ECE 445

SENIOR DESIGN LABORATORY

DESIGN THESIS

Automatic Intelligent Fishing Pod

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

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1 Introduction

1.1 Background and Overview

Fishing is a popular activity and way of life with a rich history in cultures around the world. However, traditional fishing methods require anglers to invest a lot of time, patience, and skill. They often have to wait for hours for a fish to take the bait, which can be unpredictable and frustrating. With the advancement of technology, there is growing interest in developing automated solutions to simplify the fishing process and enhance the overall experience. By accurately identifying fish species, anglers can make informed decisions about which fish to keep and which to release, helping to protect aquatic ecosystems and maintain fragile species populations. 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. This innovation aims to reduce the burden on anglers and improve fishing efficiency and convenience. By combining modern technology with traditional fishing methods, we hope to offer a new fishing experience to enthusiasts, making it easier for them to enjoy this ancient and wonderful activity.

1.2 Art of the State 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.

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 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 the whole system which 1.5V battery

1.5 Visual Aid

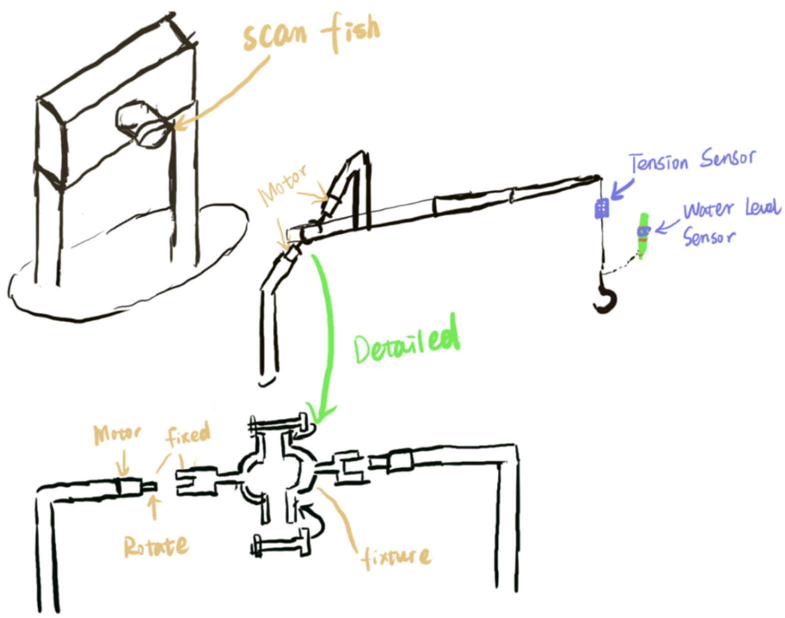


Figure 1: Visual Aid.

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.

