ECE 445

SENIOR DESIGN LABORATORY

FINAL REPORT

Automatic Intelligent Fishing Rod

Team #40

YITONG GU (yitongg3@illinois.edu)
BAIMING LI (baiming3@illinois.edu)
ZIYI SHEN (ziyis3@illinois.edu)
XINYI SONG (xinyis10@illinois.edu)

TA: Hao Guo

May 15, 2024

Abstract

This design thesis discusses a new type of fishing rod that employs technology to improve the experience of fishing, making it easier and more efficient. The fishing rod is equipped with sensors that can detect when a fish is biting the hook, eliminating the need for constant monitoring by the angler. Additionally, the rod features a camera that uses a deep learning technique, called CNN, to identify the type of fish caught in real-time. This new technology not only saves time for the angler but also contributes to sustainable fishing practices because it allows for selective fishing based on species identification. The fishing rod boasts of a sturdy mechanical structure, a power supply subsystem, and an intricate software framework that ensures its smooth operation in various environments.

Keywords: Automatic Fishing Rod, Sensor Technology, Machine Vision, Automated Mechanical Systems, Fish Species Identification

Contents

1 Introduction

1.1 Background and Overview

Fishing is a fun and exciting activity that has been around for a long time in many different cultures. But traditional fishing can be really hard because it takes a lot of time, patience, and skill. Sometimes, fishers have to wait for hours just to catch a fish, which can be super frustrating. With new technology, we can make fishing easier and more enjoyable. Our project uses sensor technology, mechanical structures, automated control systems, and machine vision to design and implement a device that can automatically detect, capture, and identify fish. Our device will also help fishers know which fish to keep and which to release, which is good for protecting the environment and keeping fish populations healthy. By mixing modern technology with traditional fishing methods, we want to give fishers a new and better way to enjoy fishing. This new device will make fishing more fun and less frustrating, allowing more people to enjoy this awesome and ancient activity. [1]

1.2 State of the Art of the Design

Creating an intelligent fishing rod involves integrating technology with traditional fishing methods to enhance efficiency, precision, and user experience. This endeavor draws from a multidisciplinary field, including mechanical engineering, robotics, sensor technology, and artificial intelligence (AI). The advent of sensor technology marked a turning point in the design of fishing rods, introducing the concept of ”intelligent” equipment. Sensors can detect changes in the environment, such as water temperature and movement, and alterations in the rod's position, signaling when a fish is biting. These sensors significantly increase the chances of a successful catch by alerting the angler to activity that might not be immediately obvious. The integration of robotics and AI into fishing rods is a relatively recent development. Robotics can automate certain actions, such as casting or reeling in the line, based on pre-programmed conditions or real-time data analysis. AI, on the other hand, can process data from various sensors to make predictions about fish behavior and suggest optimal fishing spots and times. AI can also learn from each fishing experience, improving its suggestions over time. [2]

1.3 Main contribution of the design

Our solution introduces an innovative approach to fishing by developing an automated fishing rod system. The system seamlessly integrates advanced sensor technology, mechanical construction, automation, and machine vision to revolutionize the fishing experience. The automated rod system simplifies the fishing process and greatly reduces the time and effort required by the angler. By utilizing micro-tension sensors and micro-water level sensors, the system can accurately detect fish bites, eliminating the need for continuous monitoring of fishing rods. This increased efficiency allows anglers to engage in other activities while the system handles the fishing process autonomously. A key feature of the system is the ability to accurately identify fish species using machine vision technology. After the catch, the system activates the camera to visually inspect the caught fish, providing real-time species identification.

1.4 Visual Aid

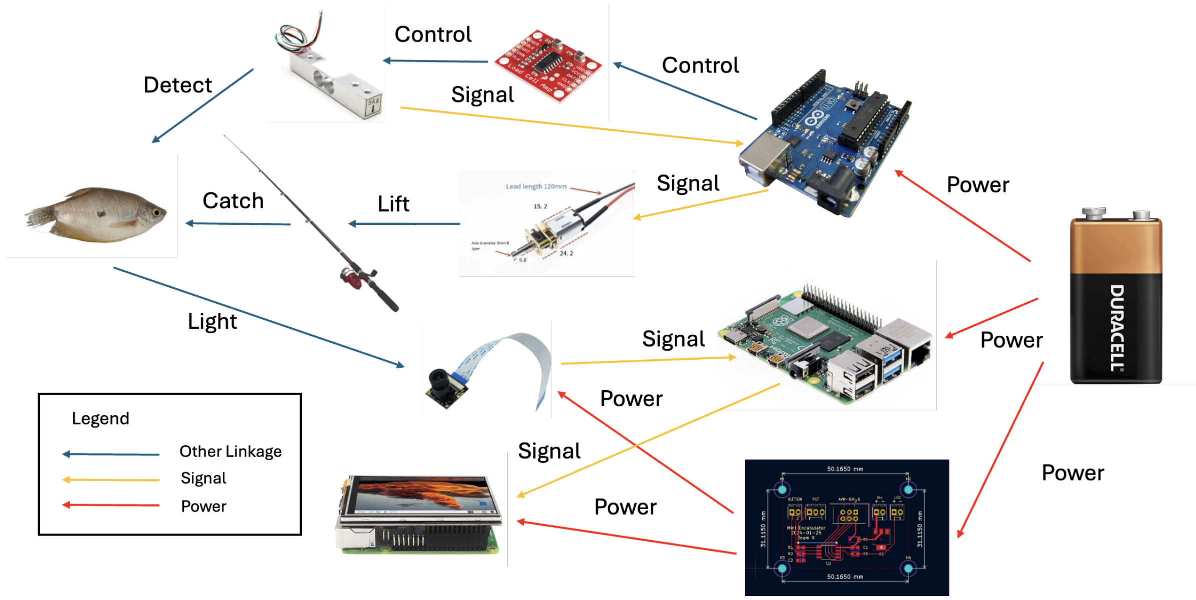


Figure 1: Visual Aid of different components of our system and the connections between them. Chips and sensors are used to detect a fish bite, after which the motor will lift the rod. The development board, camera, and display will be used to show the target fish species to the user.

1.5 High-level Requirement List

The pod's mechanics are designed for ease of use, featuring an automatic baiting system and a responsive rod lifting mechanism.

1. Bite-detecting Subsystem: The accuracy rate of catching fish is higher than 80%.
2. Identification System: An identification system is used to identify fish species with accuracy over 90%.
3. Mechanical Subsystem: Successfully catches fish from 0.03 to 1 kilogram.
4. Power Supply Subsystem: Successfully supply power stably for the whole system.

2 Design

2.1 Block Diagram

As we can see below, our project contains four parts: Bite-detecting Subsystem, Mechanical Subsystem, Identification Subsystem, and Power Supply Subsystem. We included every component we will use in our project and which part it belongs with.

