Project report

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"Fishe"

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Summary

Introduction

As climate warming is now a proven fact according to the IPCC, more and more studies want to assess the effects of carbon dioxide emissions on the earth. Carbon dioxide is shared between the atmosphere, the oceans, and the ground, mainly in forests.

However, the ocean's situation is alarming.

“There is about fifty times as much carbon dioxide dissolved in the oceans as exists in the atmosphere. The oceans act as an enormous carbon sink, and have taken up about a third of CO_2 emitted by human activity.” Wikipedia

It seems a huge part of the carbon dioxide is swallowed by the oceans. In fact, the CO_2 reacts with water to form carbonic acid (H_2CO_3), bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), decreasing the water’s pH.

The effects of these molecules haven’t been fully ascertained yet, especially in the deep sea, where high pressure prevents us from taking measures.

In this context, we want to make a robot that could be able to measure the water’s temperature and pH, and take it the deepest we can.

Chapter I : State of the art

I.1. Project definition

I.1.a. Existing models

The CNRS' labs used to have a few autonomous analysis submarines taking measures in the Mediterranean Sea, but they were approximately 1 m long and had battery problems. Now, they have been replaced by long wires with sensors at different heights.
This is why we want to build a robot in two parts: a navigation unit, and a recon unit.
We based our project, the Fishe, on the principle of a boat, so the buoyancy works like a boat's. For the propulsion, we find it easier to base it over the model of the hovercraft.
We found some models on the internet presenting boats or hovercraft piloted by Arduino.
The rest of our project isn't based on anything that we can find, it will be our own creation.

I.1.b. Project's extends, measures

Our project's goal is to make measurements of the sea current state, in order to be able to correctly estimate global warming's effects.

For now, we will only measure the water's temperature, pH, and turbidity to have info on the carbon dioxide rate and pollution.

In the future, we could consider taking some sediment from the underwater soil. However, they seem to be impossible to analyze onboard.I.2. Navigation unit

The navigation unit must be able to move on water. It is not necessarily fast, but must be maneuverable.

It must be stable enough to don't turn over on each wave, maybe could it even turn itself automatically when being thrown down.

When sailing in an area with seaweed or rocks, it would be better if it didn't hurt himself on the obstacles. That's why a large shell seems appropriate.

I.2.a. Navigation unit motorization

The navigation unit must be able to move itself, for this reason it must have a motorization that allows him to advance. We will have propulsion based on the system of a hovercraft because we thought that it will be hard to protect the motor from seaweed. So it will need a thrust propulsion. We studied two type of motor that we summarize in the following table.

Motor type	Pros	Cons	Cost estimation
Brushless DC motor	High speed range No voltage drop Stable speed	electric control driver necessary	€30 motor €20 ESC
Reversible DC motor	Easy to use	Low speed range High rotor inertia Brush change needed after a long use	€5

At the beginning, we used to think that we will use propulsion based on two motors so that we will easily direct the Fishe, however it will take too much space on the boat.

We will need a lot of control over our motor to ensure the direction of the Fishe, for exemple to move backward if it's in front of an obstacle. Our choice went for the brushless DC motor because it can rotate faster and allow a more precise control over the motor.

With this one, we need a driver, and it's the ESC that allows us to regulate the current that comes from the battery. We also found how to reverse the motor only with an arduino.

We also need propellers to navigate, for that, we search a lot of propellers like the variable or fixed pitch one, over in sale, we couldn't find anything in our budget, around one hundred dollars or the size was too large. So we decided that we will create our one propeller within the Fablab, we will model one and print it. We haven't yet decided which type of filament it will be, however our choice is rather oriented to PETG or PC because we need a decent water resistance and a piece that can sustain the rotation at high speed.

Lastly, we need to direct our boat, for that, we will fix behind the propeller a rudder on a servo motor that will direct the airflow. We will also create it in the Fablab with the same filament. It will normally be like a cage.

I.2.b. Navigation unit energy

Speaking of energy, we will use a battery to supply our motor. We studied different batteries as it follows.

