PDE3413 Systems Engineering for Robotics

Individual Project Draft Proposal Report

Automated Multi Pet Feeder (MPF)

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1. Introduction

A social robot is a physical-mechanical system that uses a variety of robotic techniques to interact with its surroundings.

They are created with the purpose of demonstrating human-like characteristics, such as hearing, seeing, and object identification using sensors and cameras. They may alter their movements based on the information they collect, such as hand gestures or vocal soundwaves.

One of the most recent developments of social robots is an automatic pet feeder. The latter is intended to aid pet owners with pet care while they are away from home.

The purpose of having sensors in a system like this is to automate the feed process completely with less/no human interference. (Jayaram, automatic pet feeder using internet of things,2019, pp.1)

Human engagement shall only occur when a refill is required or when the user physically operates the pet feeder.

1.1 Aims & Main Objectives of the Multi Pet Feeder (MPF)

1.1.1 Multiple animal detection (maximum 2)

When a pet approaches the robot, the MPF will be able to identify it using computer vision and administer food accordingly. Given that some individuals own numerous pets, this will be a smart addition.
The MPF can be set up to recognize two different animals, such as a dog and a cat, and it can also be used to identify a single animal if the owner has just one.

1.1.2 Pre-sets in terms of quantity

Approximately 55% of cats and dogs are overweight, which poses major health hazards such diabetes, kidney illness, heart, and lung disease. (McDowell, n.d)

The portioned feedings your pet needs are provided by an automatic feeder, which helps to maintain the right weight. The same will guarantee that the animals are fed adequately.

1.1.3 No earlier wake-up for Users

Many pet owners struggle with their pet waking them up in the early morning or late at night. When needed, MPF will feed the animal.

1.1.4 Food Available even in absence of Owners

We all lead busy lives, and sometimes our schedules prevent us from keeping up a regular feeding schedule for our animals. MPF provides the reassurance that your pet will be fed while you are away or at work. It will not be difficult to fit a late meeting into your schedule if you are confident that your pet will consume the same meals as always.

2. Market Size

The Automatic feeder market size was valued at $344.6 million in 2020 and is projected reach $998.7million by 2030, registering a CAGR of 8.0% from 2021 to 2030s

From the above figures and diagram there is an existing market for Pet Feeders and same is expected to grow over the year.

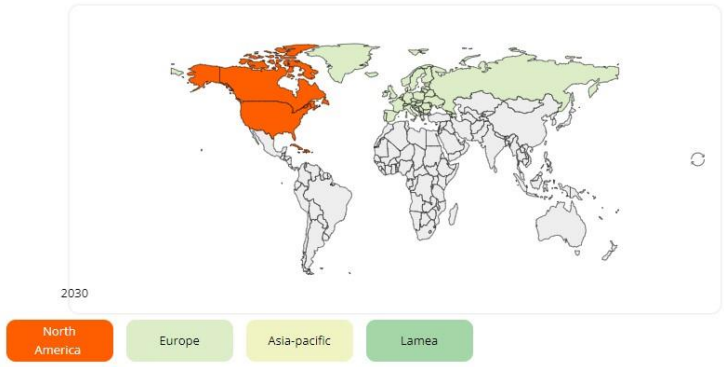

Figure 1. Market Sector (Alliedmarketresearch, Sept 2021)

2.1 Target Audience

The Pet Feeder is targeted for:

- Pet Owners who travel a lot • Pet with food disorder
- Pet Owners who have a rough time keeping up with the frequent food requirements of their pets.

2.2 How project will fit the market?

Seeing the increase in demand and that now several residences have multiple pet a new compact solution will be suited for the homes. The main selling point of this product is that it can be used for multiple pet.

3. Background Research

3.1 Review and short analysis-Existing Projects

The Microchip Pet Feeder (McPT) was made to recognize either the Sure Petcare RFID Collar Tag (one is included - one not) or the microchip that has previously been put in your pet allowing your cat to access their food while maintaining out other creatures.

Surepetcare has created a pet feeder as Figure 2.

Figure 2. Microchip Pet Feeder (Surepetcare, n.d)

3.2 Features and Structural of system

3.2.1 Feature Analysis 3.2.1 Stock Levels

This system lacks a stock level control that would alert the user when supplies are running low, and a refill is necessary.

3.2.1 Tags/Collars

Collar has a unique ID that is saved in the MPT's memory permanently. It can tell if a pet is on the pad of the pet feeder, which has both advantages and disadvantages.

It can tell if a pet is on the pad of the pet feeder, which has both advantages and disadvantages.

But as a drawback, it raises ethical and practical concerns. For instance, many proponents of animal rights oppose the wearing of collars, even though they serve an important purpose and that, given the nature of the animals we deal with, the collar tag is prone to loss or damage and thus increases user costs. Since it has a pricey and distinctive method of recognizing the collars, user will have to purchase one directly from the manufacturer.

3.2.1 Retrieving remaining food by pet for later use

Unfortunately, this pet feeder has no way to put remaining food back to the bowl which might lead to food wastage.

3.2.1 Identification of pet

The McPF does not include a method of identifying the animal because some households may have more than one cat or pet, for example, one household may have dogs and cats, necessitating the purchase of two separate devices, which will confuse the pet.