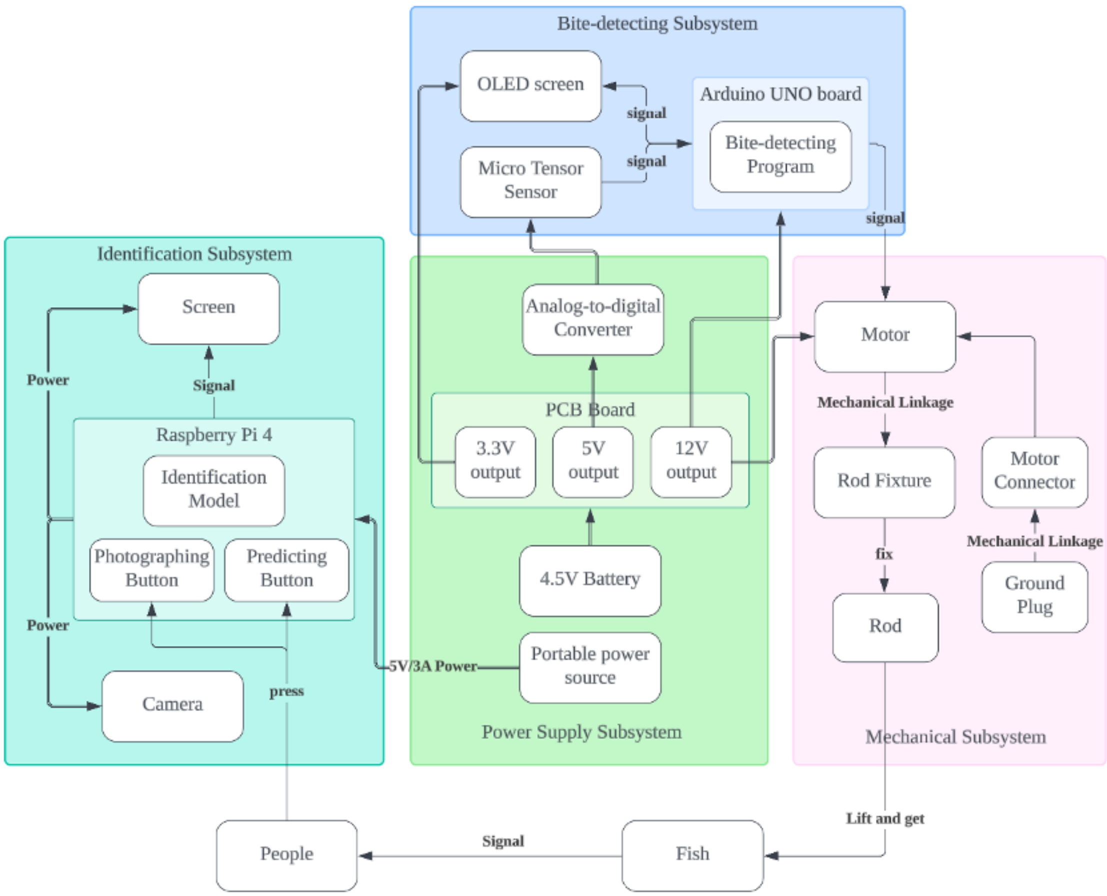


Figure 2: Block Diagram for Automatic Intelligent Fishing Pod. The power supply subsystem is responsible for supplying power to other subsystems. The mechanical subsystem will rotate the rod to catch the fish when the bite-detecting subsystem detects a fish bite. The identification subsystem will output to user the species of the fish just caught.

2.2 Physical Design

The figure below shows the physical design of our device. When the fish bites the hook, an Arduino-powered pull sensor detects that the pull is above the critical value and sends a signal through the Arduino to the motor to start spinning. The motor and the fishing rod fixture are connected through 3D printed parts so that the motor can be rotated to drive the fishing rod up. We fixed the other end of the motor with another 3D printed piece for the ground plug. The stability of our device is guaranteed because the ground plug can be inserted directly into the river soil. When we removed the fish, we used the camera and the Raspberry Pi 4 connected to the mobile power to scan the fish and identify the species.

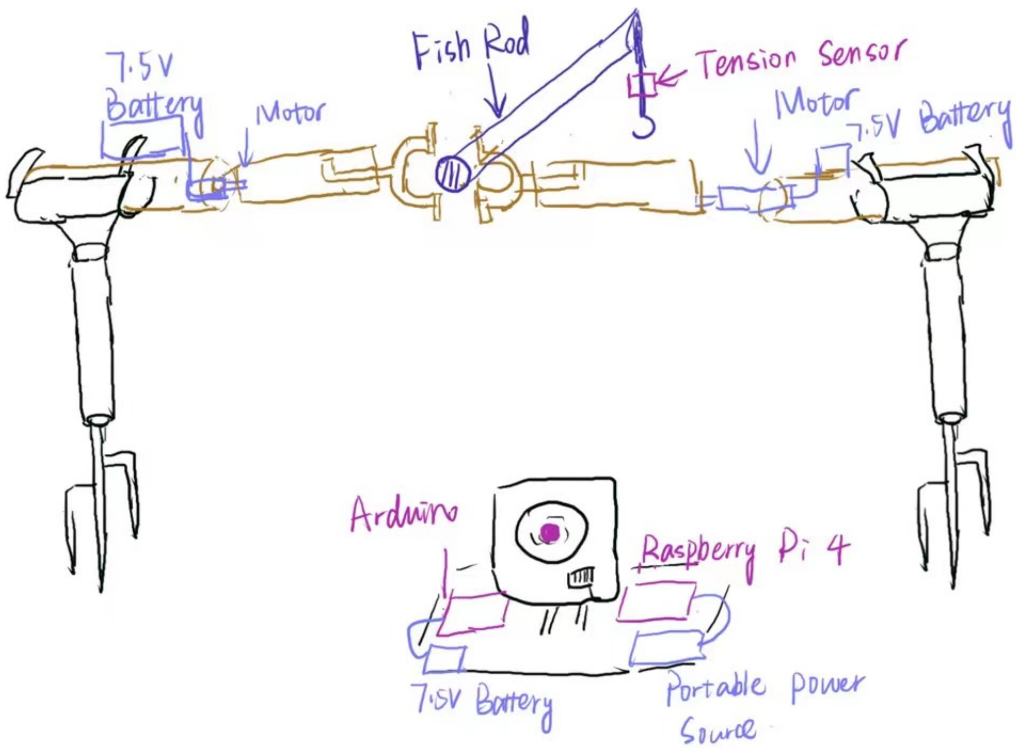


Figure 3: The rod is equipped with a sensor powered by Arduino that detects a fish bite on the hook. If the pull is strong enough, it sends a signal to the motor. The motor rotates a fishing rod fixture that is made using 3D printed parts. To keep the device stable, it uses a ground plug. We remove the fish from the hook and then use a camera and Raspberry Pi 4 to scan it for species identification.

2.3 Bite-detecting System:

The bite-detecting system is used to detect the movement of the fish. Since the hooked fish will struggle to escape, we can take advantage of this feature. This subsystem will be deployed on Arduino Uno. The applied sensor is a force sensor on the fishing wire. We also need an analog-to-digital converter between the sensor and Arduino Uno. Therefore, the data collected in real time will be transmitted and analyzed in the program to determine the movement of the mechanical subsystem. Here is the diagram of the bite-detecting subsystem.

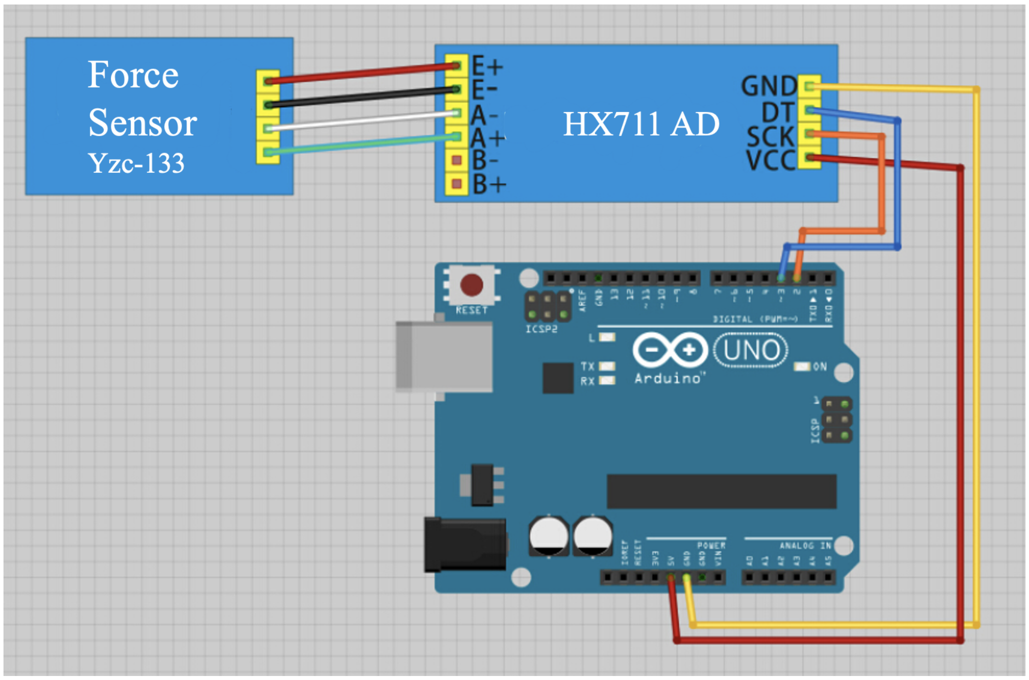


Figure 4: The circuit diagram of the bite-detecting subsystem.

2.3.1 The Force Sensor yzc-133

Firstly, there will be great tension on the fishing wire when a fish gets caught. To achieve the goal of catching fish from 0.03 to 1 kilogram, we need to prepare a tension sensor with certain precision and capacity. Secondly, we also consider the condition when the hook catches a weed or a rock, which may lead to overload if the capacity is limited. Based on the historical weather parameters' range in Haining [3], we select the yzc-133 sensor to measure the tension on the fishing wire. Some important information [4] about the sensor is shown in Table 1.

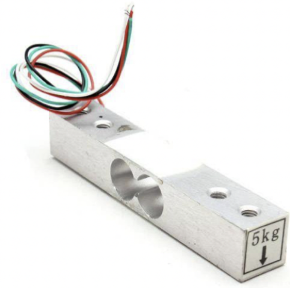


Figure 5: The Force Sensor yzc-133.

