e-YSIP 2019

Bio-Inspired Sub-carangiform FishBOT

Intern 1: Aditya Kumar Singh
Intern 2: Bhavy Shah
Mentor Name:
Rucmenya Bessariya
Lohit Penubaku
Saail Narvekar
Duration of Internship: 22/05/2019 – 05/07/2019

2019, e-Yantra Publication

Bio-Inspired Sub-carangiform Fish-BOT

Abstract

Nature has always worked as an inspirational source for the robotics world to create & innovate things in order to understand and imitate it. This project on the same basis, is all about how to design & imitate a subcarangiform fish in respect to the nature's creation. The FishBOT has got a **3 joint** body locomotion controlled using micro servos. The caudal fin is used to generate the force vortex for each forward push and also the turns are controlled only by using lateral shift of body & caudal fin.

Completion status

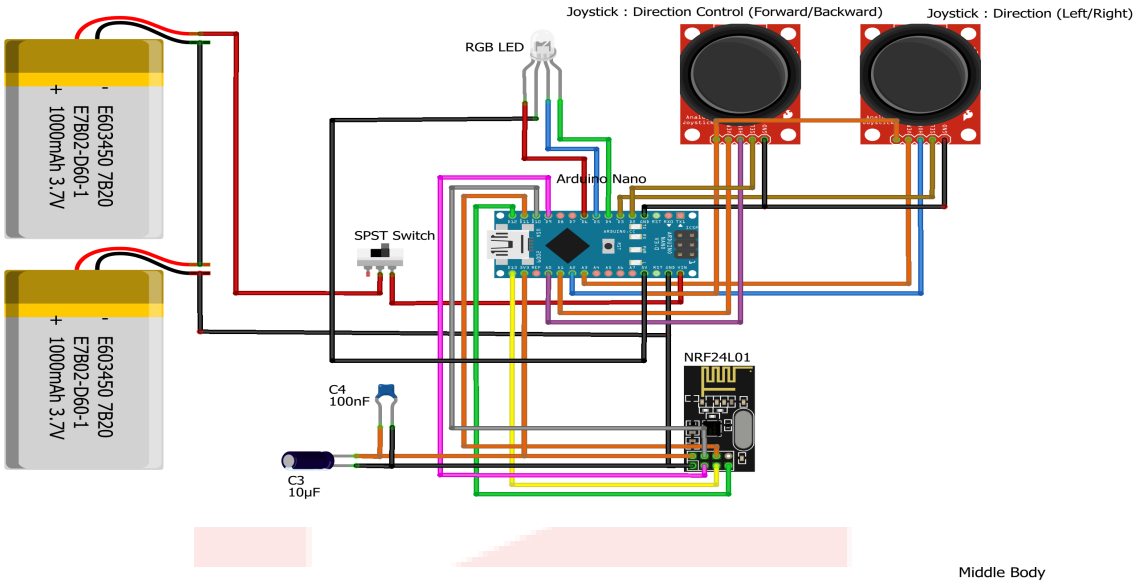
Working prototype which can swim underwater has been accomplished with great speed and efficiency as well as turning on both side can be done with **effective turning radius ranging 15 to 30 cm**. **The length of the bot is 36 cm**. Also, it is **controlled using remote by NRF24L01 transceiver module**. It has a battery backup of 30 minutes.

