FISHBOARD: An electronic device for analysis of productive data in pisciculture (fish-farming)

FISHBOARD: Um dispositivo electrónico para análise de dados produtivos na piscicultura (piscicultura)

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ABSTRACT
To attend to the growth of the demand for food, diverse technologies have been put at hand to rural producers in ways to reduce costs, losses and increase productivity. It is transforming the production at the farms and is becoming visible the use os devices such as drones, robots and apps in a new concept called Smart Farming, which take advantage of the resources from Agriculture 4.0 to promote the development of systems that monitor the production in real time, generating info used at the decision making by producers. In Smart Farming, the pisciculture production benefits itself from the use of robotics as an agent to monitor the fish tanks, assisting the decision making. This project aims to present the building of FishBoard, which is the proposal for integrations os two systems, where one is responsible of the physical part in the process of monitoring (involving logic in the data gathering) and the other one is the accessibility part (developing an app the enables the data visualisation and interpretation in real time). The physical part of the project consists in a robot, adapted with a microcontroller responsible of searching the breeding tanks surface collecting productivists infos through its sensors (water and air temperature, as well as humidity, luminosity and pH), for later sending them to a server via Wifi; once the informations are in the server, the app uses them as a data source to supply dashboards, which shows informative graphics to facilitate the interpretation and enable the decision making by the producer. The robot prototype was developed using an ESP8266 NodeMCU microcontroller and with the followings sensors of water temperature (dsi8b20), air temperature and humidity (DHT-22), brightness (P7 - GBK) and PH (ph4502c), its movement was evaluated through tests carried out in tanks of correlated dimensions and it was successful identifying obstacles and making detours. The device has been successfully connected to a remote server, where a data structure exists, and the integration of the physical system with a mobile application has also been completed.

Therefore, the results of the FishBoard prototype indicate its effective utilization in fish farming, because it is a tool that facilitates access to information by the rural producer, and consequently helps the decision making regarding the quality of the tanks water where the fish are being grown.

Keywords: Pisciculture, Sustainable Development, Mobile App, Cloud Database, Arduino, ESP8266, Microcontroller, App, Android.

RESUMO
Para atender ao crescimento da procura de alimentos, diversas tecnologias foram postas à disposição dos produtores rurais de forma a reduzir custos, perdas e aumentar a produtividade. Está a transformar a produção nas explorações agrícolas e está a tornar-se visível a utilização de dispositivos como zangões, robots e aplicações num novo conceito chamado Agricultura Inteligente, que aproveitam os recursos da Agricultura 4.0 para promover o desenvolvimento de sistemas que monitorizam a produção em tempo real, gerando informação utilizada na tomada de decisões pelos produtores. Na Agricultura Inteligente, a produção piscícola beneficia a si própria da utilização da robótica como agente para monitorizar os tanques de peixes, ajudando na tomada de decisões. Este projecto visa apresentar a construção do FishBoard, que é a proposta de integração de dois sistemas, onde um é responsável pela parte física no processo de monitorização (envolvendo lógica na recolha de dados) e o outro é a parte de acessibilidade (desenvolvendo uma aplicação que permite a visualização e interpretação dos dados em tempo real). A parte física do projecto consiste num robot, adaptado com um microcontrolador responsável por pesquisar a superfície dos tanques de reprodução recolhendo informações produtivistas através dos seus sensores (temperatura da água e do ar, bem como humidade, luminosidade e pH), para depois as enviar para um servidor via Wifi; uma vez que as informações estão no servidor, a aplicação utiliza-as como fonte de dados para fornecer painéis de controlo, que mostram gráficos informativos para facilitar a interpretação e permitir a tomada de decisões por parte do produtor. O protótipo do robot foi desenvolvido utilizando um microcontrolador ESP8266 NodeMCU e com os seguintes sensores de temperatura da água (dsi8b20), temperatura e humidade do ar (DHT-22), brilho (P7 - GBK) e PH (ph4502c), o seu movimento foi avaliado através de testes realizados em tanques de dimensões correlacionadas e foi bem sucedido na identificação de obstáculos e na realização de desvios. O dispositivo foi ligado com sucesso a um servidor remoto, onde existe uma estrutura de dados, e a integração do sistema físico com uma aplicação móvel também foi completada. Portanto, os resultados do protótipo FishBoard indicam a sua utilização eficaz na piscicultura, porque é uma ferramenta que facilita o acesso à informação por parte do produtor rural, e consequentemente ajuda na tomada de decisões relativas à qualidade da água dos tanques onde os peixes estão a ser cultivados.