Parameter	Unit	Value
Capacity	kg	5
Safe overload	%FS	120
Rated output	mv/V	1.0±0.15
Excitation voltage	Vdc	5
Combined error	%FS	±0.05
Operating temp range	°C	-21 ~ +40
In/Output impedance	Ohm	1000±50

Table 1: Specifications of yzc-133

Requirements

1. The sensor should be able to measure and output accurate data. To ensure these components work correctly, we must support a suitable voltage source.
2. The sensor should not be in contact with water, both river and rain, while in use. To protect the sensor circuit, we will also design a highly waterproof shell for this part.
3. We need to reduce the impact of the sensor itself on fishing.
4. Our fishing goal is to be able to catch fish from 0.03 to 1 kg. The bite of small fish should be detected with an accuracy of at least 80%.

Verification

1. The power supply system will enable Arduino to provide voltage to the detecting sensor.
2. To protect the sensor circuit, we will also design a highly waterproof shell for this part.
3. The sensor should be mounted on the fishing wire near the fishing rod instead of near the river, which can decrease the influence from the weight of the sensor.

4. The sensor should be mounted on the fishing wire near the fishing rod instead of near the river, which can decrease the influence from the weight of the sensor. The size of the fish is determined by the size of the hook. Accuracy can be guaranteed by the small error (0.05%) of the sensor.

2.3.2 ADC HX711AD

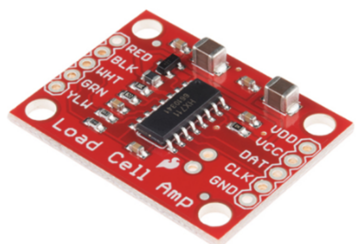


Figure 6: ADC HX711AD

HX711AD is a 24-bit analog-to-digital converter for weigh scales, which is suitable for our bite-detecting subsystem. It can change the output voltage of the sensor from analog to digital so that it can be used by MCU. Some important information [5] about this ADC is shown in Table 2.

Parameter	Unit	Value
Full scale differential input range	V	±0.5
Power supply voltage	V	2.6 ∼ 5.5
Output data coding	HEX	800000 ∼ 7FFFFF
Selectable gain	N/A	32/64/128
Operating temp	°C	-40 ∼ +85

Table 2: Specifications of HX711AD

Requirements

1. The ADC should be connected to the sensor properly with some protective measures. This is because the ADC, along with the Arduino Uno, will be placed near the motor. The distance between them is long, and the circuit is vulnerable to damage.

Verification

1. We can place the wire inside the fishing rod to make it durable and waterproof. Encasing the wire within the fishing rod protects it from water ingress, safeguarding the electrical components from corrosion and potential short circuits. Besides, threaded through the fishing rod, the wire remains neatly organized and free from entanglements. This ensures optimal cable management, preventing tangles or snags that could disrupt the circuit's functionality.

2.3.3 OLED Screen SSD13159

To show the real-time data collected from the sensor, we include a 0.96-inch OLED display in our design. When we are initializing the program and setting the Arduino board, the screen will show "Hello!" During the process, the weight of the fish on the hook will be displayed. If overload happens, an "Overload warning." will show on the screen to remind the user.

Figure 7: OLED Screen SSD13159

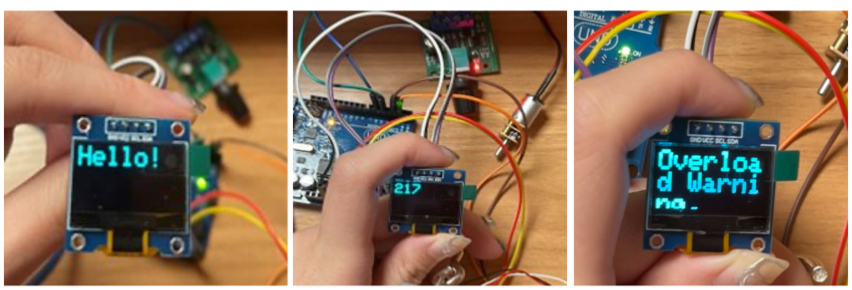


Figure 8: The Display of the OLED Screen

Parameter	Unit	Value
Power supply voltage	V	3.3V

2.3.4 The Restore Button

When the device is activated, the motor will spin CCW to lift the rod up. Therefore, to reuse the device and catch more fish, we need a restore function to adjust the position of the fishing rod. Here I designed a button to emit the signal to control the direction. The motor altogether has five I/O, including two power supply wires, one speed control wire, and one direction control wire. In my program, when user press the button, the direction will be changed from CCW to CW. Meanwhile, the duty cycle of the speed signal waveform will be changed from 10/255*100% to 128/255*100%. Thus, the motor will be activated and rotate in the opposite direction.

Motor terminations:

Terminations		I/O	Conditions	Remark
GND		IN	Ground	(black wire)Ground
Vcc		IN	DC 12V ±10%	(red wire)Power supply
FG	VOH	OUT	Min4V at 5V10KΩ pullup	(yellow wire)this is the open collector output,which can detect the rotation speed using the FG output according to the phase shift
	VOL		Min0V Max0.6V	
	FG current		Max 5mA	
	FG pulse quantity		9 pulse /round	
SPEED	Input voltage	IN	0~5V PWM调速	(blue wire)
	Speed regulation		1.2-3.3V analog voltage 模拟调速	Motor speed is proportional to Input analog voltage (blue wire)
CW/ CCW	Input voltage	IN	0~5V	(white wire)
	VIH		Min 2V	CCW
	VIL		Max 0.2V	CW

Figure 9: I/Os of the Motor

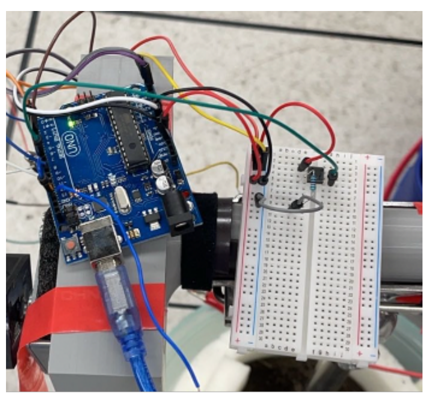


Figure 10: The Connection of the Button Circuit

2.3.5 Bite-detecting Program

When a fish gets caught, the sensor will have a linear voltage output from 0.03 to 1mV. And it should be less than 5mV under normal circumstances.

The setup part initializes all the pins we will use in our project. We have pin7 for the button, pin11 for the motor speed, pin12 for the motor direction, and pin13 for the sensor. Pin11 will generate a square wave with a certain duty cycle to control the speed of the motor. And we will set up a new output frequency for pin11 since the default setting of 980Hz is too low for smooth speed regulation. Besides, when pin12 is LOW, the motor is rotating CCW. Otherwise, it will rotate CW.

In the loop, the code will receive and check these signals continuously. And the duty cycle for pin11 will be as low as 10/255*100% to stop the motor. When the button is pressed, pin12 will be HIGH to activate the changes of direction and the duty cycle to enable the motor to spin CW. Therefore, it can go back to a specific location.

Here I used an open-source library called arduino-pwm-frequency-library . It is because we can't directly change the output frequency of the pin.

Besides, when pin12 is LOW, the motor is rotating CCW. Otherwise, it will rotate CW.

Considering the fact that it will take some time for the user to take off the fish from the hook, I added a variable called isCatch. Only after the measured weight decreases below 30g for 1s, isCatch will change from True to False again. When isCatch is False, the measured weight is over 10g and lasts longer than 0.5 second, the program will activate the motor to spin CCW for 5 seconds by increasing the duty cycle to 250/255*100%. And isCatch will be True then.

Besides, we also have overload protection. If the measured weight is too big (1kg), the program will stop automatically. To restart the device, we can press the button on the Arduino Uno board.