Battery type	Pros	Cons	Cost estimation
Lipo battery	Flat High energy density	Needs a management system (ESC)	~€30 for 3S = 11.1V
Li-on battery	High energy density	Needs a management system (ESC) Needs a lot of space	~€60 for 3.6V
Nickel-cadmium battery	High current	Low energy density (9V max) Toxic product	
Nickel-Metal battery	High current Decent density	Toxic product High discharge rate	

For that, we estimate the need of current from the battery at 6.5Amps and the voltage around 11V. In this case, because of the need for space on the boat, we thought about a Lipo battery 3S. The 3S means three Lipo cells in series with each cell having a voltage of 3.7V.
The advantage is that the management of the battery can be done by an ESC that we also need to regulate the motor. The last two batteries couldn't satisfy us either by the maximum output of voltage or by the rapidity of discharge.

I.2.c. Navigation unit equilibrium

The navigation unit must be able to navigate in open sea, with waves of potentially two meters all the time. In these circumstances, it appears obvious that it will overturn, and therefore must be restored.
We envisage a system of balance with weights to tilt the navigation module.

Type of shell	Pros	Cons	Water drag factor estimation $\frac{C_{x,i}}{C_{x,1}}$
Full solid shell	Very stable	High drag Difficult to rotate (too stable on the yaw axis)	1
Hovercraft	No drag, allows high speeds	Inflating the air cushion will cost a lot of energy Low stability, needs a lot of work on equilibrium to keep the unit up and on the right direction	~0
Kayak-like shell	Very stable on the pitch Perfectly stable on the yaw axis, can turn and keep a direction	Not very stable on the roll axis	0.6
Double shell (catamaran)	Very stable in all axes, perfectly stable on yaw Almost no drag	Heavy constraints on the structure	0.4
Inflatable and rigid shell (Zodiac-like)	Very stable in all axes	The propeller must be underwater	0.7

I.3. Recon unit

The recon unit must dive deep under the sea to take measurements, so its buoyancy must be reviewed. Then it must of course come back to the navigation unit to recharge itself and don't lose all the data it collected.

It could be towed by the navigation unit to avoid unnecessary motors in the recon unit. In this case, the buoyancy must be highly negative to allow the unit to dive deeply.

Moving method	Pros	Cons	Cost estimation
Almost neutral buoyancy + propellers	Freedom of movement	Difficult to implement and to use Uses tremendous amount of energy to move	2 small servos for the directions + 1 brushless for the propeller = €50
Almost neutral buoyancy + jellyfish-like propelling	Constraint movement Almost no energy consumption	Unidirectional movement, needs a lot of research	2 small servos for tightening the shell : €30
Negative buoyancy + wire	Use simplicity Weight No energy consumption	The cable could wrap up the unit, so its shape must be fixed The dive depth is limited by the wire's length The unit will only drift, it won't be possible to control it	One 100 m tall fisher wire : €13 One DC motor to wind the cable back in its coil : €15 Constraints on the navigation unit