Palavras-chave: Piscicultura, Desenvolvimento Sustentável, Aplicação Móvel, Base de Dados Nuvem, Arduino, ESP8266, Microcontrolador, App, Android.

1 INTRODUÇÃO

The current population growth, both in Brazil and in the world, causes some problems that are intensified by overpopulation and, as a result, humanity will need innovative actions to solve them. Problems such as hunger, depletion of natural resources and major changes in the ecosystem are emerging and worsening throughout the years. To minimize them in ways they do not cause big impacts on the way humans live today, researches need to develop innovative and low-cost technologies with high productivity that solve the difficulties of agricultural production [1].

According to [2], for years man has studied the lack of natural resources resulted from their unsustainable use and from the demographic explosion of the world population. The 21st century context, which involves big technological advances and global awareness, becomes the perfect scenery for development and improvement of sustainable technologies that collaborates in a positive way with the environment and, at the same time, supply men's needs. This way, a substantial progress capable of helping the fighting against the previous problems, is the support and use of Agricultura 4.0, which consists of adapting current agriculture to ICT (information and communication technology) concepts [3].

The Agricultura 4.0 fuses the most innovative concepts of technology, such as sensors, communication between machines and mobile devices, cloud storage, graphic painel for statistics analysis, automation and the execution of remote processes with the internet of things, making possible the creation of countless solutions that can contribute directly with the productivity and efficiency of the agricultural sector [3]. With the integration of a data management production system, with the internet of things, it is possible to make the process even more efficient, being able to obtain, view and control information from distance due to the fact that the process is connected via internet [4].

From the high demand for food , due to the population growth and from the conscious about the evolution and integration of technology, the fish farming appears as a practical option to the food production because it offers a high quality result for human consumption, made with great care in animal feeding, control of growth rates and water properties [5]. However, the pisciculture consists of the fish production inside controlled environments, an agricultural activity that has been growing rapidly in Brazil and that can make an expressive contribution to society, as a form of sustainable development, as well as for the owner of the property, which can generate extra income bringing several benefits to its production.

Nevertheless, associating new technologies with fish farming is a challenge that several research companies and universities are working on. Studies such as [6] present research on how robots can be used in fish farming as a monitoring agent for animal behavior. Other works, such as [7], focus on the application of ICT in robotization through the construction of ROVs (Remotely operated underwater vehicle) or underwater vehicle operated remotely as an automated agent in IoT (Internet of Things) for monitoring the production parameters of the animal and water quality. Therefore, it is understood that there is a great opportunity for technological research in the area of fish farming and this work presents a new application in this sector.

1.1 HYPOTHESIS

The relation between researches involving Agriculture 4.0 and Pisciculture has currently demonstrated that the use of IoT devices can be beneficial to rural producers because they are able to collect data on production (zootechnical indexes) that will serve as support in decision-making about the current state of production. Thus, a field of research emerges that proposes the use of sensors distributed in a robotic device that moves over water, enabling rural producers to gain access to information about water quality and, consequently, the cultivation of fish in real time, which facilitates decisions and avoids losses in its production.