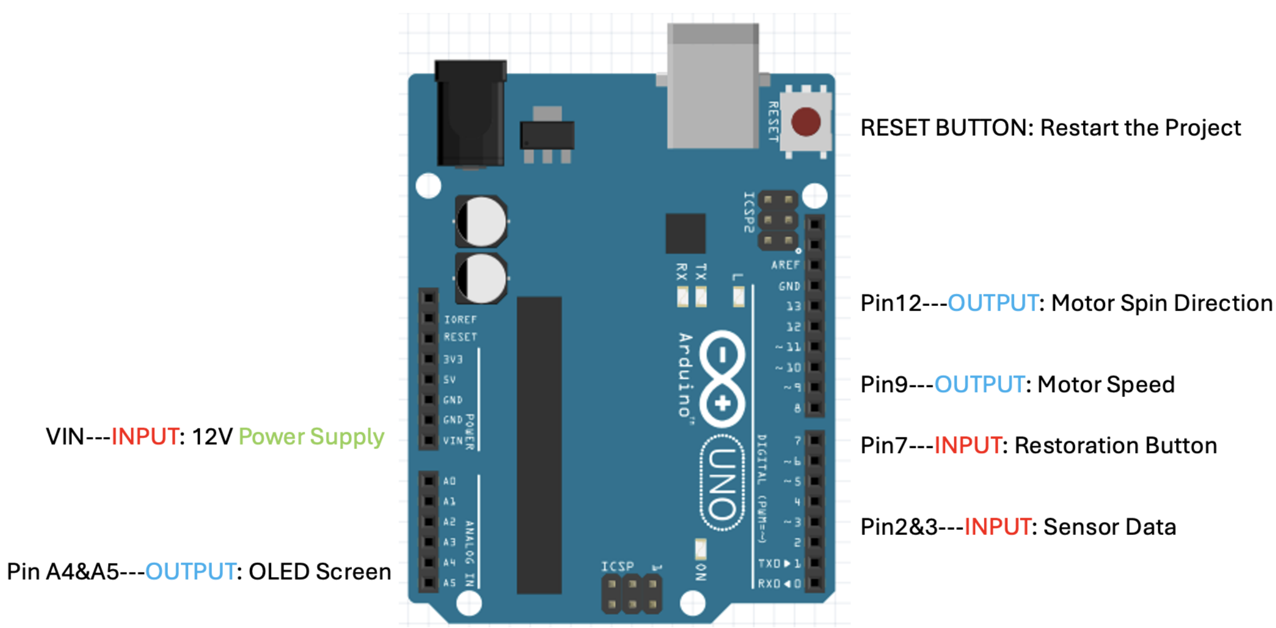


Figure 11: Arduino linkage

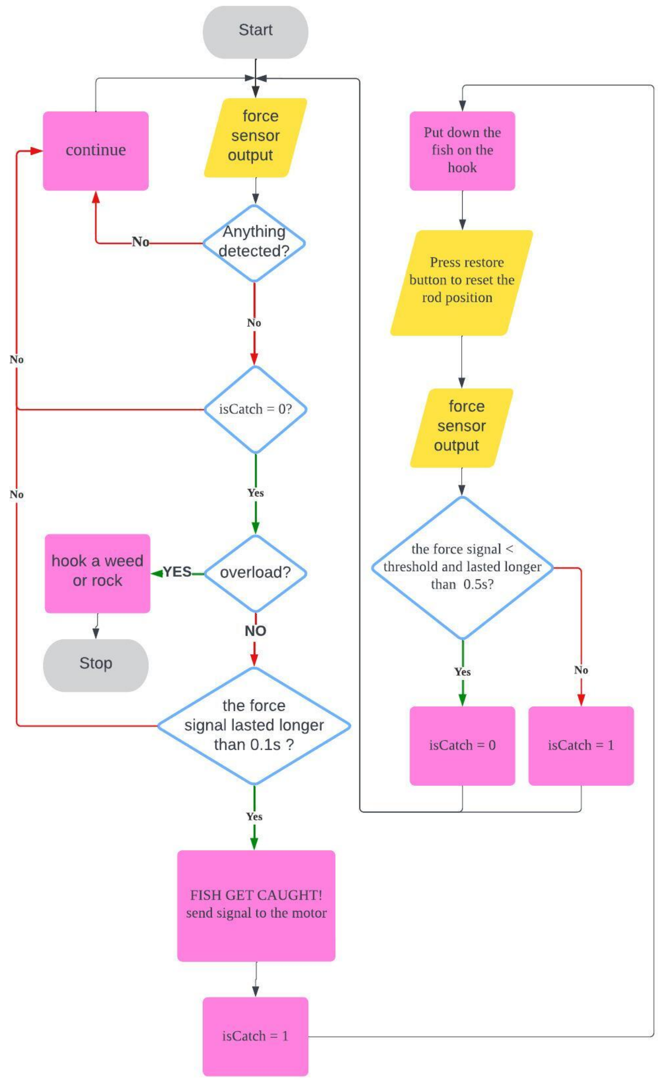


Figure 12: The Flowchart of the Arduino Program

Requirements

1. Define a maximum allowable weight threshold that the force sensor can reliably handle without risking overload. This threshold should be determined based on the specifications of the sensor and the capabilities of the system components.

Verification

1. The program will power off the sensor if the output is out of capacity. We have an if statement inside the program. If the measured weight is over 5kg, it will print "Overload warning." and then exit. We can press the button on the Arduino board to restart the program.

2.4 Identification System:

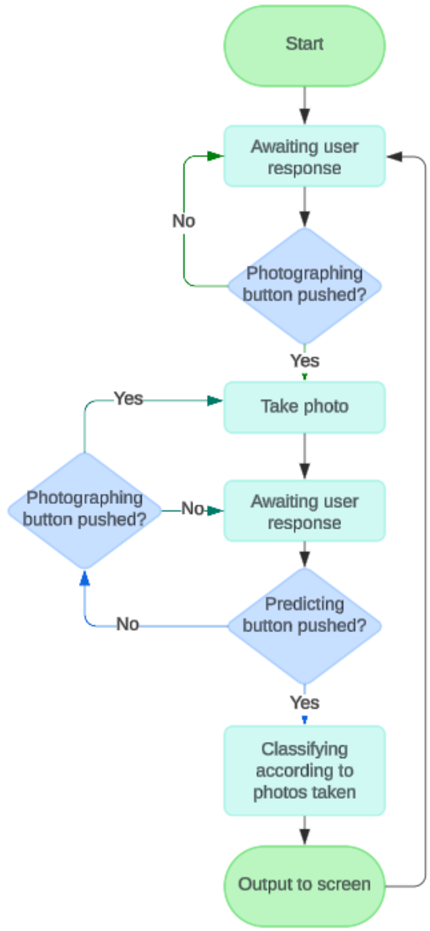


Figure 13: Identification Subsystem flowchart

The identification subsystem is used after the fishing process. This subsystem aims to take a photo of the fish that get caught and then identify the species of it. To achieve this, a high-resolution camera captures an image of the fish and then sends it to a pre-trained model for prediction-making. A camera and a development board perform the whole process. A touch screen supports the users' interface.

The image taken from the camera is the input of our model, which is then loaded into the development board. The data used to train our model will be labeled images of freshwater fish that weigh from 0.03 kg to 1 kg and can be caught in rivers and lakes. The model's output is the fish species. This is a classification process that takes images as input. Convolutional Neural Network (CNN), a type of deep learning algorithm that can automatically detect image patterns, is applied to this target. After the prediction is made, the predicted name of the species will be displayed on a screen for the users.

2.4.1 User interface

After the model is trained, it is loaded onto a development board. The development board is connected to the camera, taking several images of the fish caught. The testing procedure of this subsystem is conducted together with the power subsystem, which will power the Raspberry Pi 4 Model B development board, requiring a voltage of 5 V, 3 A [6]. The development board, Raspberry Pi 4 Model B, also supplies power to the camera and displays and transmits data. Users can interact with the identification system via the touching screen attached to the development board.

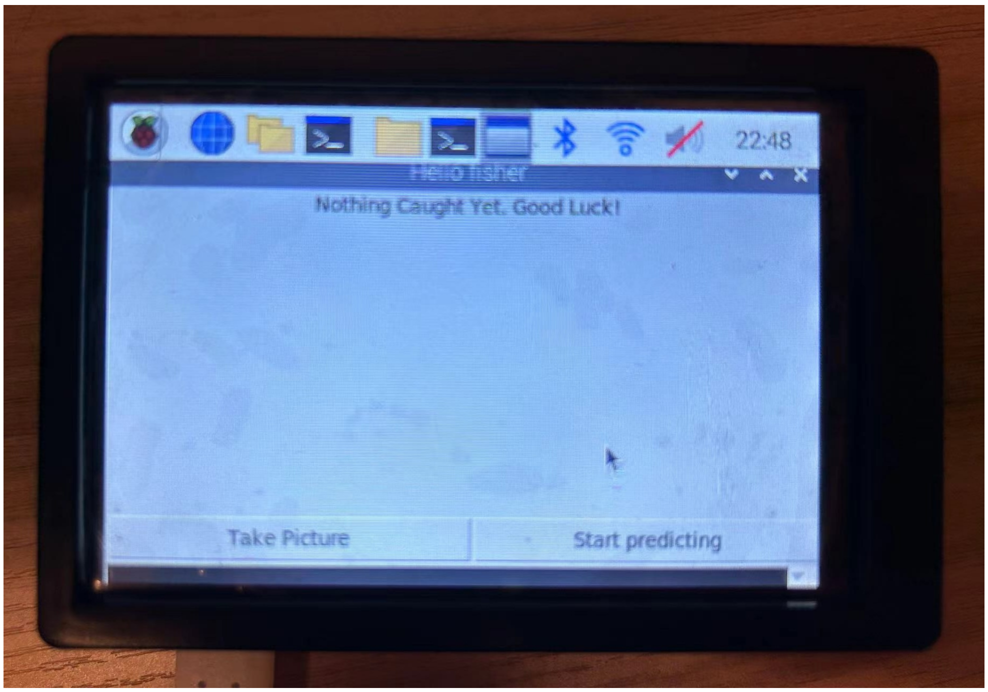


Figure 14: User Interface demonstration. Users can take photos and start predicting using the two buttons on the screen.