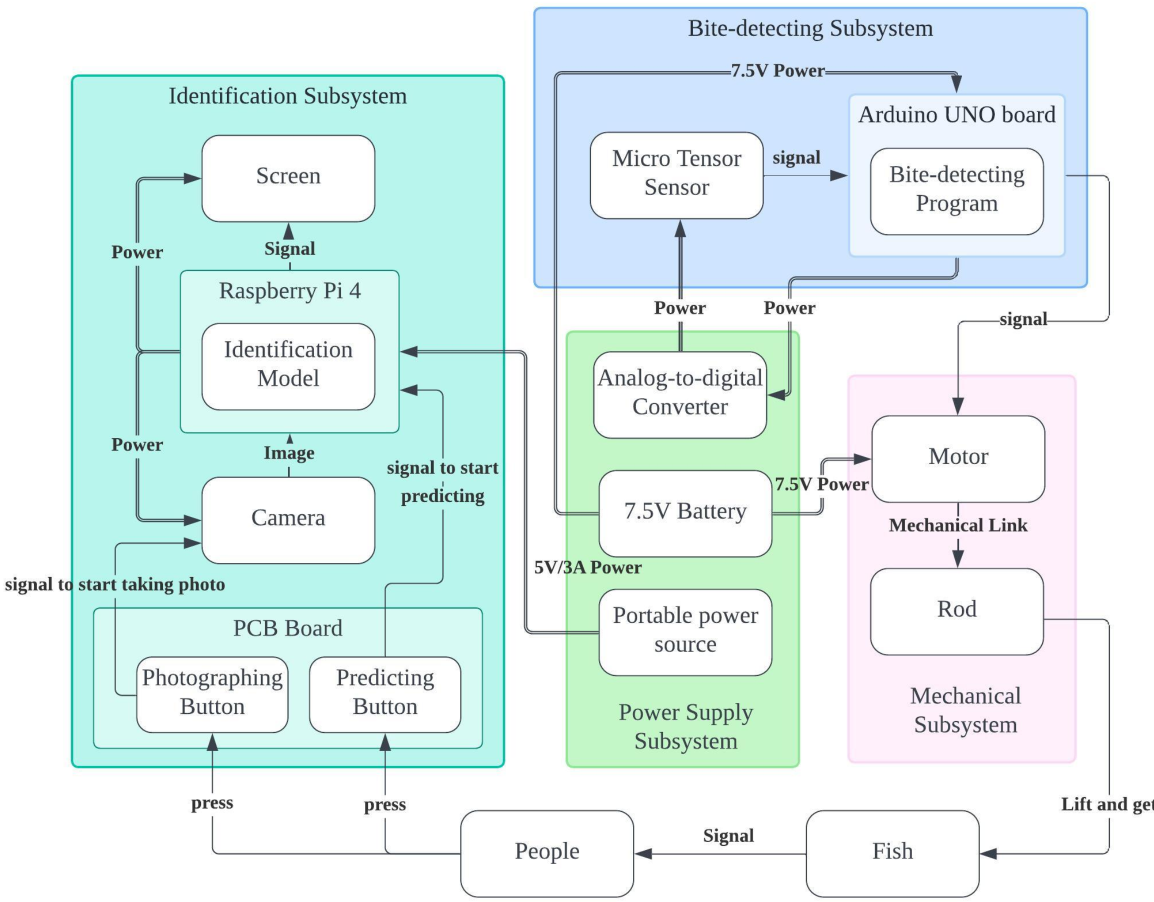


Figure 2: Block Diagram.

2.2 Physical Design

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

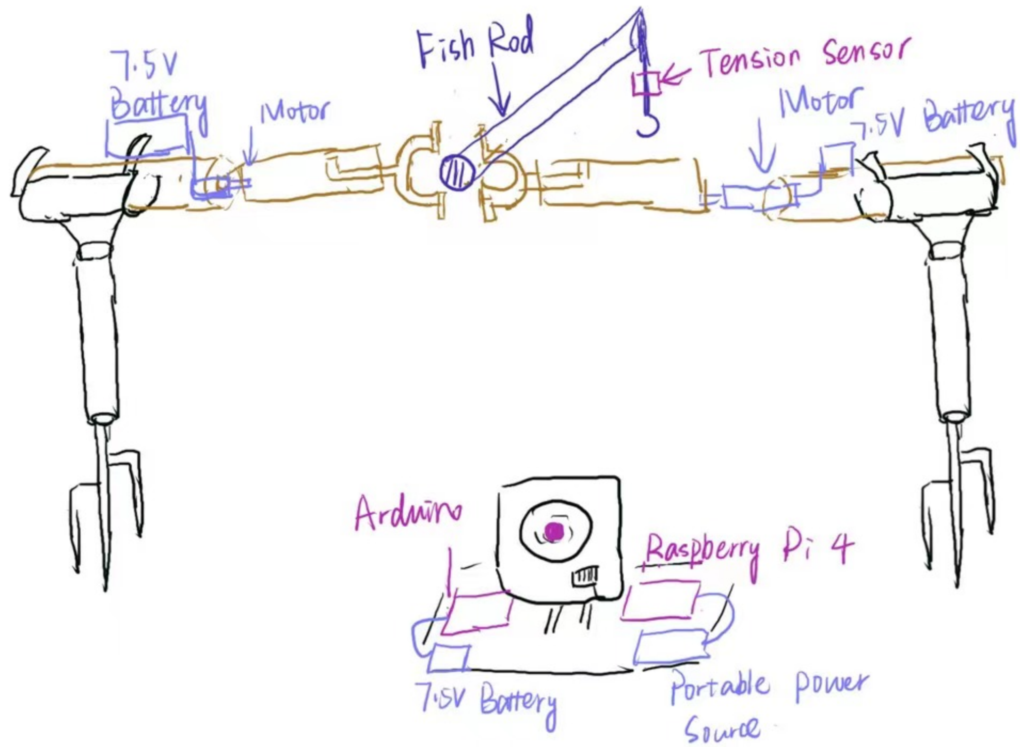


Figure 3: Physical Design

determine the movement of the mechanical 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 [1], we select the yzc-133 sensor to measure the tension on the fishing wire. Some important information [2] about the sensor is shown in Table 1.