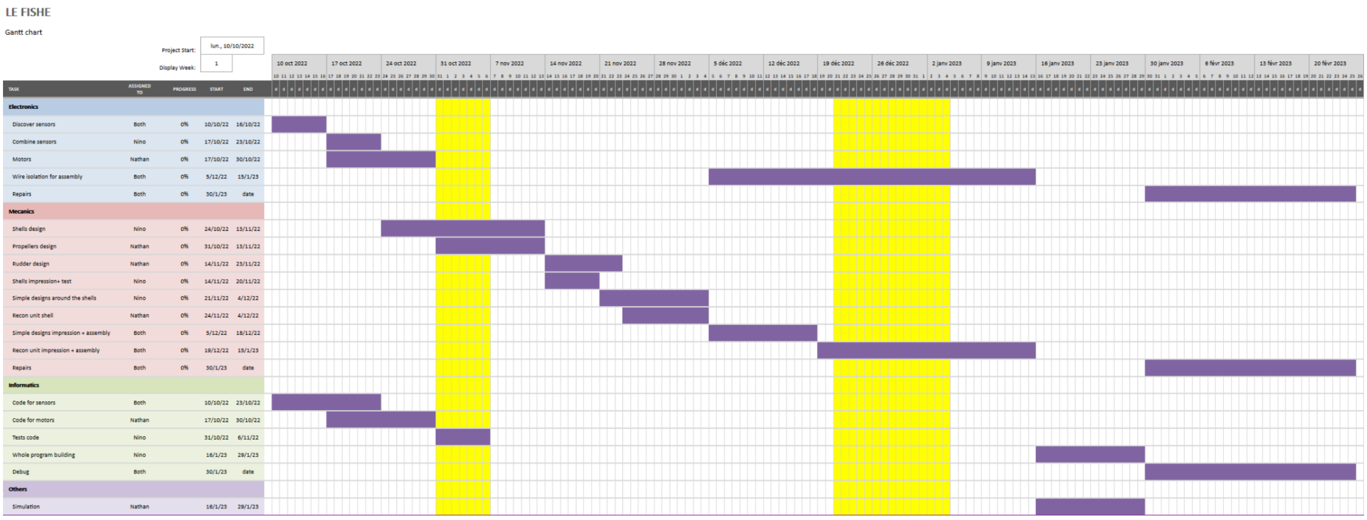
I.4. Communication between the units

Transmission method	Pros	Cons	Cost estimation
Wired connection (the cable holding the unit could be a USB cable)	Exchange simplicity Continuous control over the unit Battery not needed in the recon unit	The wire must be handled with a lot of precaution The wire can't be taller than 25 m approximately because of the wire's magnetic inductance USB repeaters can be used, but they must be supplied in power by batteries that must be recharged.	4* 25 m of repeaters = €360 4 batteries : €80 =€440
Connector	Exchange simplicity	Crucial unit placement when docking, a simple millimeter drift will prevent the exchange from occurring The connectors must be protected from water	USB connectors : €9 USB-C connectors : €20 +constraints on the shells
Wi-Fi/Bluetooth (+induction for charge? See induction)	Discussion range : being docked isn't necessary to exchange data Wireless communication, no connector is needed	Costs a lot of energy Needs another way of exchange for power supply, see induction	Wi-Fi : 10*2=€20 BT : 10*2=€20
Induction	Wireless communication, no connector is needed	Very hard to implement Contact is necessary to charge	Qi's induction coil : €15 *2=€30 Wireless close range Arduino communication device : €11 * 2

Chapter II. Organization

In order to make this project come to an end, we must organize ourselves properly.

This is why we have realized a Gantt chart as follows.



[Gantt Chart on Excel]

We also have a [Github repository].

Conclusion

To realize our project, we decided to use a brushless DC motor which will be at 6.5Amps and 12V consumption. To adapt and stabilize the current, we will use an ESC controller which can be adapted to a 3S LiPo battery.

In addition, to allow it to move forward, we need a propeller fixed on the motor, which will be printed in the Fablab to and fixed on the motor. This allows the Fishe to move, thanks to a thrust propulsion.

To rotate it, a rudder is needed. This one will also be printed. It will be fixed to a servo motor so that he can direct the airflow of the propeller.

The shell’s type isn’t fixed yet, but we think we will use a catamaran-like shell

The recon unit won’t move by itself, it will go down using its own weight, and be brought back by the navigation unit towing it.

The two modules will communicate via bluetooth or wifi, and the navigation unit will save all data collected on an SD card.

The recon unit will have a small battery since it only needs to power some sensors, and will be charged by induction on the navigation unit.

Bibliography

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Le robot inspiré des méduses se déplace comme le nageur le plus efficace de la nature
jellyfish propulsion
How do jellyfish swim? | Earth | EarthSky
forces applied by swimming jellyfish

Drag coefficient - Wikipedia

profiles aerodynamics / hydrodynamics profiles NACA

Intergovernmental Panel on Climate Change - Wikipedia

AR6 Synthesis Report: Climate Change 2022 — IPCC

Carbon dioxide - Wikipedia

Arduino based hovercraft

aircraft propellers and how they work

Annex A. Needed materials

- Fisher wire
- Turbidity sensor
- Small battery for the recon unit
- Batterie Lipo 3s 6500mAh 80C 11.1V
- ESC 30A Lynxmotion Multirotor BEC 1A (Avec Connecteurs) - RobotShop
- Kyrio A2212 Brushless Motor 2200KV Outrunner Brushless Motor
- Waterproof servomotor