This way, uniting the hardware concepts, uniting hardware concepts such as sensors, motors and boards, with software concepts such as frontend and backend, raises the possibility of creating a robotic system that can control, transmit, receive and monitor visualizations over the received data. Therefore, the possibility of creating a tool that monitors the quality of the water in the fish farming tanks emerges, it would assist the treatment of most of the cultivation problems, such as the lack of time to take care of the tanks and the lack of information about how the process must be done.

As from the Water Quality Manual [8], the main aspects that need to be monitored are divided in physical aspects: temperature, color, turgidity, visibility, and transparency; and in chemical aspects: pH, alkalinity, hardness, dissolved oxygen and ammonia. Based on these features, this work presents the hypothesis of a robot that can monitor, from the surface of the fish farming tanks, the environment conditions for the fish farming in a confined system, using sensors and data transmitters that allow its visualization and, later, the decision making by the rural producer.

2 OBJECTIVES

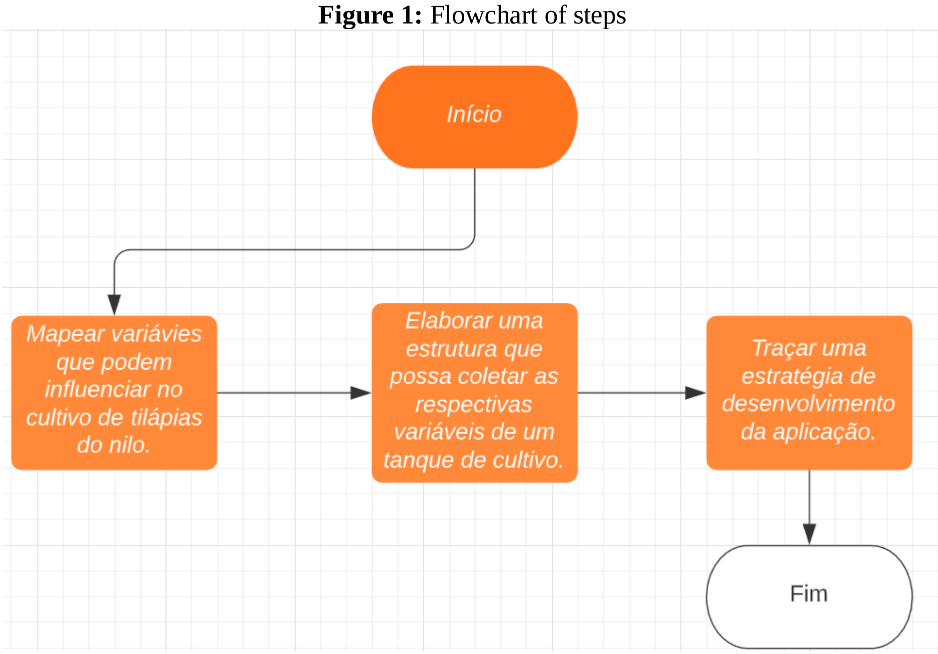
The main goal of this project is building an electronic device that moves in the water surface of the fish farming tanks with the capacity of collecting information about the water quality, informing to the producer the indicators in real time that will serve as input for decision making. The specific objectives are:

- Uniting a set of sensors that will assist the information gathering about the water quality of the pisciculture tanks;
- Assemble a structure that floats on water and supports the weight of the sensors;
- Elaborate a logic in the code that will control the sensors and the structure during the process of information gathering;
- Elaborate an algorithm to control the movement of the structure in ways that it avoids collisions and covers the largest possible area;
- Transmit the data collected via sensors to a remote server; and
- Present this data on a mobile device so that the rural producer can make his decisions regarding the production.

3 METHODOLOGY

The proposed methodology for solving the problem of this work is based on three phases as shown in Figure 1.

Figure 1: Flowchart of steps

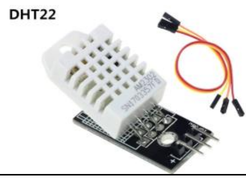


According to Figure 4, its steps are described below: mapping variables that can influence the Nile tilapia cultivation; develop a structure that can collect the respective variables from a cultivation tank; and outline an application development strategy. These steps are detailed below.