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.

Figure 4: The Force Sensor yzc-133

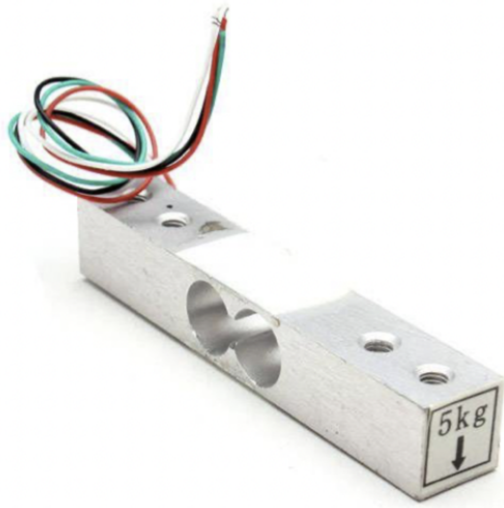


Table 1: Specifications of yzc-133

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

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%.

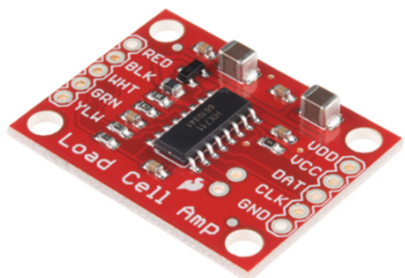
Verifications

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 size of the fish is determined by the size of the hook. Accuracy can be guaran-

teed by the small error (0.05%) of the sensor.

2.3.2 ADC HX711AD

Figure 5: 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 [3] about this ADC is shown in Table 2. **Requirements**

Table 2: Specifications of HX711AD

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

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.

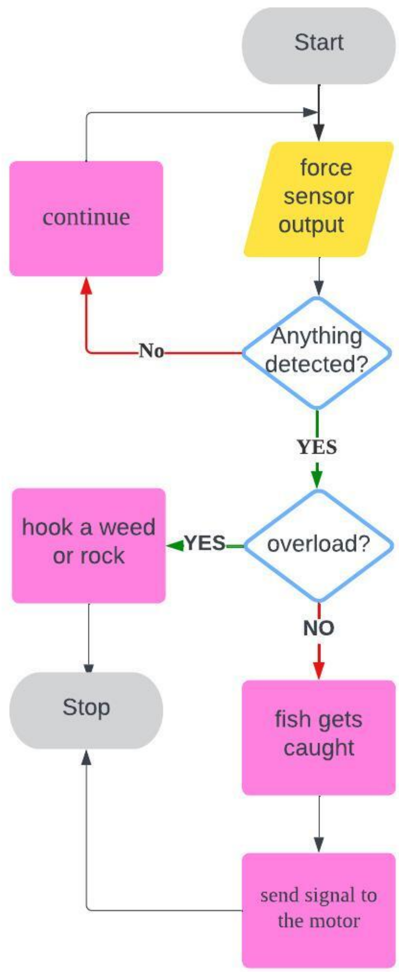
Verifications

1. We can place the wire inside the fishing rod to make it durable and waterproof.

2.3.3 Bite-detecting Program

When a fish gets caught, the sensor will have a linear voltage output from 0.03 to 1 mV. And it should be less than 5mV under normal circumstances. Here is the brief flowchart of the detecting program on the Arduino board.