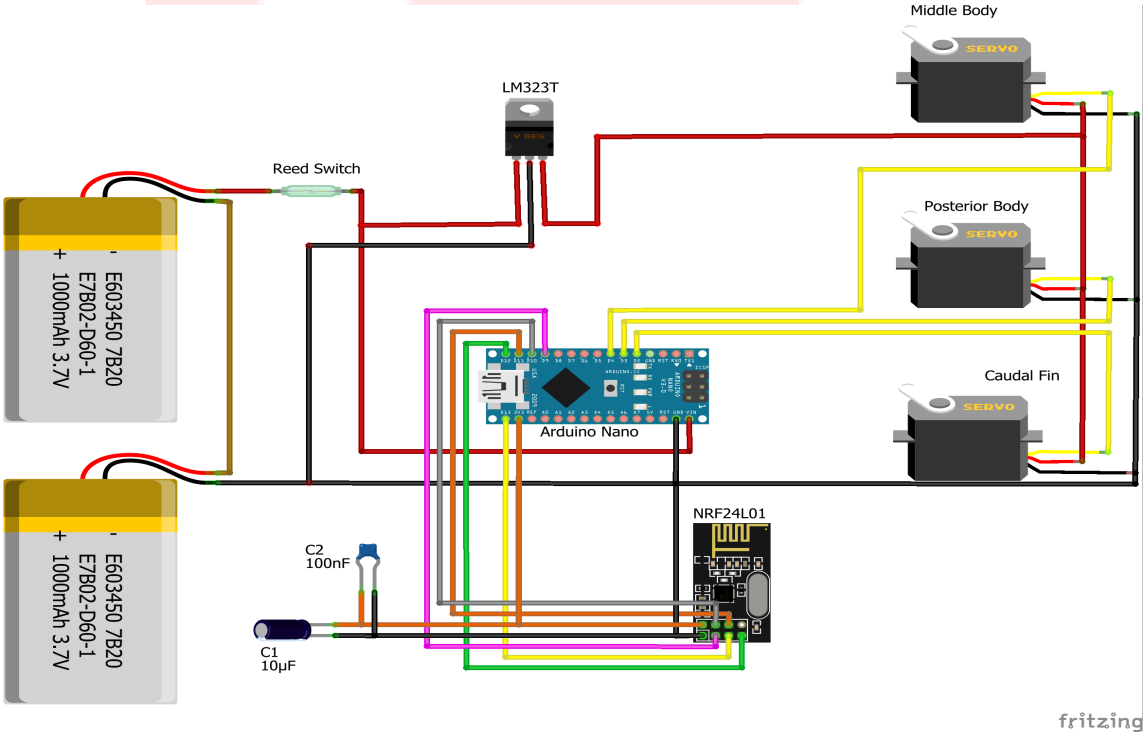
1.1 Hardware parts

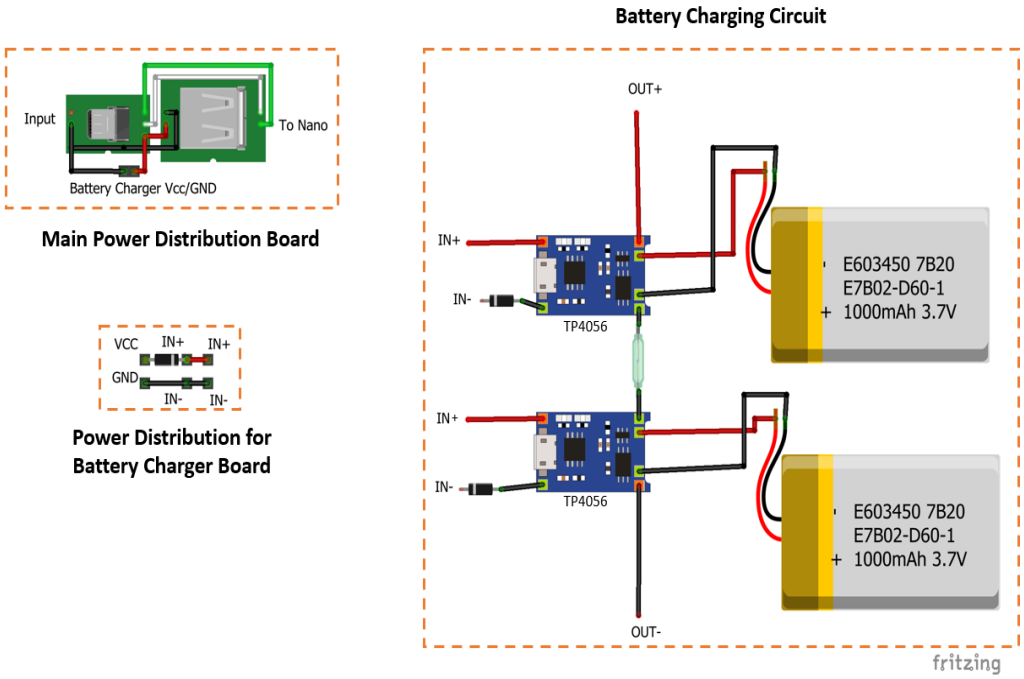
- Arduino Nano (with Cable) (2 Pcs), Datasheet, page 1, Vendor link
- NRF24L01 Module (2 Pcs), Datasheet, page 1, Vendor link
- Lipo Battery, 3.7 Volts (4 Pcs), Vendor link
- Micro Servo Motor (3 Pcs), Datasheet, page 1, Vendor link
- LM323T Voltage Regulator (1 Pc), Datasheet, page 1, Vendor link