3.2.1 Food holder in metal

Because of the way the product is designed, it can hold both wet and dry food. Bowl capacity is 400 mL, which is equivalent to two pouches of wet food.

3.2.1 Battery powered

This product has a 6-month battery life, which is ideal if the user is away for an extended period and there is no power in the home.

3.2.2 Structural Analysis 3.2.2 Button Placement and function control

Pros:

1. A minimalist approach that is not tampered with by the pet.
2. Easily accessible from the side

Figure 3. Button Placement and interaction board (Surepetcare, n.d)

Cons:

1. There are not many options, and the interface is not very user-friendly.
2. The pet ID is permanently stored and must be returned to the factory for hard reset. There is no leeway.
3. There is no variety of options available, and the same is not aimed at people who are less familiar with technology.

3.2.2 Lid opening

Pros:

1. It is a better sanitary option because food does not spill everywhere.
2. Proper food control if you have multiple pets. Only pets with tags will be responded to by the lid.

Figure 4. Lid Mechanism (Surepetcare, n.d)

Cons

1. The mechanical lid should take some time to open, allowing the pet to leave.
2. The opening of the lid is determined by the tags. If two tags are too close together, a conflict will occur, and the machine will need to be restarted.

3.2.2 Movement of lid details Pros:

1. The way the lid will use data from previous opening and closing to adapt to the pet, which is an adequate method of learning the animal to optimize optimal use.

Figure 5. Lid Adaptation (Surepetcare, n.d)

Cons

1. The initial adaptation will be difficult and unpleasant for the pet.

3.3 Review and short analysis-Existing Technologies

3.3.1 Contextual Info

Many animal species are still becoming extinct because of hunting, and governments can only do so much by enacting laws and conducting regular surveys. However, conducting a survey is a challenging task, especially without the assistance of technology.

This project's smart camera employs Python code with pre-trained TensorFlow models for forest monitoring and survey. The models assist us in matching and mapping the image in frame with the trained data of the model, and thus in identifying those animals.

Figure 1 shows images of elephants being detected using the author's prototype. Figure 2 depicts the author's prototype, which employs a Raspberry Pi (or RPi) with a camera module.

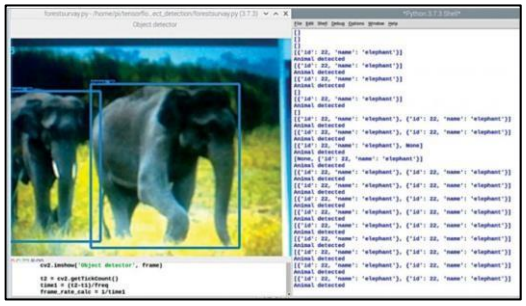

Figure 6. Elephant being captured by prototype (Kumar Sinha, Sept 2021)

Figure 7. Pi Camera for Survey (Kumar Sinha, Sept 2021)

3.3.2 Technological Analysis + Costing for Pi Camera Implementation

The Raspberry Pi uses its camera to take a video image, and the OpenCV module is used to separate the video into frames. The image of the discovered species is then processed using OpenCV and other modules, and it is mapped with a category and trained detection model. When an animal species is recognised but not included in the category list, the output is "none" and the image, data, and date are saved in the database folder for later analysis.

Bill of Materials — Table 1

Component name	Quantity	Description	Approx. Cost (₹)
Raspberry Pi 4/Zero W	1	Any version of RPi	4,500
RPi camera	1	Camera module	300
HDMI/RCA cable	1	For video output	200
Wires	Depends	For connection	30
Total cost			**5,030**

Figure 8. Costing Table (Kumar Sinha, Sept 2021)

The total cost for the Full protype was INR 5030 equivalent to Roughly Mur 2515.The pros of this system is that it is cheap and need very how maintenance but a major con is that we have to feed the RaspberryPi With existing data for it to be able to get a more or less accurate result.

This technology can be used to train a pet feeder to identify different animals so as to be able to analyse and process the data for actions to be taken by the robot.

4. Proposal

4.1 Description and concept behaviour.

A Multi-Pet Automated Feeder that distributes and monitors food. The same will be able to store food and identify which pet is visiting its base and will provide appropriate food. It will also have an interface for human to react directly on it. If food is left over after a while, it must be returned to the food storage. This MPF must also have a water dispenser. The concept behaviour will be in details below. (Refer Section 4.2.2 Flow of System)

4.2 Review and short analysis-Proposed projects

4.2.1 System Architecture

The System architecture connection shall be as per diagram 9. More details is be given in a flow chart and the flow of data shall be given in full detail refer to Section 4.2.2.