The program is packed into an executable file and supported by required Python libraries. It is easy to use, requiring only a single click on the icon of the executable file to start working, without any need to install packages related to machine learning or image processing.

We also considered the potential for this program, where users might be interested in predicting fish species in different areas. In this scenario, users only need to replace the pkl file with their own model with the same name and enter their target fish species in the labels line-by-line. It makes possible easy replacement when a better model is trained with a larger dataset and wiser model construction. This also shows the potential of implementing this program in a wider range.

2.4.2 Training dataset Construction

Data Resizing

Our model takes three-channel RGB images as input. The camera used in the design has a resolution of 2952*1944. The images we used to construct our training set and testing set are too small for that resolution, so we decided to resize all input images to 648*488 in pixels. When performing predictions in real-world scenarios, we resize the photos taken into that size as well before passing them to our model.

For images of sizes $(\alpha * 648) * (\alpha * 488)$, shrinking or expanding is applied to resize the images. For shrinking, each new pixel is calculated by the average of a block of old pixels. For a pixel in the new image at location (m, n), the RGB value vector is calculated by:

$$\sum_{i,j}(Prev\_RGB[m * \lceil \alpha \rceil + i][n * \lceil (\alpha) \rceil + j])/\lceil (\alpha) \rceil^2)$$

For expanding, each pixel in the original image is simply expanded to a block of pixels, the size of which is $\lfloor (1/\alpha) \rfloor * \lfloor (1/\alpha) \rfloor$. To prevent changing the size of fish in images, shrinking or expanding is applied first for those whose size cannot be represented by $(\alpha * 2952) * (\alpha * 1944)$). Then, rows and columns are added to pad the resized image to the target size.

This relatively small dataset can be exposed to the potential risks of over-fitting [7].

Data Augmentation

To avoid overfitting, we have implemented a data augmentation technique to enlarge the dataset. This technique involves processing the images in various ways, such as applying random noise to the image (Noise), blurring the image by a specified amount (Blur), and rotating the image slightly (Rot). By applying these methods, we can generate new images similar to the original ones but with slight variations. This, in turn, helps to prevent the model from memorizing the training data and overfitting. When writing code for this part, we referenced the image_augmentor project by code box on GitHub. [8]

Currently, we have used data augmentation to increase the size of the dataset to ten times its original size. This means that we have generated nine new images for every original image using the data augmentation methods mentioned above. By doing this, we can provide the model with a larger and more diverse training dataset. This, in turn, helps the model generalize and perform better on unseen data.

2.4.3 Model construction

To prevent overfitting and other unwanted factors from interfering with the accuracy of our small dataset, the structure of our CNN is carefully chosen. Experiments conducted by L. Brigato and L. Iocchi on 10 classes using CNN show that for small-data problems, low-complexity CNNs are comparable to or better than high-complexity ones [9]. Thus, the model is not composed of complex structured layers.

The CNN architecture is made of two convolutional and two max-polling layers as feature extractors and minimize the standard classification loss represented by:

$$\frac{1}{t}\sum_{i=1}^{t} L_c(y_i, f_\theta(x_i)) \tag{1}$$

During training, the train and test sets are partitioned from the dataset as disjoint sets. The dataset is shuffled before training. We reached an accuracy of 91.45% on the test set in our model.

After the model is trained and loaded into the development board, it makes predictions using images representing different fish poses. It lets the results vote for the final prediction.

2.5 Mechanical System:

2.5.1 Rod Holder to the Ground

Design Procedure: Initially, we considered utilizing 3D printing to fabricate a rod holder with a pointed end for insertion into the ground. However, due to the high costs associated with 3D printing for this application, we opted to adapt commercially available products. This change not only helped reduce costs but also capitalized on the robustness of pre-tested designs.

Design Details: The rod holder, crafted from stainless steel, is designed to penetrate 10 to 13 cm into the soil, offering stable support against wind forces and dynamic loads from captured fish. The design ensures the holder maintains sufficient height (57 cm from the ground to the horizontal support) to keep the fishing rod elevated, thus preventing it from touching the ground. Additionally, the chosen material's hardness (56sim60 HRC) ensures that the structure can endure necessary torques without breaking.

Table 3: Specification of Fishing Ground Plug

Parameter	Unit	Value
Height from ground to horizontal support	cm	57
The depth of the ground thrust into the soil	cm	$10 \sim 13$
Hardness of stainless steel	HRC	$56 \sim 60$

Requirements:

1. The ground plug should allow enough height for the fishing rod to be recovered so that the end of the fishing rod does not touch the ground.
2. The ground plug needs to withstand the force of the wind and the gravity of the fish while it is firmly anchored in the ground.
3. The place that holds the 3D-printed rod needs to withstand a certain torque to ensure that it does not break.

Verification:

1. This problem can be avoided by measuring and reserving the height of the ground plug.
2. The torsion force and gravity generated by 0.03 kg to 1 kg fish were simulated to determine the bearing capacity of the ground plug.
3. By buying back the physical product and 3D printing part, the experiment simulated the stability of the lock-in device.

2.5.2 Motor

Design Procedure: Upon detecting a fish by sensors, a signal is transmitted to an Arduino-like microcontroller, activating the motor. At first, we chose two small variable-speed motors to drive both sides of the rod simultaneously. Since the manufacturer did not give the specific torque that the motor can withstand, we found that the motor could not drive the fishing rod in the subsequent measurement process, so we replaced a larger motor.

Design Details: The motor's dimensions and operational parameters allow for speed adjustment via the voltage supplied by the Arduino, facilitating stable low-speed operation essential for handling fish weighing between 0.03 to 1 kg. As for the new motor, according to the manufacturer's description, it can withstand 140 pounds of torque. Therefore, for our fishing device, a new motor can replace the original two motors, which can also achieve better control.

Table 4: Specification of Motor

Parameter	Unit	Value
Length, width and height of the motor	mm	34*12*10
Motor shaft diameter	mm	3.0
Motor speed	RPM	$4 \sim 40$
Motor speed	V	$1.5 \sim 9$

Requirements:

1. Speed regulation can be performed according to the voltage input of Arduino, and the speed can be stabilized at a relatively low speed as far as possible.
2. It can withstand the torque provided by $0.03 \sim 1$ kg fish struggling with it.

Verifications:

1. Connect and experiment with the Arduino program and code.
2. Use the dynamometer to measure the force of the general fish struggle and apply a similar torque to the motor to test whether it can rotate normally.

2.5.3 The Linkage and the Fixture for the Fishing Rod

Design Procedure: The initial design of the linkage system utilized 3D-printed components attached to screws and nuts. However, to enhance the rigidity and ensure a secure fit, we considered adapting a steel pipe clamp to suit the diameter of the fishing rod.

Design Details: The linkage connects the motor shaft to the fishing rod fixture, enabling the mechanical lifting of the rod upon motor activation. This arrangement guarantees

Figure 15: 5840-3650 Motor

that the fishing rod is effectively raised without slippage. The overall length of the linkage (350 mm) and the hardness of the PLA material used (88 Rockwell) are chosen to withstand the torque generated during fishing, ensuring durability and functional reliability.

This structured format directly incorporates all functional requirements into the design discussions, eliminating the need for a separate "requirements" section and streamlining the content for clarity and coherence.