Figure 6: Bite-detecting Program flowchart



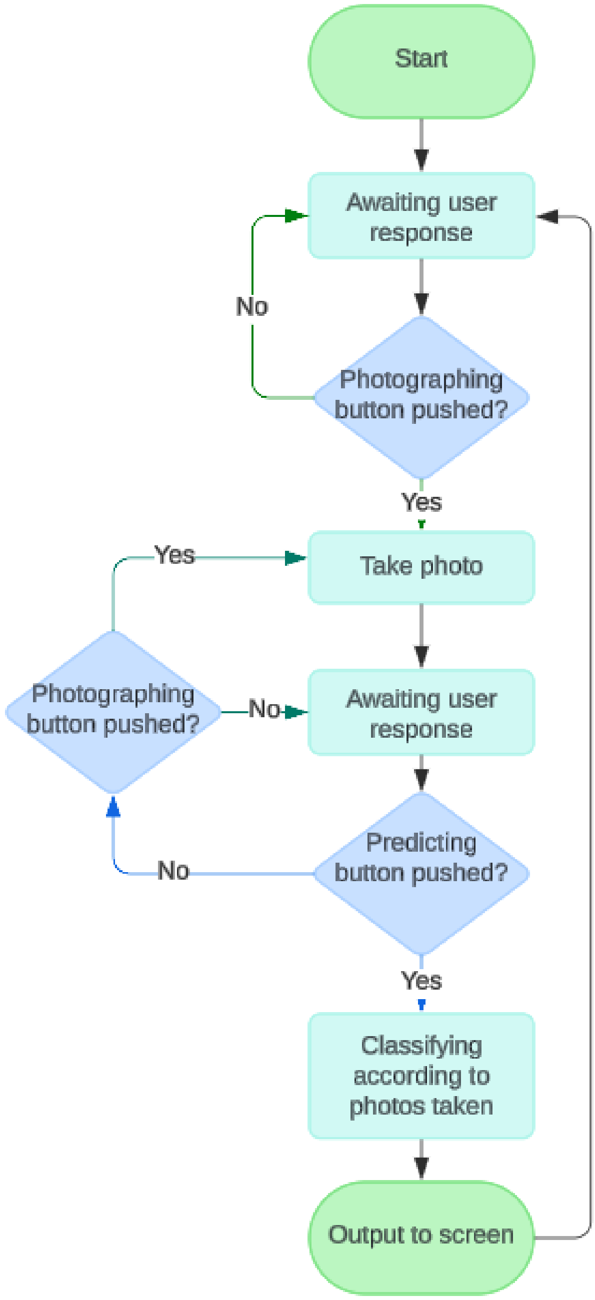
Requirements

1. The program should be able to avoid overload of the force sensor.

Verifications

1. The program will power off the sensor if the output is out of capacity.

Figure 7: Identification Subsystem flowchart



2.4 Identification System:

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 PCB board will be attached to let human users input the signals for taking photos and the signals for starting the prediction.

The image taken from the camera will be the input of our model, which will be loaded into the development board. The data used to train our model will be labeled images of freshwater fish that weigh from 0.03kg to 1kg and can be caught in rivers and lakes. The model's output will be 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 suitable for this target. After the prediction is made, the predicted name of the species will be displayed on a screen for the users.

Requirements:

1. This whole design should be able to stand alone. Thus, the identification subsystem should not rely on computers.
2. The model should make predictions based on fish species that can be caught in the testing area. The weight of the fish caught should be in the range of 0.03 kg to 1 kg.
3. The model is expected to achieve an accuracy of at least 90%, which is a high level of accuracy.

Verification:

1. After the model is trained, it will be loaded onto a development board. The development board will be connected to the camera, taking several images of the fish caught. The power subsystem will power the Raspberry Pi 4 Model B development board.
2. The dataset used for training is designed to include possible freshwater fish species that can be caught in rivers and lakes in the east part of China, including Carassius auratus, Cyprinus carpio, Parabramis pekinensis, Siniperca chuatsi, Pelteobagrus fulvidraco, Mylopharyngodon piceus, Hemiculter leucisculus and Neosalanx taihuensis. Further investigation into candidate species will be conducted to construct a proper dataset for the model.
3. Several methods are to be taken to ensure accuracy. The train set and the test set will be disjoint sets. Before training, the dataset will be shuffled. The model is to be trained a proper number of times to reach a high accuracy on the test set. After the model is trained and loaded into the development board, it will make predictions according to several images representing different fish poses and let the results vote for the final prediction.