3.1 VARIABLE MAPPING

The mapping of the variables collected and analyzed is based on the previous consultation in manuals that describes the tilapia cultivation, as for example the Quality Water Manual defined by Embrapa [8]. The following variables were defined for analysis as shown in Table 1.

Table 1: Variáveis para análise

Id_v	***Nome***	***Foto do sensor***
1	Water temperature (ds18b20)	
2	Air temperature (DHT22)	
3	Water's pH (PH4502c)	
4	Ambient brightness (GBK P7)	
5	Air humidity	

3.2 STRUCTURE ELABORATION

The skeleton of this project can be divided into three structures, them being: Support structure (the base on which the entire physical part will be supported); Electrical structure (the cable connections in the microcontroller); and Logical structure (how the device will work). They are detailed below:

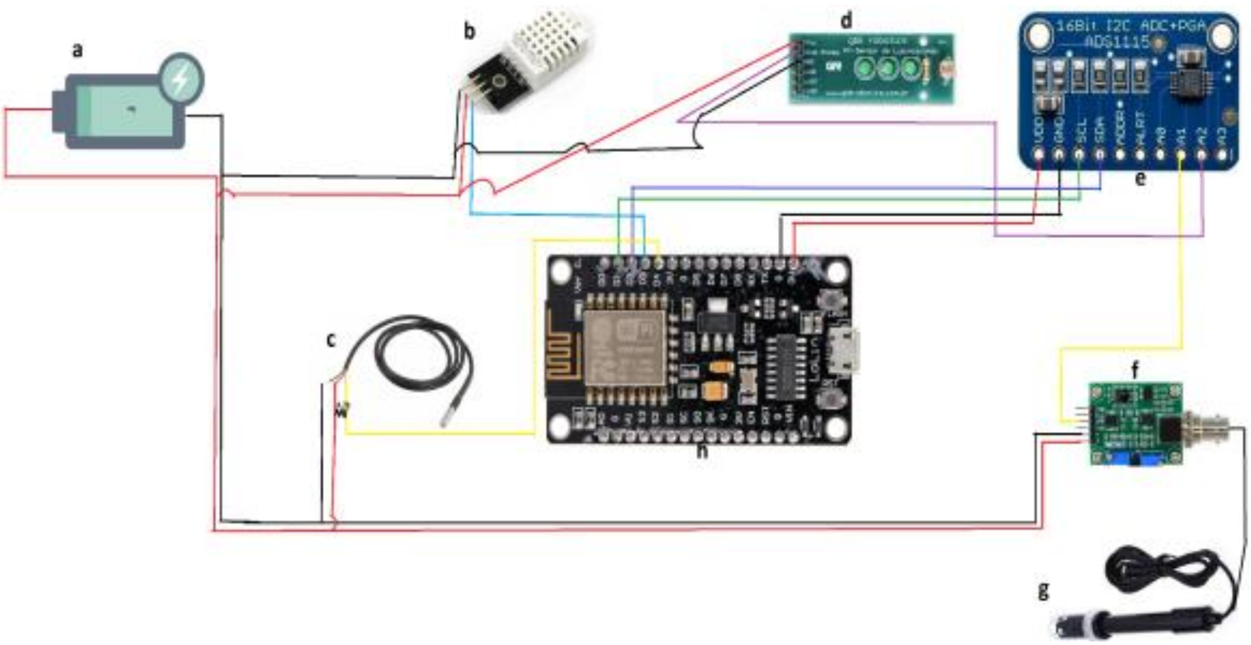
a) Support structure:

To make the final value of the project more accessible, a 1.5L polystyrene box was used, which costs between 2.59 and 5.97 USD in popular markets in Brazil. This box was chosen because it has enough volume to store all the electronic components and generate enough buoyancy to keep the entire structure floating on water, playing the same role as an acrylic case that has an average market price 3 times more expensive. In this way, the project cost was reduced by adopting Styrofoam.

b) Electrical structure:

In this project, a set of microcontrollers was used, where one was responsible for locomotion of the device and the other responsible for data collection. The microcontroller used for locomotion can be seen in Figure 2.