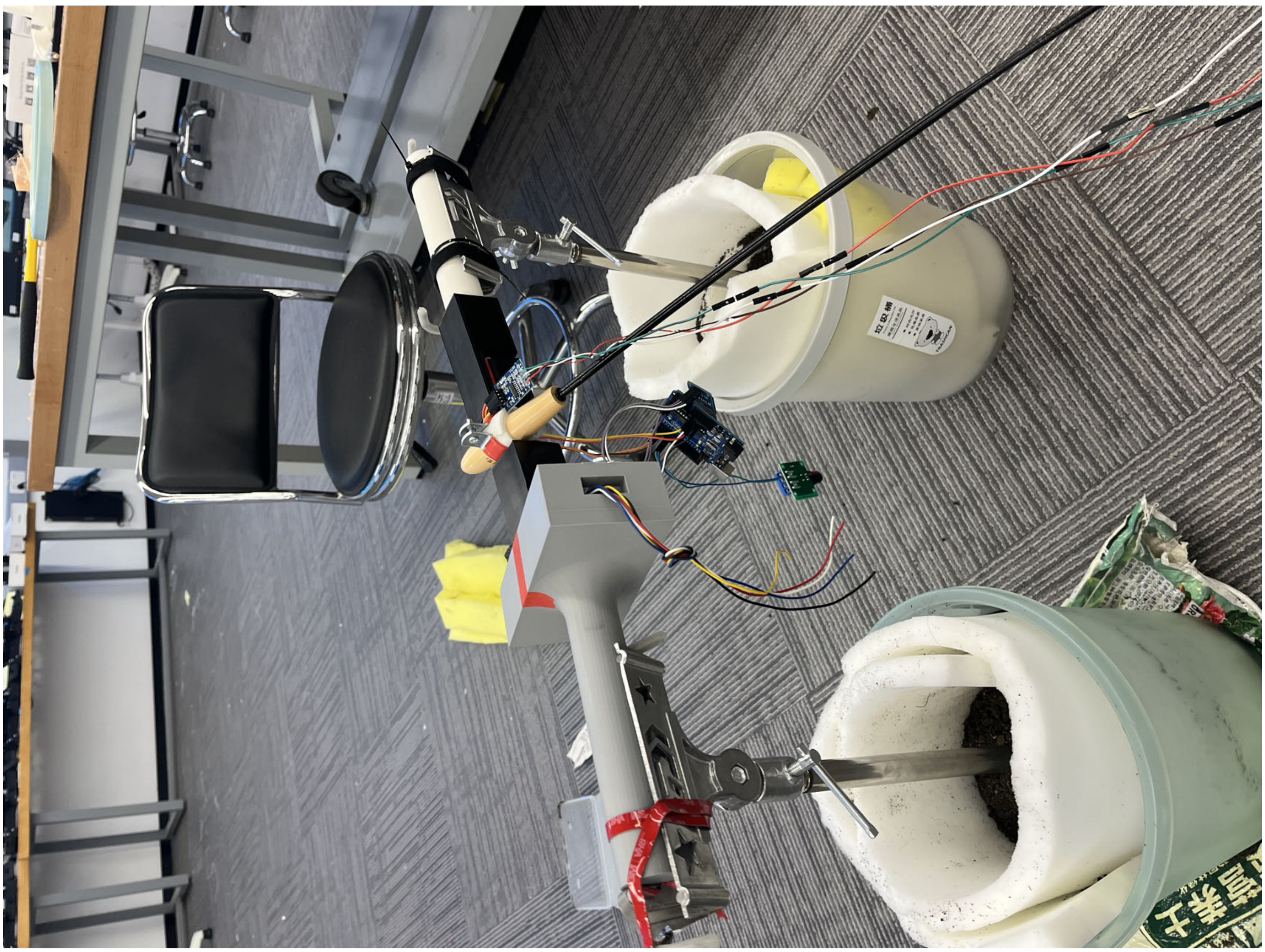
Requirements:

1. Two 3D modeled parts, keeping them non-sliding.
2. 3D printed parts need to withstand the torque required to fish.

Verification:

1. The expansion error of 0.5 mm is maintained in the Fusion360 modeling software and then modified according to the 3D-printed entity.
2. Based on the measured torque mentioned earlier, computer simulations were carried out to test whether the PLA material was subjected to reasonable pressure.

Figure 16: Rod Holder to the Ground



2.6 Power Supply Subsystem:

The power supply subsystem supplies stable power to each subsystem, including the linkage between each subsystem and its independent parts. In our design, we have chosen to use batteries and a portable power source to ensure a reliable power supply. For the rod-lifting device, we have decided to employ an Arduino UNO to control the sensors and motors. The power requirement for the Arduino UNO is 12 V. Additionally, the motor requires a 12 V power source, the LED screen needs a 3.3 V power source, and the tension sensor requires a 5 V power supply. To avoid using too many power sources in our project, we decided to use a PCB design. The PCB includes a boost module to increase the voltage provided by three 1.5 V batteries, and a regulator module that provides 12 V, 5 V, and 3.3 V power to different parts of the entire system. The PCB design is as shown in Fig.16. It is power up by the batteries and the recommended battery voltage is approximately 3.7 V. Since the input voltage is significantly lower than 12 V, our design incorporates a boosting module to raise the voltage and a regulator module to control the output voltage.

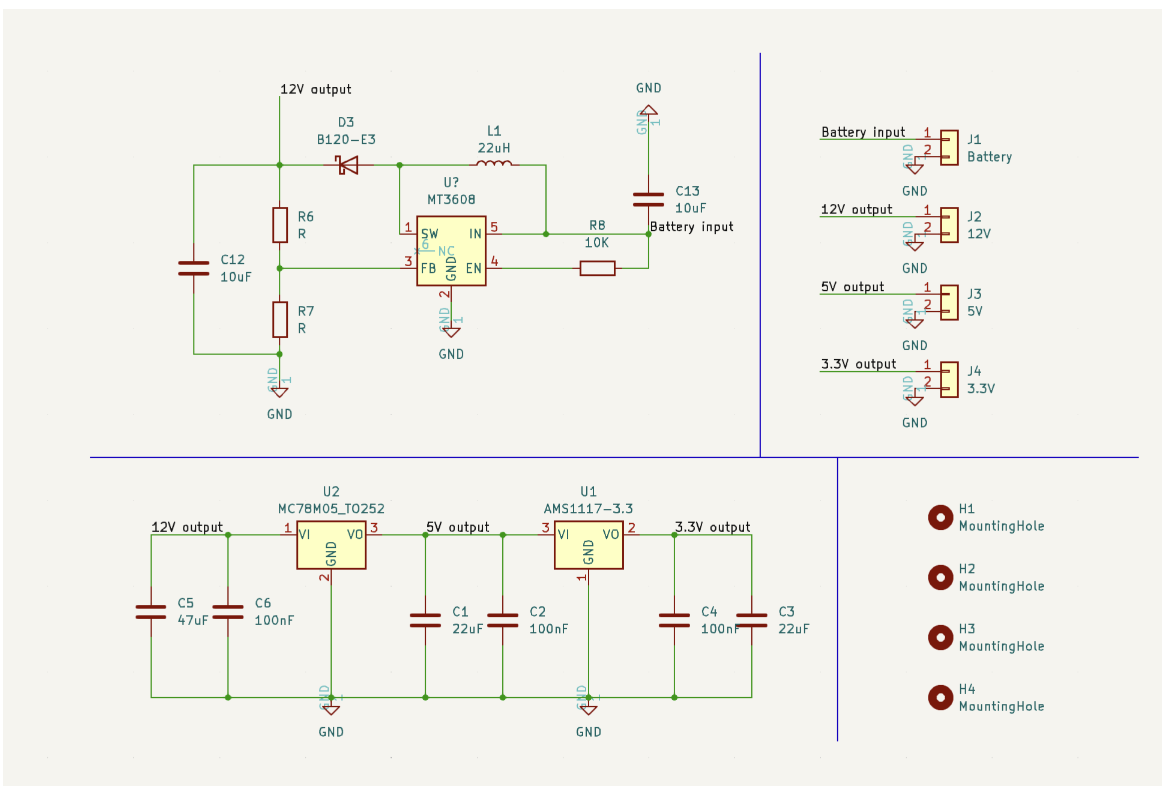


Figure 17: PCB design. In our design, we have a boosting module and a regulator module.

For the Identification subsystem, we load the trained model into the Raspberry Pi to identify the fish species. The power supply we chose for the Raspberry Pi is a 5 V/3 A portable power source. The camera and screen we use in the identification subsystem connect directly with the Raspberry Pi and get power from the board. Thus, here we only need two sources of power, which are three 1.5 V batteries and a 5 V/3 A portable source.