[4]

Figure 8: Camera

Table 3: Table for ov5647 Camera

Parameter	Unit	Value
Lens size	inch	1/4
Resolution	Pixel*Pixel	2592*1944
Power supply	V	3.3
Size	mm*mm	24*25

Figure 9: Raspberry 4 Pi Model B

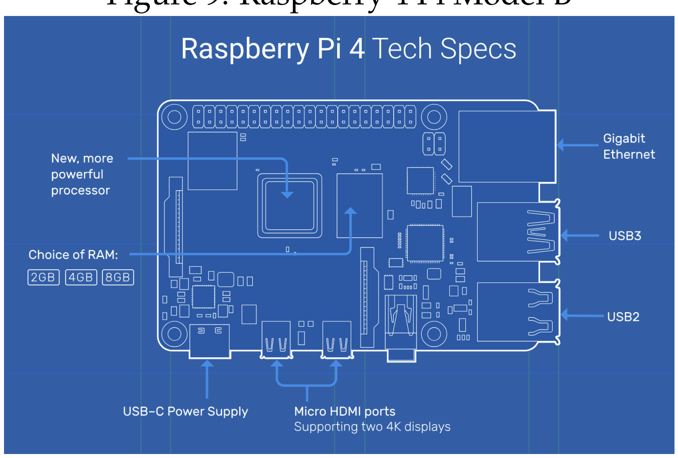


Table 4: Table for Raspberry Pi 4 Model B

Parameter	Unit	Value
SDRAM	GB	1, 2, 4 or 8 (depending on models)
Power supply voltage	V	5
Frequency	GHz	1.8
Operating temp	°C	0 ~50

Figure 10: Screen

Table 5: Table for touching screen

Parameter	Unit	Value
Power	W	2
Screen size	inch	3.5
Power supply	V	3.3
Size	mm*mm*mm	35*90*61

2.5 Mechanical System:

2.5.1 Rod Holder to the Ground

For the connection between the fishing rod holder and the ground, our initial idea was to use 3D printing to insert it into the ground for fixing, so the end of the holder was designed as a pointed shape. But because of the high cost, we searched the Internet for ready-made products and modified them.

Figure 11: Rod Holder to the Ground

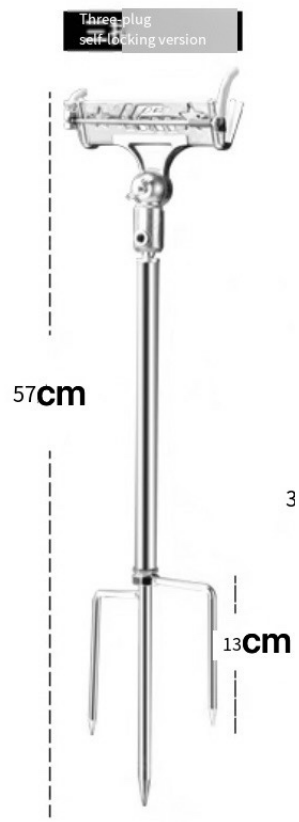


Table 6: Specification of Fishing Ground Plug

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

Verifications:

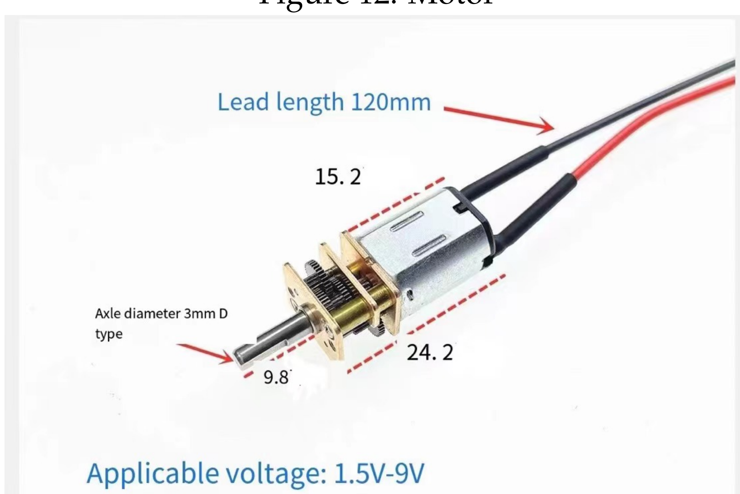
1. This problem can be avoided by measuring and reserving the height of the ground plug.
2. The torsion force and gravity generated by 0.03kg to 1kg fish were simulated to determine the bearing capacity of the ground plug.
3. By buying back the physical product and 3D printing part, the experiment simulated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

2.5.2 Motor

When the two sensors reach the critical value, the signal of catching the fish is simultaneously transmitted to the mechanical device, which is transmitted to the motor through a microcontroller similar to Arduino, so that the motor starts to turn. Taking into account the bite time of the fish, the motor turns about three seconds after the sensor reaches the critical time.