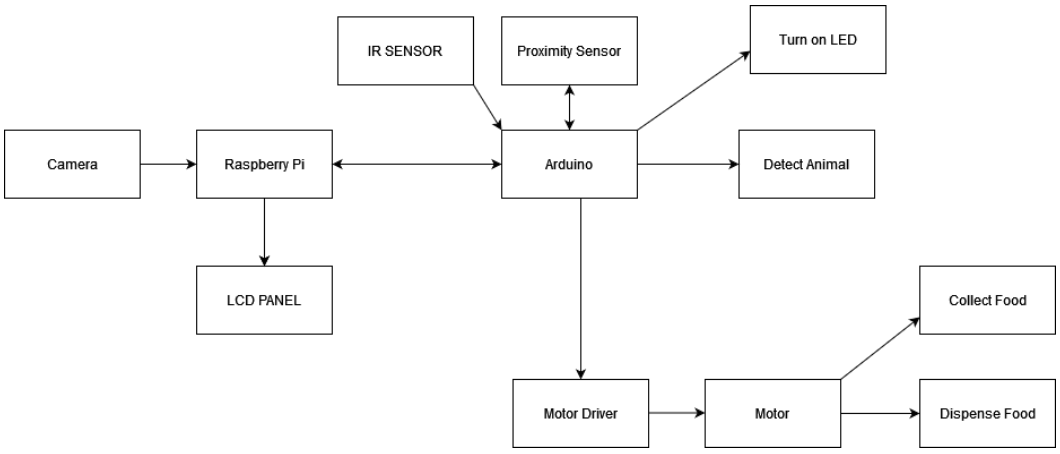

Figure 9. Block Diagram

4.2.2 Flow of the System

The sensors will interact between each other and with the Arduino & raspberry pi to generate action exactly like human using sensors to the brain. The flowchart below will give more detail about the flow of data and how sensors react between each other

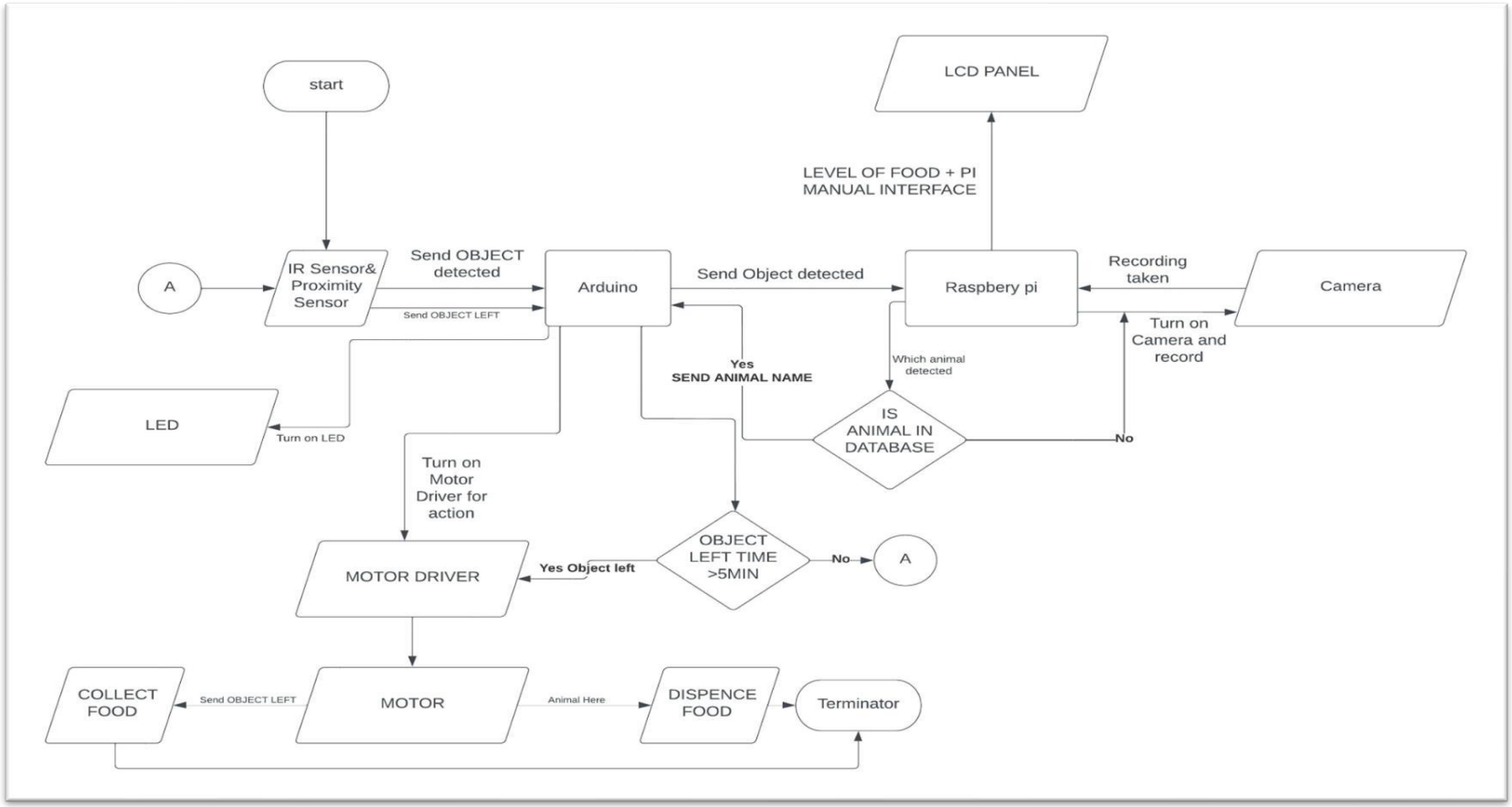

Figure 10. Flowchart

5. System Breakdown

To create an effective robot, we must first divide the system into smaller pieces and investigate its technological needs, which will serve as a guide for testing the system and identifying potential flaws.