1.1. HARDWARE PARTS

- TP4056 Battery Charger (2 Pc), Datasheet, page 1, Vendor link
- 2-Axis Joystick Module (2 Pc), Datasheet, page 1, Vendor link
- RGB LED(Common Anode) (1 Pc), Datasheet, page 1, Vendor link
- Connection diagram







1.2 Software used

- Arduino IDE, Version:1.8.5, Link
- Solidworks Version: 2019, Link
- Installation steps:
  - Arduino IDE : Installation Guide
  - Solidworks : Installation Guide

1.3 Assembly of Mechanical design & Electronics hardware

Getting Mechanical design model.

Get the Solidworks design of parts and assembly from this link: Link

Getting mechanical parts

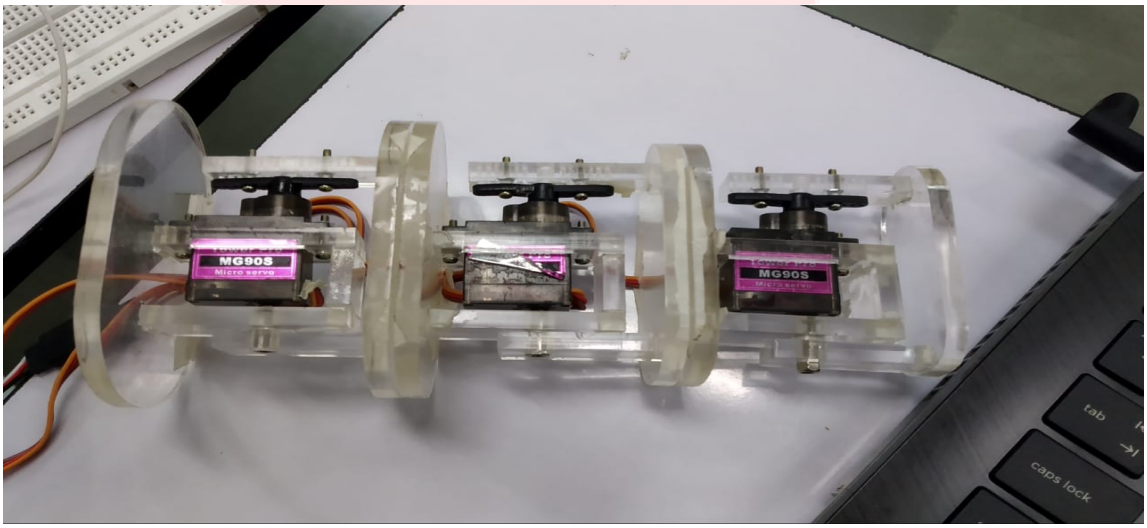
Get the acrylic parts laser cut and the head & nose portion of the fish 3D printed.