For the selection of the motor, we try to use a small speed, can withstand the torque of the larger motor, so that it can withstand the larger weight of the fishing rod. The picture is a finished motor we selected from the Internet. The size parameters are shown in the figure. By connecting the governor, its speed can be adjusted from 4rpm to 40rpm. At present, we plan to choose a speed of 4rpm for the experiment.

Figure 12: Motor



Requirements:

Table 7: 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 ~40
Motor speed	V	1.5 ~9

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 $\sim$ 1kg fish struggling with it.

Verifications:

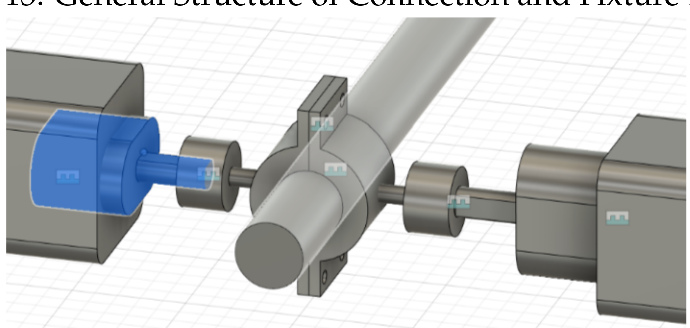
1. Connect and experiment with the Arduino program and code.
2. Use the dynamometer to measure the force of the general fish struggle and apply a similar torque to the motor to test whether it can rotate normally.

2.5.3 The Linkage and the Fixture for the Fishing Rod

The linkage device at both ends of the motor is shown in the figure. The shaft of the motor links the fixture so that the jig and fishing rod rise as the motor rotates.

For the fixation between the fixture and the fishing rod, we initially used the 3D printing situation to manufacture. Screws are threaded through four holes and secured by nuts. If the stiffness of the 3D printed part is insufficient, we consider buying the finished steel pipe clamp from the Internet and modifying it to make its size conform to the fishing rod.

Figure 13: General Structure of Connection and Fixture Device



Requirements:

1. two 3D modeled parts, keeping them non-sliding.

Figure 14: The Structure Connecting the Ground Plug to the Motor

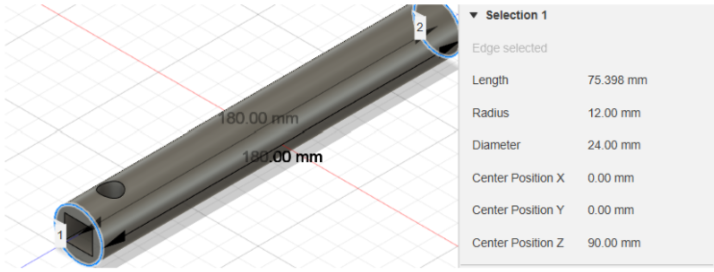


Figure 15: The Structure of Connecting the Motor to the Rod Fixture

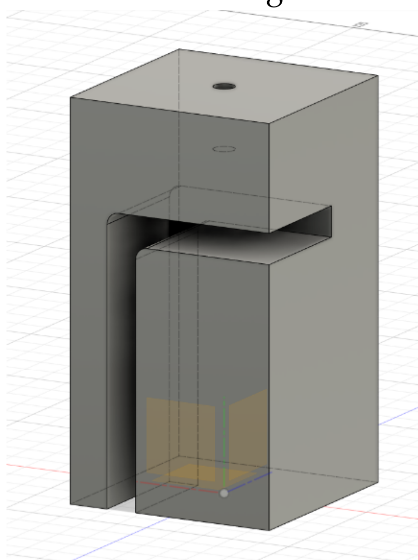
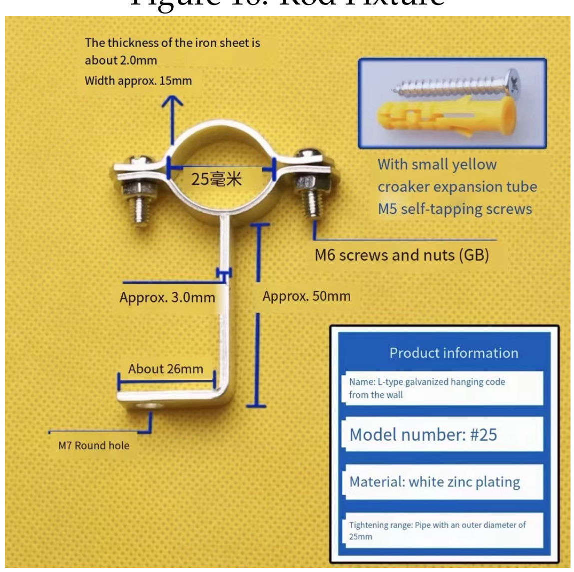


