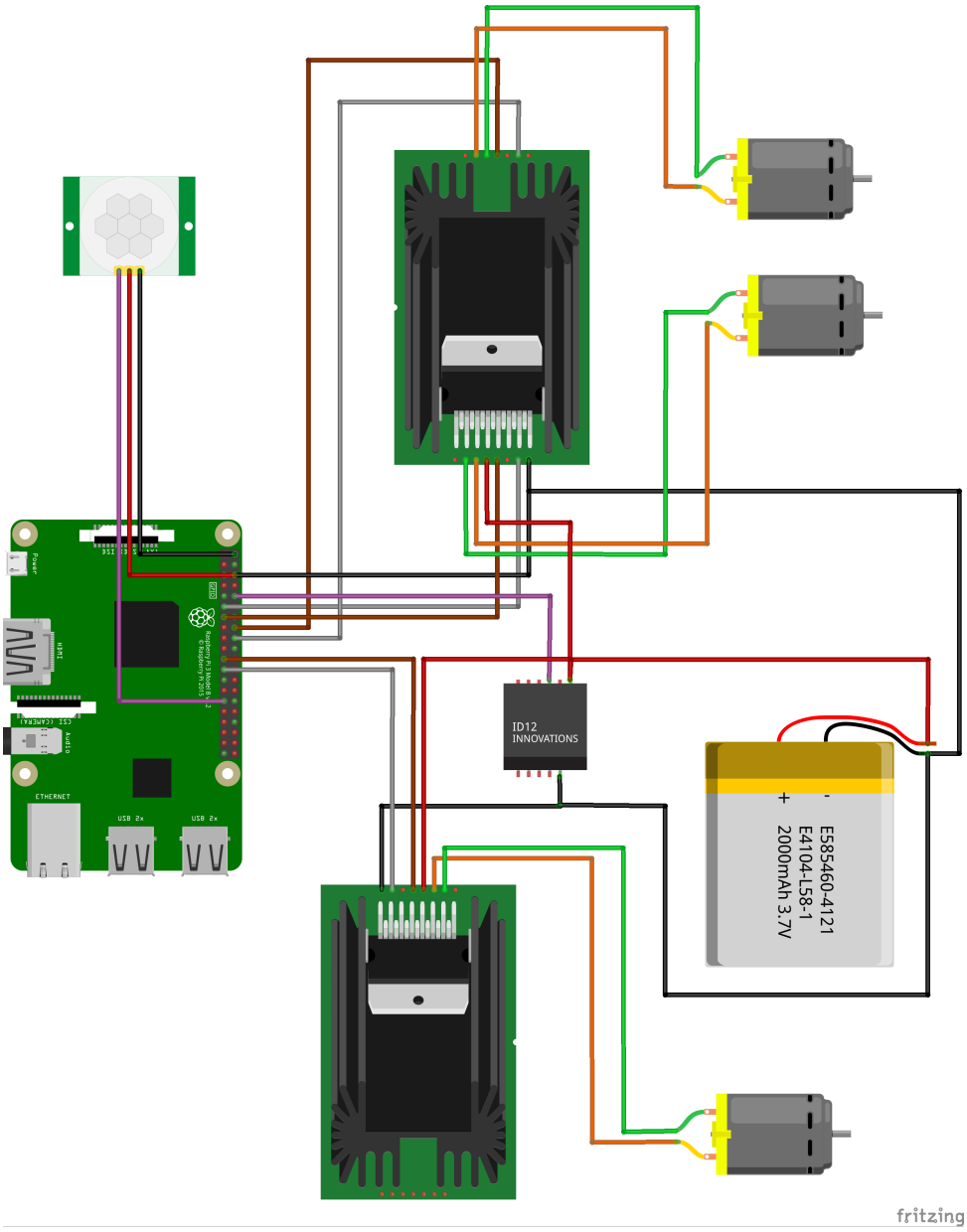


Figure 12: Dropbox - Schematic diagram

10 Algorithm Flowchart

10.1 Gates

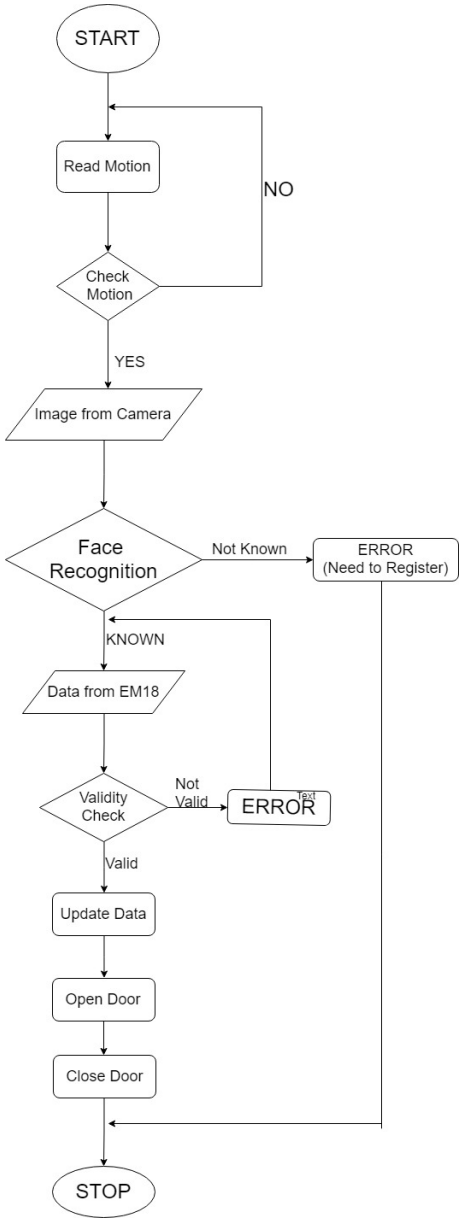


Figure 13: Algorithm Flowchart - Gates

10.2 Dropbox

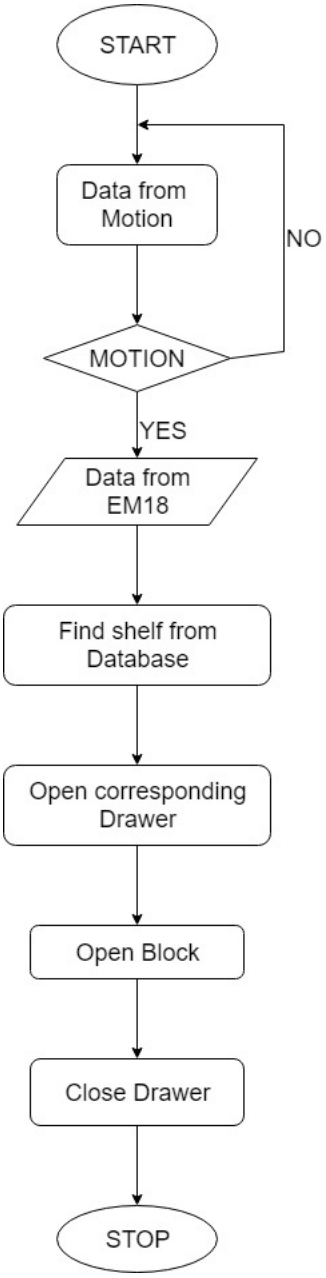


Figure 14: Algorithm Flowchart - Dropbox

11 Manufacturing and Assembly

11.1 Gates

Proposed to be made of wood to be lightweight. Wood is cost-efficient as compared to metal. Fitting and carpentry work-shop will suffice for their manufacturing.

Blocker

We were able to manufacture the blocker out of a plywood in the carpentry shop. A coupling, used for fixing the DC motor to the blocker was manufactured using mild steel rod with the help of lathe and drill machine.

Outer Gate Body

Outer body was made up of ply wood requiring the carpentry shop, wood cutting machine, drill machine and screwdrivers. The slit for the blocker was cut using a cutting machine.

11.2 Dropbox

Proposed to be made of wood and Aluminium Frames to be lightweight. Wood is cost-efficient as compared to metal. Aluminium rods were used to make the structure and wood pieces were mounted on it. Fitting and carpentry work-shop will suffice for their manufacturing.

Book stop mechanism

A system to stop the book while the corresponding drawer is opening is an important part of the dropbox assembly. It was made by fixing a wood piece on a drawer slider and a motor to move it. This needed the carpentry and drill machine.

Drawer mechanism

Proposed to be made of wood and drawer sliders were attached to it. Sliders were fixed with rack. Gears were mounted on motor. The teeth of Rack and gear are tightly attached and a motor is used to open and close the drawer. Fitting and carpentry work-shop will suffice for their manufacturing.

12 Cost Estimate

S.No.	Item	Quantity	Total Cost
1	Raspberry Pi	2	5980
2	L298n Motor Driver	3	852
3	DC Motors 15-kg cm	2	1468
4	DC Motors 5-kg cm	3	1347
5	Em -18 RFID reader	2	1180
6	Motion Sensor	2	218
7	Lipo Battery	2	3980