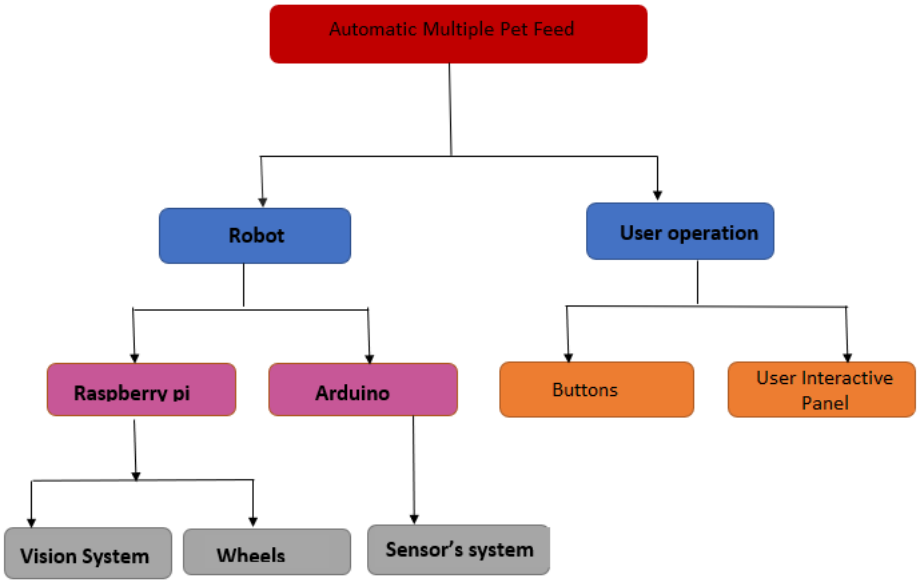

Figure 11. System Breakdown

6. System Requirements

General Requirements

General requirements	
ID	Requirement
R01	The system should provide food to the animal in front of it
R02	The system should be easy to interact
R03	The system must be user friendly.
R04	The system should be lightweight for user to place it and plug in into ac supply
R05	The system's components should be easily accessible for maintenance.
R06	The system should be ready by latest March.

Figure 12. General Requirements

Robotic System		
Sub Systems	**ID**	Requirement
Raspberry Pi	Rasp01	The system should be powered by AC
	Rasp02	The raspberry pi should communicate with the camera to allow for vision of Object coming close to the MPF
	Rasp03	The Raspberry Pi will send signal to the Servor Motors & Water Oump
	Rasp04	The Raspberry Pi Should be the relay between the camera and the sensors
	Rasp05	The servor Motor & DC motors gets instruction for the Raspberry Pi to Open Valve to dispense food and move the cart
Arduino	A01	The system should be powered by AC as the raspberry Pi
	A02	A full check is done upon start to check if all sensors are good and operation
	A03	The Ultrasonic sensor,IR sensor,Servo Motors& DC motors connect to the arduino
Vision	V01	The Vision of the robot consist of Camera
	V02	The camera is made sure that its pointed toward the entrance of the Pet Feeder
	V03	The Camera Will start recording as soon as IR & Ultrasonic Sensor Detect Object Near the Robot
	V04	OpenCV is used to analyse the data to check if it's an animal or not
	V05	The camera operation of turning on and off will be autonomous
Pulley	P01	The pulley will be connected to a motor together with a belt which is connected on both side of the food moving storage internally
	P02	The Pulley needs to be position such that it is horizontal with the centre of mass of the cart
	P03	The Pulley rotation need to stop when food container is reached for delivery and resume when delivery is done to move the food kart
Sensor System	S01	All Sensors need to be properly positioned on the robot
	S02	All the motors need to be properly connected to the arduino with its driver to be able to be powered on
	S03	The Sensors should be configured to read appropriate data and react based on input data
	S04	Data read for sensors need to be communicated to respective part of the robot as shown in the flow chart

Figure 13. Robotic System & Sub Systems

User Operations		
Mode	**ID**	Requirement
User Interactive Panel	UIP01	The UIP will be implemented using simple ROS for user to interact
	UIP02	The Panel should provide an interface for pre-set amount of food to be delivered
	UIP03	The Panel should provide user with current stock and level
	UIP04	The panel should give warning message if there is any error
	UIP05	The Panel also will provide the user with a manual feed mode
	UIP06	It should provide an option to select which animals are present in the house for easy processing of data by the robot

Figure 14. User Operations Table

7. Component for data collection and action creation

All social robot-like human- have different sensors to collect data from the environment and process it to do an action.

You shall find the sensor & component list below which will be required for the proposed project.

• Object Detection

1. **Proximity Sensors (Sharp GP2Y0A41SK0F)**
A PSD (position sensitive detector), an IRLED (infrared emitting diode), and a signal processing circuit are merged to form the distance measurement sensor unit. The adoption of the triangulation approach

prevents the diversity of the object's reflectivity, the ambient temperature, and the operation length from having a significant impact on the distance detection. The voltage output by this gadget is determined by the detection distance.