MT3608	A DC-DC boost converter IC.	
	Integrated 80mΩ Power MOSFET 2 V to 24 V Input Voltage Adjustable Output Voltage Up to 28 V Output Voltage	
	1 SW Power Switch Output. SW is the drain of the internal MOSFET switch. Connect the power inductor and output rectifier to SW. SW can swing between GND and 28 V. 2 GND Ground Pin 3 FB Feedback Input. The FB voltage is 0.6 V. Connect a resistor divider to FB. 4 EN Regulator On/Off Control Input. A high input at EN turns on the converter, and a low input turns it off. 5 IN Input Supply Pin. Must be locally bypassed.	
MC78M05	A 5V linear voltage regulator.	
	Input Voltage (5.0 V $\sim$ 18.0 V) Output Voltage (4.8 V $\sim$ 5.2 V) Peak Output Current (TJ = 25°C) (700 mA)	
	Pin 1. Input 2. Ground 3. Output	
AMS1117-3.3	A 3.3V linear voltage regulator.	
	Input voltage (VIN to GND) Max: 15V Output voltage 3.267 $\sim$3.333 V	
	Pin 1. Input 2. Ground 3. Output	

Table 5: Chip used in PCB design

After getting the data, we need to decide how the circuit was connected and the suitable value of resistors, capacitors and inductors.

MT3608, Boost Converter, Output V = 12 V [10]

Given the parameters:

$$V_{FB} = 0.6\,\mathrm{V}, \quad V_{out} = 12\,\mathrm{V}$$

We use the formula:

$$V_{out} = V_{FB} \times \left(1 + \frac{R2}{R1}\right)$$

Solving for $\frac{R2}{R1}$:

$$20 = \frac{R2}{R1} + 1 \implies \frac{R2}{R1} = 19$$

Choosing $R2 = 3.6\,\mathrm{k\Omega}$, we get:

$$R1 = 3.6\,\mathrm{k\Omega} \times 19 = 68.4\,\mathrm{k\Omega}$$

From the datasheet and common design practices, an inductor value between 10 µH and 22 µH is typical for the MT3608. So we choose 22 µH here. A 10 µF capacitor is commonly used to ensure adequate filtering without causing excessive bulk or cost. It provides a good balance between size, cost, and performance. So we choose 10µF here. And for the R8 = 10 kω, it is just protecting the chip because, without it, the pin4 will be directly connected to the power source. Thus the chip or the module will work safely and efficiently.

MC78M05, 5 V Linear [11]

The MC78M05 regulates the input voltage down to 5 V. It requires input capacitors (C5, C6) and output capacitors (C1, C2) for stability. The input capacitor (C5) is 47 µF and the output capacitor (C1) is 22 µF, which are typical values to ensure stable operation.

AMS1117-3.3, 3.3 V Linear Regulator [12]

The AMS1117-3.3 regulates the input voltage (5V) down to 3.3 V. Similarly, input capacitors (C1, C2) and output capacitors (C3, C4) are used for stability. Capacitor values used are 22 µF for input and 100 nF for output, which align with typical recommendations for stability.

Requirements:

1. Supply power for Arduino UNO with 7∼12 V.
2. Supply power motor with 12 V.
3. Supply power tension sensor with 5 V.
4. Supply OLED screen with 3.3 V.

5. Supply power for Raspberry Pi 4 Model B with 5 V/3 A portable power source.

Verification:

1. As mentioned in the datasheet of Arduino Uno R4 Minima, the recommended input voltage is 6-24 V if using Pin VIN. It can also use 5 V DC via a USB-C connector. We finally choose 12 V to make sure the power supply is enough.[13]
2. As mentioned on the Raspberry Pi website, It can use 5 V/3 A DC via a USB-C connector.[6]
3. For PCB, the voltage of three 1.5 V batteries turns out to be 4.83 V. And the port of 12 V output is 11.86 V; the port of 5V output is 5.12 V, and the port of 3.3 V is 3.28 V.

2.7 Tolerance Analysis

2.7.1 Feasibility Analysis

The whole system will be tested in a relatively more stable environment in the lab. A water tank is supposed to simulate the climate of peaceful open water, which is a better choice for fishing than in fierce waves. Also, it is easier for the fishing process to be triggered because the density of fish can be controlled in this case. In this testing process, fish can be attracted to our system much more efficiently than in open water. Overall, the proposed testing plan enables us to show the functions of our design more conveniently. Several factors still need careful consideration in cases of natural open water and our proposed testing plan.

2.7.2 Hardware

As for the force sensor, we have successfully linked it to Arduino and can output the force apply on the force sensor. We will use spring tensioner to test the accuracy of our electrical tensor sensor. We will later on working on the test of the stability of power supply subsystem. The testing plan including using voltmeter to test the voltage between positive pole and negative pole of each component to see if it is stable. Also, while we use PCB to power up the camera and screen linked to raspberry pi, we will also test to get the suitable voltage that can be apply to them.

Table 6: Specification of Motor

Components	Power
Arduino Uno R4 Minima	Input voltage (VIN): 6-24 V DC Current per I/O Pin: 8 mA
Force Sensor yzc-133	Working Voltage: 5 V Working Current: $\approx$ 5 mA Power: $\approx$ 25 mW
ADC HX711	Working Voltage: 2.6$\sim$5.5 V Working Current: $\leq$ 1.5 mA Power: $\leq$8.25 mW
OLED	Working Voltage: 3.3 V
Motor	Power supply voltage: 12 V
Raspberry Pi 4 Model B	5 V/3 A

2.7.3 Software

The model implemented for the identification subsystem will be tested on both the test set, which is a partition from the dataset, and real-world cases. Before putting into use, the model will undergo multiple tests on the different randomized partitions of the dataset after the training process is finished to prevent over-fitting. The performance will be evaluated by four dimensions: classification accuracy, precision, recall, and f1.

Table 7: Expectations for accuracy

Accuracy Measurement	Measured Value
Classification accuracy	90.88%
Precision	95.38%
Recall	88.57%
F1	91.85%

Classification accuracy represents the proportion of correctly classified images.

$$ClassificationAcc = \frac{TruePos + True_Neg}{TruePos + TrueNeg + FalsePos + FalseNeg}$$

Precision represents the proportion of correctly predicted positive instances (true positives) out of all instances predicted as positive.

$$Precision = \frac{TruePos}{TruePos + FalsePos}$$

Recall represents the proportion of correctly predicted positive instances (true positives) out of all actual positives.

$$Recall = \frac{TruePos}{TruePos + FalseNeg}$$

F1 represents a combinational measurement of Precision and Recall.

$$F1 = \frac{2 * Precision * Recall}{Precision + Recall}$$

2.7.4 Mechanical System

Due to the weight of the fish and the resistance to the hook, we need to analyze whether the fragile 3D printed part can withstand these forces[14]. When the fishing line pulls up the fish, the maximum force is the resistance of the water, and the formula is:

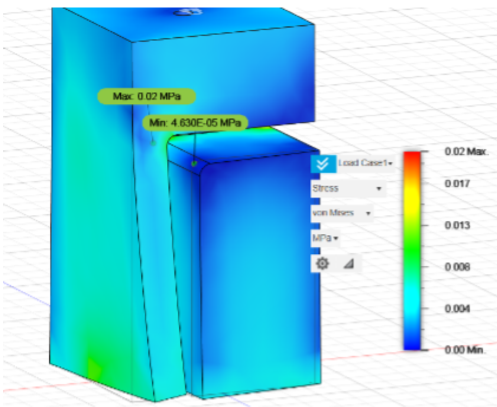
$$F_{drag} = 0.5 \times drag\_coef \times A \times v^2$$

The range of drag coefficient is generally 0.1 to 0.2. We choose the maximum resistance coefficient to calculate whether the 3D printed part can withstand the force of the fish bite. The weight range of our target fish is 0.03sim1kg, here we choose the maximum 1kg. After calculation, the resistance of the fish weighing about 1kg to the hook is around 3.6N. In addition, the gravity of a 1kg fish is 9.8N, we use these two main forces to sum up the torque of the fish:

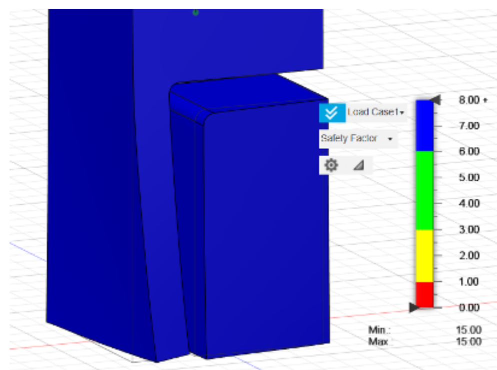
$$\tau = F \times r$$

About 14N*m of torque is applied to the part, and the simulation analysis with Fusion 360 is as follows:

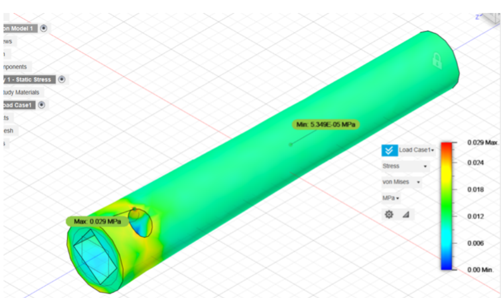
Safety Factor of Motor Connecting Structure The Safety Factor of both parts is around 15, much higher than 2, so the risk of collapse is relatively small.