8	Gears	3	300
9	Rack	3	360
10	Ply Wood	-	4000
11	Cloth	-	600
12	WebCam	1	1099
13	Jumper Wires	100	200
14	Aluminium Frame	-	1300
15	Screw, Nut ,Nails	-	200
16	Slider	3	540
		Total	23,624

13 Impact

- Faster book issue
- Faster book returns at check-out desks
- Removes need to stand in queues
- Very low maintenance costs
- Low installation costs
- No manual intervention needed
- Fully automated

- Dropbox saves time not just for the user but also for the library staff, as after sorting, it's comparatively easier to keep the books back into their place.

14 Future Scope

LibWalk is an easy to implement and practical way for future library management. Our world is fast moving towards biometrics and the likes of face and speech based authentications. Face Recognition as of today has reached a very high degree of precision. LibWalk has two parts, viz, the book issue system and the dropbox. The first module does not need any extra investment for implementation. Maybe there would be some cost incurred to install the access control doors, but that's minimal to even the operating costs. This module can be added by library in a matter of days. You just need the library server to install the software. The system is extremely scalable. Response for face recognition is very fast. So it can recognize a face in leass than half a second even for a database of a few thousand faces.

Further, this system can be extended to other things like cloth shops. Wearables can be fitted with small RFID tags and face data can be use to sell the items to the person as he walks out with it.

15 Conclusion

Developing a contemporary check-out and management system is the need of the hour. Many of our systems are now relying on biometrics like finger-prints and face recognition. Just using image processing seemed to be to costly a solution. When mixed up with RFID technology this proves to be a great, efficient and cost effective way to manage our libraries.

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