Waterproofing servo motors

- Unscrew the servos from the bottom. On the circuitry parts apply 2-3 coatings of plasticizer resin.
- On the top gear part, apply hydrophobic grease and then screw it back.
- Further, apply multiple coatings of the resin on entire servo motor body (keeping care near the shaft part) and let it dry.
- Before fitting the servo motor on the assembly, just test it once for underwater conditions.

Assembling the skeleton body

- Assemble the skeletal part joint wise and also place the motors in each joint. Assemble each joint to get the complete body.
- For joining the parts, any adhesive which glues together acrylics can be used.
- Be careful while joining, all the parts attached to the main hub should be 90 deg. This is to ensure that the chain has minimal deformation.
- Finally you should have something like this:-



Waterproof Electronics

- Similar to motors, waterproof all electronics components using plasticizer resin. Make sure to apply 2-3 coatings.
- Waterproof the electronics only when they are placed on their position in final PCB. Avoid applying coating on the pins of the microcontrollers or other circuits.

Circuit assembly

- Assemble the circuit as per the given circuit diagram in section 1.1.
- The circuit can be designed on perfboard. This you have to do it on your own. There is no footprints for this.
- Finally test the circuit once before fitting it in its actual position.

Electronics in fish

- After successful testing, place the electronics in fish body as per suitable positions.
- Look for the wire lengths of servos motor carefully. Dont't restrict the servo movements because of the wires.
- Before sealing, test the whole setup again. From reeed switch to communication between remote and BOT everything.

Assembling the head body

- Now, assemble the head & nose using silicon and also cover the whole body with plasticizer and then coat with epoxy for water proofing.
- Test for the waterproofing of the BOT completely before actually deploying it in pool.