Figure 2: Device circuit



The elements of Figure 2 are described below:

A) A 5v battery: a 5 volts lithium battery responsible for supplying energy to the circuit;
B) Sensor DHT22: sensor responsible for measuring temperature and humidity of the ambience;

C) Ds18b20 Sensor: sensor responsible for the water temperature measuring/

D) GBK p7 Sensor: sensor responsible for capturing the light intensity incident on the water surface;

E) ADS1115 digital analogue converter: module responsible for converting the analogue signal to a digital signal from the luminosity and pH sensor.

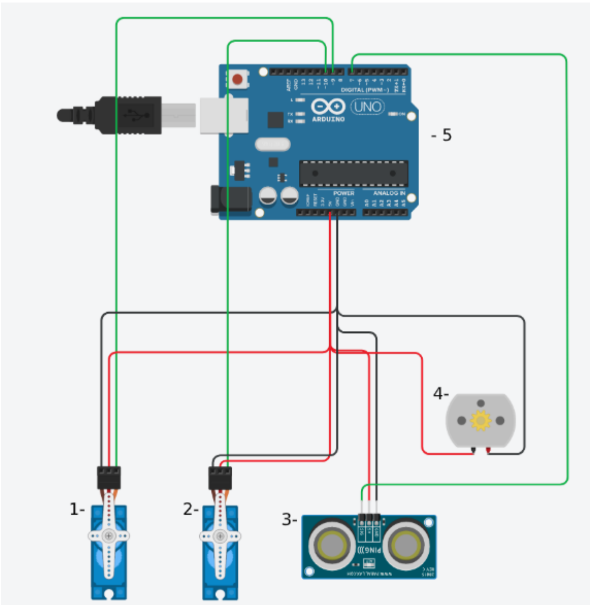
F) Ph4502c controller: responsible for managing the pH sensor.

G) Ph4502c controller electrode: responsible for capturing the pH measurement.

H) NodeMCU ESP2866: microcontroller used to manage the sensors.

The microcontroller used for locomotion can be seen in Figure 3:

Figure 3: Micro controller circuit



The elements presented in Figure 3 are described below:

1- Servomotor 1: the servomotor is a special motor in which it is possible to control its rotation through commands that cause the rotor to turn small angles at a time, resulting in a more precise and controlled movement than conventional DC motors. Servomotor 1 in particular is responsible for rotating the base structure of the ultrasonic sensor.

2- Servomotor 2: Servo motor 2 is responsible for rotating the rudder, changing the direction of the device's course.

3- Ultrasonic sensor: this sensor has the ability to emit high frequency sound waves and is also able to capture its echo, from this principle it is possible to calculate the distance between the object that emitted the echo and the sensor. In this project, the ultrasonic sensor is responsible for being the robot's vision, which identifies obstacles in its path and informs the algorithm when to change direction.

4- DC motor: DC motor: the direct current motor is an electric motor responsible for rotating the propeller located at the bottom of the boat, causing it's propulsion.

5- Microcontroller: the microcontroller is the device responsible for managing all the other sensors mentioned. It is in the microcontroller that the code responsible for managing and commanding the operation of the sensors is recorded.

c) Logical structure:

The logical structure of this project consists in using one servo motor that will be responsible for the rudder movement of the device and consequently change its route; a set of another servo motor with an ultrasonic sensor, which will be responsible for measuring distances from nearby objects; and a DC motor that will be responsible for propelling the device.