Figure 15.Analog Distance Sensor (Pololu, 2022)

Same will be used to detect any incoming object
In Short, the Distance is directly proportional to the voltage output by the sensor

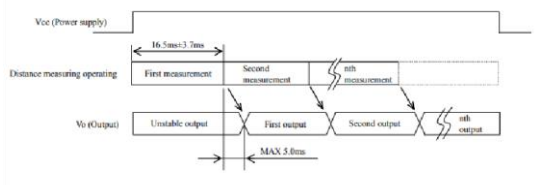

Figure 16. Timing Chart (Global Sharp, 2022)

Operating Voltage of 4.5 to 5.5 V
Minimum Time on to get 1st Output time: 16.5ms±3.7ms(refer to Figure 12).

• Machine Vision

2. **Raspberry Pi Camera Module 2** The 8-megapixel Sony IMX219 sensor in the v2 Camera Module (compared to the 5-megapixel OmniVision OV5647 sensor of the original camera).
Both still images and high-definition video can be captured using the Camera Module 2.
Same used to capture the object detected and will be sent to the raspberry pi for further processing
Recommended Input Voltage 5V and Input Current 2A

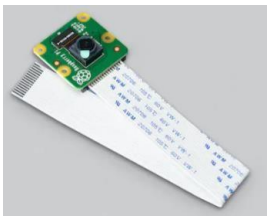

Figure 17. Pi Camera Module 2 (Raspberry Pi Foundation, 2022)

• Water Level Control

3. Water Level Sensor ADV00089
An inexpensive, simple-to-use water level recognition sensor, the water level sensor is made by having several exposed parallel wire traces that measure the volume of the water droplets.

The sensor will provide analogue values straight to the analogue input pins on your Arduino board, where they may be read and processed further.
Ideal for any upcoming project using a water level alarm.
3.3V to 5V is the operating voltage and less than 20mA.

Figure 18. Pi Camera Module 2 (Raspberry Pi Foundation, 2022)

As Figure 15 shows the Water
Level is Indirectly proportional to the resistance.
This will be our control for us to check the level of water

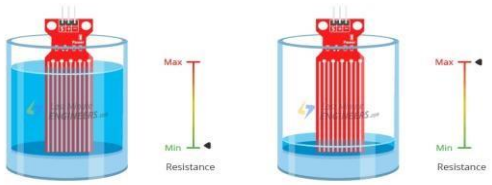

Figure 19. Water Level Sensor in scenario (Lastminuteengineers, n.d)

8. Feature Analysis

8.1 Detection & Identification of Pet

As soon as pet come close to the sensor the Robot will detect the animal thus starting the identification process. Computer vision will be implemented to Identify which pet shall be used using camera. The Project use camera vision linked to capture the face& body of the pet and shall compared that to a database as explained above in Section 1.1.1. Base on the outcome the respected food shall be delivered

8.2 Selection of Food

After pet has been identified a plate shall be move on the x plane to collect proper food. (More details in Structural Analysis). After selection of food, the plate shall move on the Y plane down next

to the out-source to the bowl. (More details in Structural Analysis). When the plate come to the outside it shall be tiled by a motor to empty the plate into the food bowl. After that same shall be reset to initial position.

8.3 Level of Food in Stock

Stock shall be monitored like a being in low stock same shall light a red bulb next to the slot for the corresponding food. (An on-board interface shall be implemented depending on the time frame).User will have to interact with it and refill same

8.4 Food storage

Food will be stored internally to avoid contamination of food and risk of heal issue of the pet

8.5 Control Panel

The MPF shall have a control panel where user will be able to interact and have full control on the system manually.

9 Structural Analysis

9.1 Outside structure

The MPF Shall be a box like structure. Below you shall find the plan of the Robot.