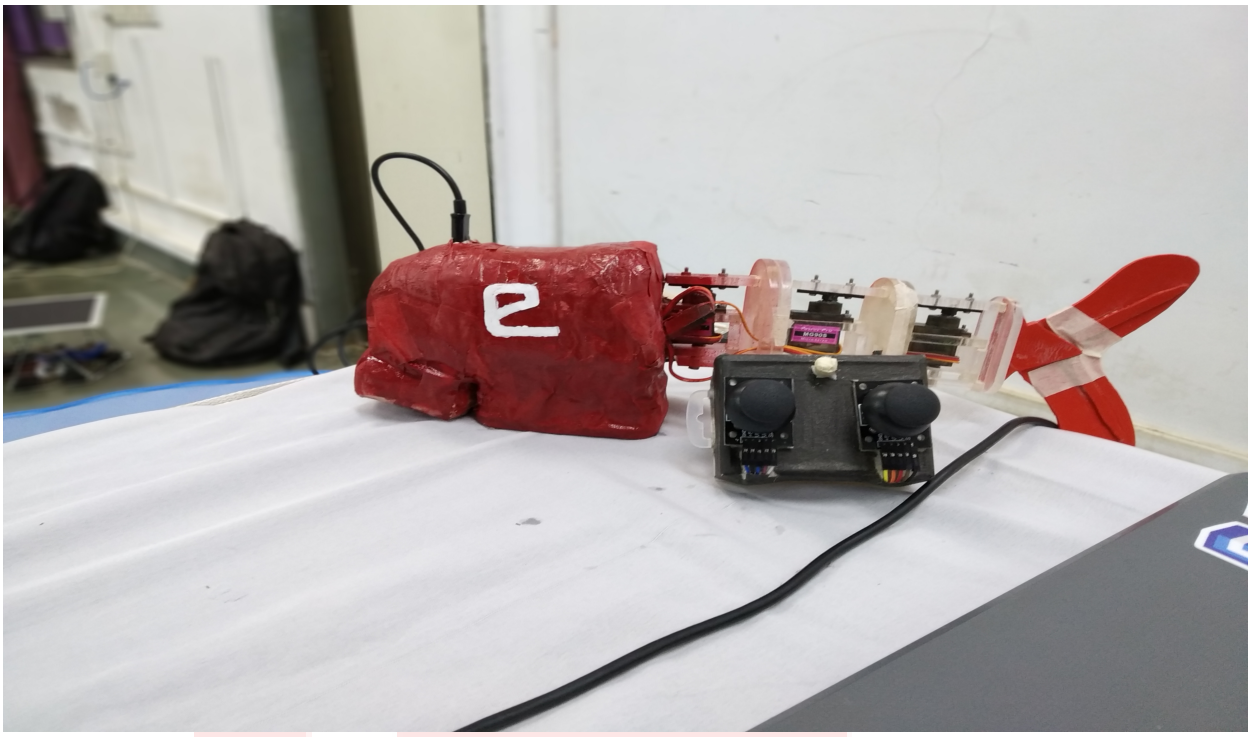
1.4 Software and Code

Github link for the repository of code

Brief explanation of various parts of code:

- **NRF Communication:**
  1. For maximum distance, power is kept maximum.
  2. Data transfer speed is set to 250Kbps.
  3. Auto acknowledge is enabled.
  4. Remote send 'F', 'B', 'L', 'R' to BOT and the BOT receives it along with speed ranging from 0-4. For handshaking the BOT sends back numbers to tell that data was received successfully.
- **Fish's Motion:**
  1. The fish's motion is inspired from one of the famous undulatory motion - "Serpentine Motion".
  2. More information about the motion can be obtained here:- Link
  3. For turning along with the parameters, the first link can be fixed to its respective turn side and rest all links can be moved.
- **Remote:**
  1. The remote uses handshaking technique to communicate with the BOT.
  2. The commands used can be found in the code itself. Along with direction, speed is also sent in form of numbers ranging from 0-4.
  3. The more the joysticks are bent, the more will be speed. This is done via mapping the ADC values from the joystick to 0-5 using map() function.

1.5 Use and Demo



Usage Instructions:

- Handle with care or it may cause water-proofing issues.
- Do note that the magnetic-switch is off while charging batteries or data transfer.
- Do not sink completely in water.
- If at any time during operation, bubbles start coming out of the BOT, immediately take it out from the water.
- While plugging in for charging or data transfer, make sure that the USB port is not wet.

Youtube Link of demonstration video

1.6 Future Work

- More efficient control of buoyancy can be resulted into variable depth swims.
- Size of the fish can be reduced by optimizing mechanical design and also using smaller electronics.
- It can be made in autonomous working style.
- Design can be made more imitating by implementation of subsidiary fins.
- More features can be added as per requirement.

1.7 Bug report and Challenges

- Size of the fishbot increases considerably on implementing regular size components.
- Water-proof mechanical design is hard to obtain with sufficient repellency to water.
- Electronics water-proofing to a certain perfection was challenging.
- Maintaining the body buoyancy so that fish remains stable while its motion is a challenging task to accomplish.
- Providing proper occupancy to all components with getting them to work efficiently as well as maintaining minimum size.

Bibliography

[1] Larry Hardesty, *Soft robotic fish moves like the real thing*, 2014

[2] Huosheng Hu, *Biologically inspired design of Autonomous robotic fish at Essex*, 2006

[3] AIRO, The MIRO maker, *MIRO: The only biomimetic robotic fish in the world*, 2018

[4] Jaywant H Arakeri, *Fluid Mechanics of Fish Swimming*, 1997

[5] computerphile, *Robotic fish - computerphile* https://youtu.be/F1tS-qGCE0U, 2019

[6] Eric Dirgahayu, *RoboFish made from PVC water pipe*, 2015

[7] Junzhi Yu, Shifeng Chen, Zhengxing Wu, Weibing Wang, *On a Miniature free-swimming Robotic fish with multiple sensors*, 2017

[8] Joseph DelPreto, Daniela Rus, *Sofi- The soft robotic fish*, 2014