Figure 16: Rod Fixture



2. 3D printed parts need to withstand the torque required to fish.

Verifications:

1. The expansion error of 0.5mm 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.

2.6 Power Supply Subsystem:

A power system supplies the power of each subsystem, including the linkage between each subsystem and independent parts such as the buoy's power. We use batteries and a portable power source to provide a stable power supply. In the rod-lifting device, we will use Arduino UNO to control and supply power for the sensors and motors. The battery we use to supply the Arduino board is a 7.5V battery. For the Identification subsystem, we load the trained model into berry Pi to identify the kind of fish. The power supply we chose for Raspberry Pi is a 5V/3A portable power source. The camera and screen we use in the identification subsystem connect directly with Raspberry Pi and get power from the board.

Requirements:

1. Supply power for Arduino UNO with 7.5V battery
2. Supply power for Raspberry Pi 4 Model B with 5V/3A portable power source.

Verifications:

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 5V DC via a USB-C connector.[5]
2. As mentioned on the Raspberry Pi website, It can use 5V/3A DC via a USB-C connector.[6]

2.7 Tolerant Analysis

2.7.1 Hardware

2.7.2 Software

The accuracy of the model should be over 90 percent.

Table 8: 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: 5V Working Current: $\approx$ 5mA Power: $\approx$ 25mW
ADC HX711	Working Voltage: 2.6$\sim$5.5V Working Current: $\leq$ 1.5mA Power: $\leq$8.25mW
Motor	Power supply voltage: 1.5$\sim$9V
Raspberry Pi 4 Model B	5V/3A

3 Cost Analysis

3.1 Bill of Materials

Components	Cost	Member
Arduino Uno R4 Minima	¥ 120.9	Baiming Li
Force Sensor yzc-133	¥ 21.6	Yitong Gu
ADC HX711	¥ 5	Ziyi Shen Xinyi Song
Motor	¥ 31.8	Baiming Li
Raspberry Pi 4 Model B	¥317 (2GB)	Yitong Gu
PLA Material	0.65¥/g ∼¥400 (The institution may supply)	Ziyi Shen Xinyi Song
Ground Plug	¥60	Baiming Li
Rod Fixture	¥16	Ziyi Shen Xinyi Song
Camera ov5647	¥28	Yitong Gu
Screen	¥49.5	Yitong Gu

4 Schedule

4.1 Weekly Schedule

Week	Tasks	Member
4/1	3D print and test the connector	Baiming Li
4/1	Constructing dataset for the model	Yitong Gu
4/1	Test the sensor and the ADC	Ziyi Shen Xinyi Song
4/8	Optimize 3D printed parts based on installation problems Compare the practicability of different print fillings.	Baiming Li
4/8	Constructing model	Yitong Gu
4/8	Finish coding on the Arduino Uno Connect the bite-detecting subsystem	Ziyi Shen Xinyi Song
4/15	Test the hardware near the river.	Baiming Li
4/15	Test the bite-detecting subsystem with a water tank and goldfish indoors	Ziyi Shen Xinyi Song
4/15	Training Model	Yitong Gu
4/22	Loading model into development board	Yitong Gu
4/22	Test the bite-detecting subsystem along with the mechanical subsystem	Ziyi Shen Xinyi Song
4/29	Testing and debugging model with camera and screen	Yitong Gu
5/6	Test and debug the whole project together	Baiming Li Xinyi Song Yitong Gu Ziyi Shen

5 Ethics and Safety

5.1 Ethical Considerations

According to the IEEE Code of Ethics [7], 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. 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.

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