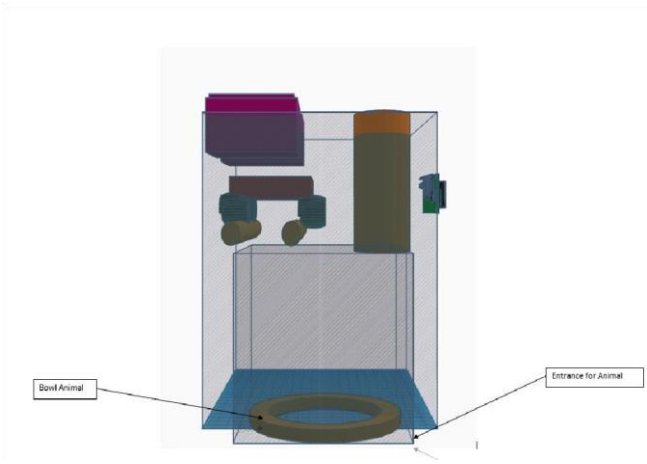

Figure 20. Front View of MPF

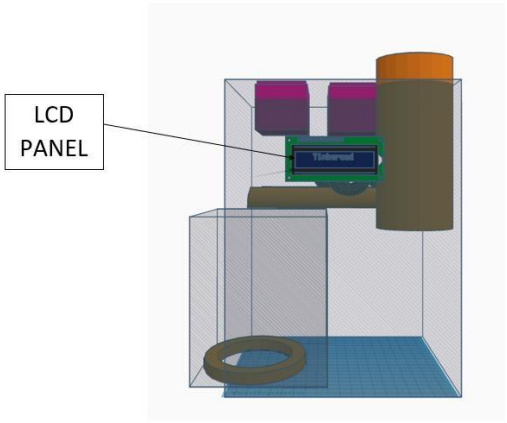

Figure 21. Side View of MPF

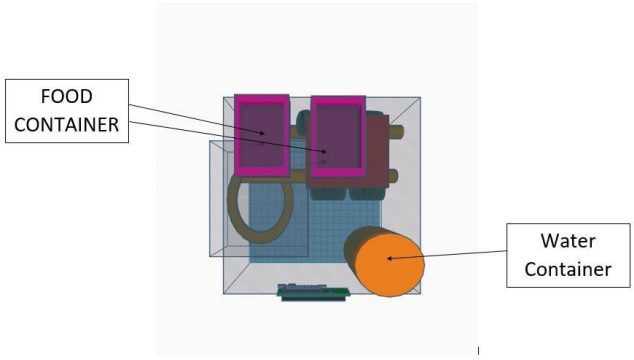

Figure 22. Top View of MPF

Proximity sensor & IR shall be placed on 4 sides of the MPF so as it can detect the animal coming from all areas. The Pi Camera will be placed only on the Front View since the bowl of food is there thus the MPF will dispense food when the animal is in front of the ball. LED will be in the small partition where the food will be given to create a cosy environment for the animal.

9.2 Sensor Placement & Component Placement

7.2.1 IR & Ultrasonic Sensor

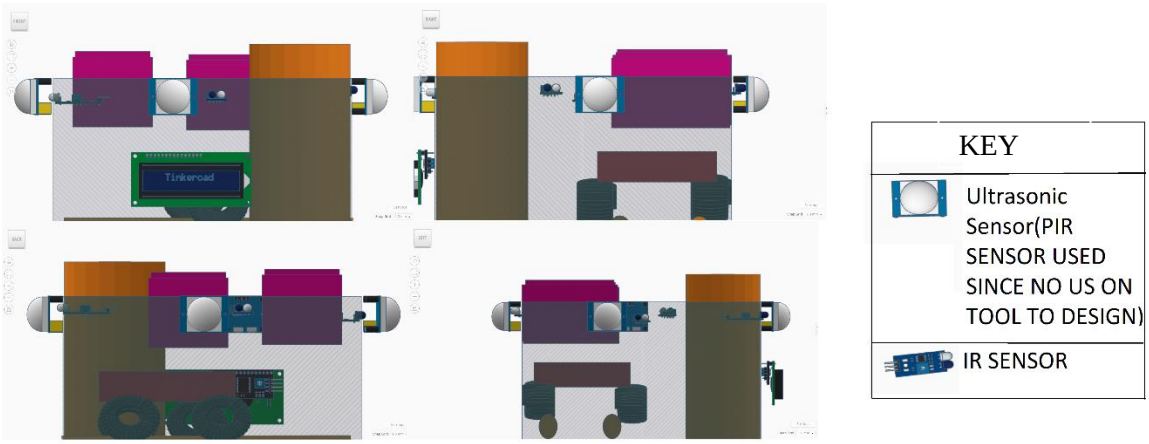

Figure 23 Side View of movement system

9.1.1 Movement of plate for food dispense

The plate shall be place on wheels. Same structure will be put on two rods and a chain shall be attached to both end of structure.

For the movement of the plate same shall act as a pulley system to move right and left (x-axis) refer to Figure 19

For the Movement up and down system shall be same as x-axis put just on y-axis

The pulley will work with a motor. Refer to Figure 19

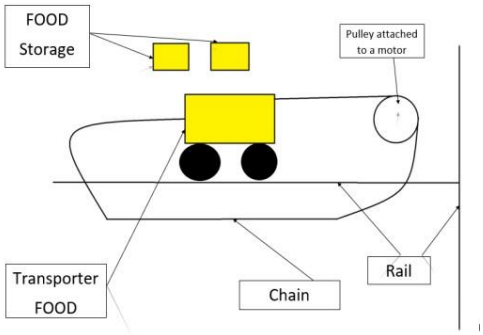

Figure 24. Side View of movement system

10. Bill of Materials

Some projects might turn out costly when all cost is taken into considerations. Below you shall see a breakdown of items require

Qty	Component	Model No.	Price(Rs) incl VAT
Already Bought			
1	Raspbery PI	R-PI4-4	9250
1	MicroSd Card	KI0-MSD16	240
1	Water Level Sensor	A-WLS	35
6	Obstacle Sensor PhotoElectric	KIT-FC51	45
4	Ultrasonic Distance Measuring	HC-SR04	60
1	ABS Plastic Enclosure Rasp Pi	A-ACRY PI4	150
1	Submarine Pump	SUBMP10 85	85
40	Dupont Wire Female Female	DPWF-F20	2
1	LCD Touch Screen 5 Inch	A-LCD5	1600
1	Raspberry PI4 Camera	R-PI-CAM	250
1	Arduino Uno	ARD	500
1	Arduino Sheild	-	450
		Supplied by Transcom Total	12667
Not Bought Yet			
8	Acrylic Pane	-	3200
4	Metallic Rode	-	400
		Supplied by General Store Total	3600
		Gross Total	16267

Figure 25. Component Bills

11. Testing the System

11.1. Component Testing

Proximity Sensors (Sharp GP2Y0A41SK0F)

For this test we shall require 1 Arduino Uno. Sharp Proximity Sensor measuring tape and three breadboard cables. The test consists of setting predefined distance from sensor to object and check if the sensor can detect the object at the pre-defined distance. The circuit will be as below.