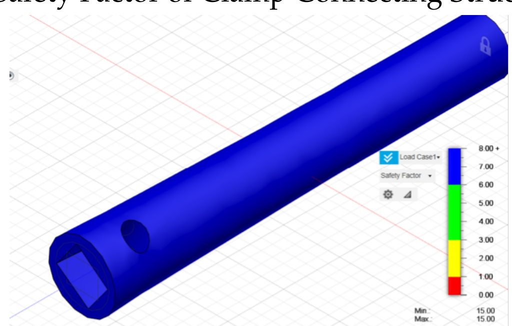
(a) Stress of Clamp Connecting Structure



(b) Safety Factor of Clamp Connecting Structure



(c) Stress of Motor Connecting Structure



(d) Safety Factor of Motor Connecting Structure

Figure 18: Stress and safety factors of Connecting Structures

3 Cost Analysis

3.1 Bill of Materials

Components	**Cost**
Arduino Uno R4 Minima	¥ 120.9
Force Sensor yzc-133	¥ 21.6
ADC HX711	¥ 5
Miniature Motor	¥ 31.8
5840-3650 Motor	¥ 125
Raspberry Pi 4 Model B (comb)	¥ 591 (4GB)
PLA Material	0.65 ¥/g ∼¥ 400 (The institution may supply)
Ground Plug	¥ 60
Rod Fixture	¥ 16
Camera ov5647	¥ 28
Screen	¥ 49.5
Fish	¥ 77.5
PCB print	¥ 21
Electron components	¥ 76.91
Portable Charger	¥ 99
In Total	¥ 1723.21

3.2 Labor Costs

Labor cost: The labor cost is an important part for the senior design and the cost are estimated as below.The estimated salary for person is 100 Yuan/ hour (standard salary for Zhejiang University undergraduates). The normal work time per week is estimated for 8 hours according to our estimation for the senior design. We have 6 weeks to complete our senior design project.

$$100\frac{yuan}{hour} \times 8\frac{hours}{week} \times 6weeks \times 4person = 19200yuan$$

3.3 Grand Total

$$GrandTotal = 19200yuan + 1723.21yuan = 20923.21yuan$$

4 Conclusion

This project was designed to modernize the traditional fishing experience by integrating sensor technology, mechanical automation, and machine vision. Our comprehensive design successfully caught the fish automatically and can identify the fish species. The system's architecture effectively combines a bite-detection subsystem using precision sensors, a mechanical structure robust enough to operate in varied environmental conditions, and a sophisticated identification system powered by a convolutional neural network capable of real-time fish species identification. This integration ensures operational effectiveness and enhances the fishing experience by reducing the time and effort traditionally required.

The system achieved a significant reduction in the need for constant angler supervision through its reliable bite-detection technology, which boasts an accuracy rate of over 80%. Additionally, the identification system has been rigorously tested to achieve an accuracy rate exceeding 90%, demonstrating its capability to support sustainable fishing practices. However, uncertainties such as the device's long-term durability under diverse environmental conditions and its adaptability to various aquatic species remain. To mitigate these uncertainties, ongoing field tests and potential design iterations are recommended, including adjustable performance specifications to handle a wider range of environmental impacts and fish behaviors.

In summary, the Automatic Intelligent Fishing Rod represents a significant advancement in fishing technology, substantially improving efficiency, sustainability, and user engagement. While some challenges remain, the project's alignment with ethical standards and its potential global and environmental impact highlight its value and necessity in modernizing fishing practices to meet contemporary needs.

5 Ethics and Safety

5.1 Ethical Considerations

According to the IEEE Code of Ethics [15], we recognize the importance of prioritizing the safety, health, and welfare of the public in our professional activities. Therefore, when developing our automatic fishing rod system, we will take the following precautions to address ethical concerns:

1. Accuracy Assurance: To ensure accurate identification of fish species, we will rigorously test and validate our machine vision algorithms, with mechanisms in place to verify and correct misidentifications.
2. Humane Treatment of Fish: Our design will prioritize humane handling and minimizing stress and injury to fish during capture and handling, aligning with ethical principles of respect for animals.
3. Equipment Safety Checks: Before deployment, we will conduct thorough checks of all components and systems to ensure they meet safety standards and are free from defects or malfunctions.
4. Risk Assessment: We will perform comprehensive risk assessments to identify potential hazards associated with the operation of the automated fishing rod system. Mitigation measures will be implemented to minimize risks to users and bystanders.

By adhering to these ethical guidelines, we aim to develop and deploy our automatic fishing rod system responsibly and ethically, in line with the principles outlined in the IEEE Code of Ethics.

5.2 Safety Measures

1. Safety is a top priority in the design and operation of the automatic fishing rod system. The system is equipped with various safety features to mitigate risks and ensure user protection.
2. Robust construction: The fishing rods and components are constructed from durable materials to withstand the rigors of fishing environments.
3. Automatic shutoff: The system is equipped with automatic shutoff mechanisms to deactivate the motor and prevent accidents in case of malfunction or entanglement.
4. User instructions: Detailed user manuals are provided to guide users on the proper setup, operation, and maintenance of the system. This includes instructions on handling equipment safely and using appropriate protective gear.
5. Environmental safeguards: Measures are implemented to minimize environmental impact, such as avoiding damage to aquatic habitats and non-target species.

References

[1] D. Sahrhage and J. Lundbeck, *A history of fishing*. Springer Science & Business Media, 2012.

[2] T. Sasaki, S. Serikawa, and Y. Kitazono, "Fishing support system: Tying fishing line automatically," in *Proceedings of the 7th ACIS International Conference on Applied Computing and Information Technology*, 2019, pp. 1–6.

[3] "Haining Weather Forecast." (2024), [Online]. Available: https://lishi.tianqi.com/haining/.

[4] Manufacturer. "YZC-131A Datasheet." (2022), [Online]. Available: https://datasheethub.com/wp-content/uploads/2022/10/YZC-131A.pdf.

[5] A. Semiconductor. "HX711 Precision 24-bit Analog-to-Digital Converter (ADC) for Weigh Scales." (2024), [Online]. Available: https://www.digikey.cn/htmldatasheets/production/1836471/0/0/1/hx711.html.

[6] R. P. 4. T. Specs. (2024), [Online]. Available: https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/.

[7] X. Ying, "An overview of overfitting and its solutions," *Journal of Physics: Conference Series*, vol. 1168, no. 2, p. 022022, Feb. 2019. DOI: 10.1088/1742-6596/1168/2/022022. [Online]. Available: https://dx.doi.org/10.1088/1742-6596/1168/2/022022.

[8] codebox. (2024), [Online]. Available: https://github.com/codebox/image_augmentor/tree/master.

[9] L. Brigato and L. Iocchi, "A close look at deep learning with small data," in *2020 25th International Conference on Pattern Recognition (ICPR)*, 2021, pp. 2490–2497. DOI: 10.1109/ICPR48806.2021.9412492.

[10] AEROSEMI, Inc., *Mt3608 high efficiency 1.2mhz 2a step up converter*, 2008. [Online]. Available: https://www.olimex.com/Products/Breadboarding/BB-PWR-3608/resources/MT3608.pdf.

[11] Onsemi, Inc., *500 ma positive voltage regulators*, 2000. [Online]. Available: https://www.onsemi.com/pdf/datasheet/mc78m00-d.pdf.

[12] Texas Instrument, Inc., *Lm1117 800-ma, low-dropout linear regulator*, 2000. [Online]. Available: https://www.ti.com/lit/ds/symlink/lm1117.pdf?ts=1716793198743&ref_url=https%253A%252F%252Fwww.datasheets.com%252Fzh-tw%252Fpart-details%252Flm1117t-adj-texas-instruments-17131300.

[13] Arduino. "Arduino UNO R4 Minima." (2024), [Online]. Available: https://store.arduino.cc/products/uno-r4-minima.

[14] J. Southard, "4.6: Flow resistance.," *Geosciences LibreTexts*, Mar. 2021. [Online]. Available: https://geo.libretexts.org/Bookshelves/Sedimentology/Introduction_to_Fluid_Motions_and_Sediment_Transport_(Southard)/04%3A_Flow_in_Channels/4.06%3A_Flow_Resistance.

[15] Ieee.org. "IEEE code of Ethics." (2024), [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-%208.html.