If the object can detect the object at predefined distance the sensor is working properly.

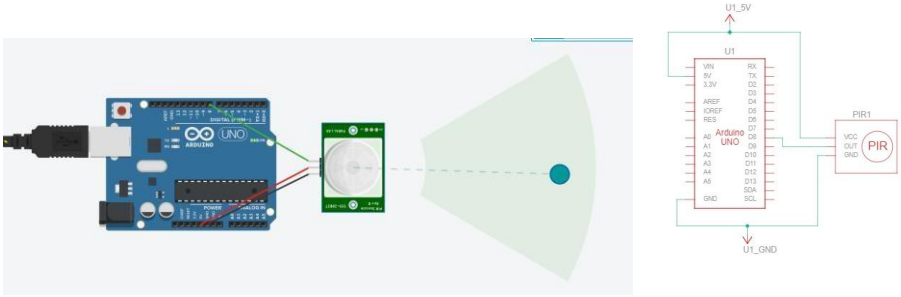

Figure 26. Connection Arduino with Sensor & Pin Out diagram

Raspberry Pi Camera Module 2

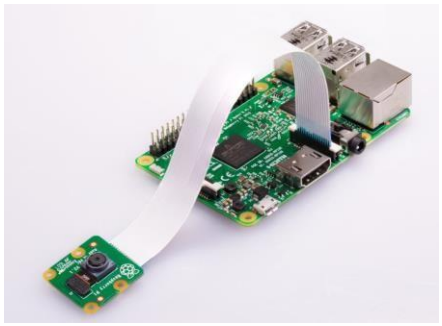

Figure 27. Connection Piboard with PiCam(Rasberrypi Foundation,2022)

For this test we will require The Raspberry Pi board, Raspberry Pi Camera Module 2 and object. We can test if it can identify object using OpenCV sample test

We will have to connect the Pi Camera to the Pi Board as shown in Figure 20. In the System configuration of the PI board, we will have to enable the camera.

If we get an output image the camera is working with proper identification the test is successful

Motor Testing

For this test we will require a DC motor together with an Arduino. This will just test If the motor is working. You can also vary the amount of Power supply to it to see if it has a good speed range since calibrating on the rod/rail require precision

For the Arduino to run the motor a motor driver is Required Model L293D

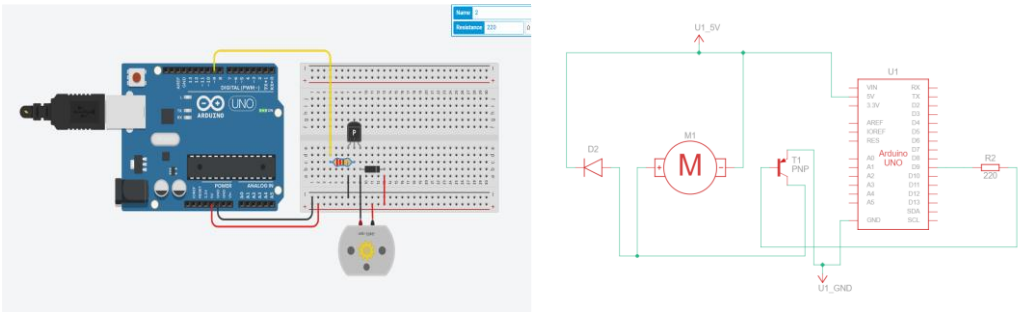

Figure 28. Motor Connection and Pin Out Diagram

Ultrasonic Sensor

For this test we will require a an ultrasonic sensortogether with an Arduino. The sensor can be moved to test if it's taking the data correctly

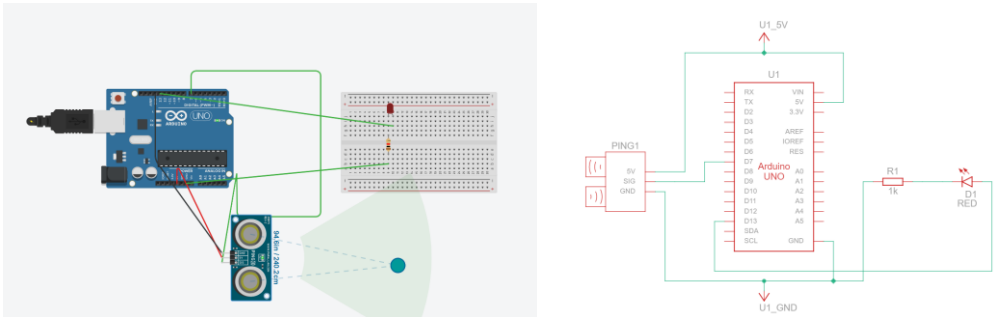

Figure 29. Ultrasonic Sensor and Pin Out Diagram

Below you shall find a snippet of code for the testing phase.

```
/* Ping))) Sensor

   This sketch reads a PING))) ultrasonic rangefinder and returns the
   distance to the closest object in range. To do this, it sends a pulse
   to the sensor to initiate a reading, then listens for a pulse
   to return.  The length of the returning pulse is proportional to
   the distance of the object from the sensor.

   The circuit:
    * +V connection of the PING))) attached to +5V
    * GND connection of the PING))) attached to ground
    * SIG connection of the PING))) attached to digital pin 7

   http://www.arduino.cc/en/Tutorial/Ping

   created 3 Nov 2008
   by David A. Mellis
   modified 30 Aug 2011
   by Tom Igoe

   This example code is in the public domain.

 */

// this constant won't change.  It's the pin number
// of the sensor's output:
const int pingPin = 7;
const int ledPin = 13;

void setup() {
  // initialize serial communication:
  Serial.begin(9600);
  pinMode(ledPin, OUTPUT);
}

void loop() {
  // establish variables for duration of the ping,
  // and the distance result in inches and centimeters:
  long duration, cm;

  // The PING))) is triggered by a HIGH pulse of 2 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  pinMode(pingPin, OUTPUT);
  digitalWrite(pingPin, LOW);
  delayMicroseconds(2);
  digitalWrite(pingPin, HIGH);
  delayMicroseconds(5);
  digitalWrite(pingPin, LOW);

  // The same pin is used to read the signal from the PING))): a HIGH
  // pulse whose duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(pingPin, INPUT);
  duration = pulseIn(pingPin, HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

  // Print the distance
  Serial.print("Distance: ");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

  // Turn on the LED if the object is too close:
  if(cm < 100) {
    digitalWrite(ledPin, HIGH);
  }
  else {
    digitalWrite(ledPin, LOW);
  }

  delay(100);
}

long microsecondsToCentimeters(long microseconds) {
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}
```

Figure 30. Source Code for Testing

12. System Testing

- The robot must be able to use the proximity sensor to detect the pet and start turn on the machine. Same need to be calibrated
- The robot must be able to capture the photo and process it to give the correct food. The raspberry pi should give the correct answer.
- Calibration is required for the rod & the food transporter so as it moves exactly under the boxes and move exactly into the bow
- Water container should be tested for any leaks since we are dealing with electronic component.
- Software testing shall be done on all the whole system and the inference system also need to be tested and see if all required function is working correctly.
- The robot shall be able to resist small bumps and crashes since we are dealing with a pet and some pet can be aggressive.
- Do a full testing with all the component together and see if the sensors are giving the proper data.
- The output of the whole system shall be as below
- Proper food and amount of food delivered
- Proper Water Level display

- Proper Alert Sign when low in stock
- Proper timing to collect the food back in the storage section

13. Functionality Test Cases

To check if robot is successful and efficient in terms of technicality, these test cases can be ally

COMPONENT/ID	Test Requirements
Rasp01/A02	Input voltage should be properly checked for not to burn out the board
Rasp02/V01	Check & Test calibration of camera
Rasp03	Test if RaspPi Sending correct into to motors and check for power
A02	Test if all sensors are powered on
A03	Check if all connection is ok and run some dummy test
V04	Connect Monitor to Robot to visualise and check if accurate data is being collected
P01	Check if pulley well mounted to motors and if spinning correctly
P03	Check if pulley on kart is moving horizontally
S01	Test Ultrasonic sensors with different distances
S02	Test motors if moving in clockwise and anti clockwise direction
S03	Check if all codes are correct for robot to function efficiently
S04	Check if data is well received between the arduino and the raspberry pi and the sensors by running dummy test

Figure 31. Test Cases

14. What are the potential pitfalls of your system?

- Power Supply- The Robot should have enough power to supply to the two motors.
- The size of the entrance for the animal should be enough
- High speed movement animal cannot be detected using this model
- It can only feed 1 pet at a time
- If knocked down, internal part may move
- Since we are dealing with water, circuits may get damage.
- No cold storage in case some food needs to be refrigerated.

15. Future implementation?

- Same can be altered to serve animal in zoos such as ass wheel to the robot for it to move to different section in a zoo.
- A cooler can be install in the storage section can be implemented to store cold food.
- The project can be made in bigger version so as 4 animal can eat at the same time at the different side of the robot.
- Internal calibration can be more refine and it auto calibrate every time the pet feeder restarts.
- A mobile app/webapp can be developed for the user to interact with it

Reason why above features not implemented right now.

i. Budget. This implementation requires better component and more accurate one and these component are more expensive
ii. Time constraints. Since the project is on a whole scale of 4 month the implementation of all these features will be really challenging

16. Project Planning

Project planning is a key aspect for the success of this project. Below you shall find a Gantt Chart for the Project Plan.

PDE3413: Multi Pet Feeder

	January				Febuary				March
	Week1	Week2	Week3	Week4	Week1	Week2	Week3	Week4	Week1
Planning and gathering of materials									
Purchasing components									
Alternatives									
Testing each component									
Construction									
Assembling Pet Feeder									
Building Cart Platform for Movement									
Assembling kart together with sensors									
Put all side panels together and add sensors & LCD Panel									
Coding									
Coding of all components									
Coding ultrasonic and servo motor.									
Coding Camera Vision									
Coding User Interface									
Testing									
System testing (each sensor)									
Integration testing acceptance									
Completion of project									
Project done									
Presentation report									

Figure 32. Gantt Chart

16. Conclusion

To conclude this social robot is a small prototype that has a great utility in our live. Robots are taking the spotlight in every industry. The outcomes not only demonstrate a significant advancement in the social robot technology's pet monitoring system, but also satisfy pet owners' needs.

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