3.3 DEVELOPMENT STRATEGY

The development strategy chosen for this project was the use of the agile Scrum methodology, where the whole development is divided by steps and these are broken down into different tasks. The steps are called Sprints and in these sprints small tasks are added, which are not great features, but small parts of those features facilitate the organization and the documentation and productivity of the developer.

For the organization and implementation of Scrum in the project, the JiraSoftware tool was used, which consists of a table divided into 5 columns: tasks to be done, tasks being done, code review, testing and ready-made tasks. The description of the activities of these columns is described below:

1.Tasks to be done: this column aims to support the developer organize the tasks that have not yet been done.

2.Tasks being done: this column aims to prevent the developer from starting a task that is already being done by someone else.

3.Code review: this column is for the developer to take a brief look at the added code and check if there is something wrong.

4.Test: this column serves to highlight the tasks that have already been completed and should be tested to confirm that its requirements have been met.

5.Finished tasks: this column is used to organize tasks that have already been completed.

Another tool utilized with the painel JiraSoftware was the GitHub, which was used to control the versioning of the project. A public repository for the project was created with the intention of making the application available to anyone interested. This repository is available at: https://github.com/thlindustries/piscicultura. A methodology of creating a branch (project's ramification) for each task was also adopted because the Scrum painel has the option of continuous integration with the GitHub repository, so it's possible to link the tasks created in the JiraSoftware painel directly with the repository branches, making it even easier to organize and document the project.

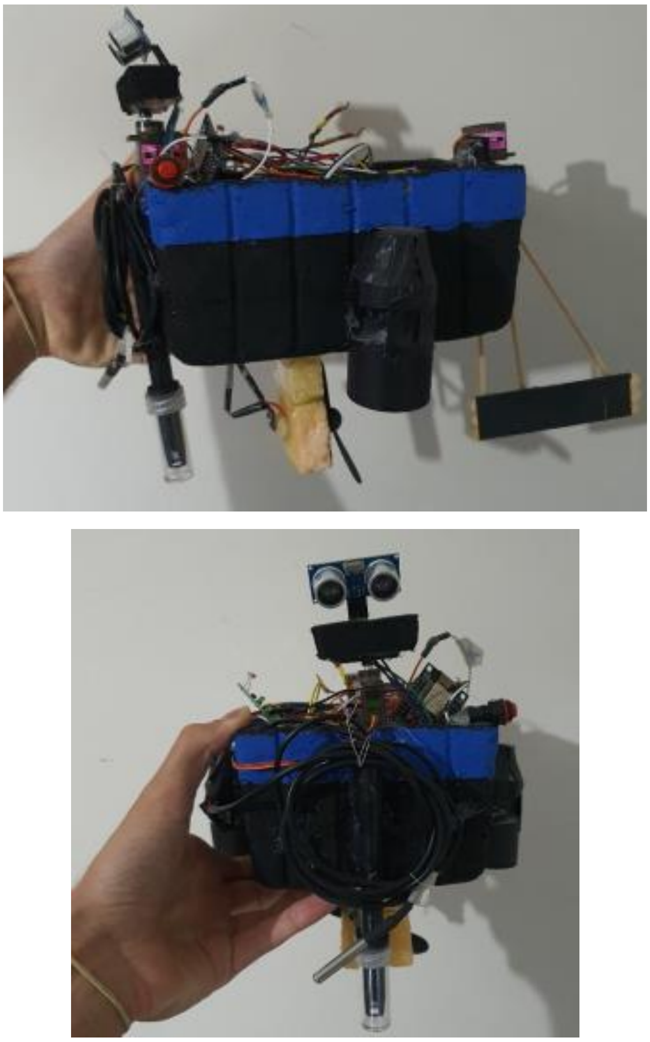
4 DEVELOPMENT OF THE SOLUTION

For the development of the application, the MySQL Server database in cloud was used through a service called SaveInCloud to store the data collected in the field tests. The development of the application consists of four stages, which are: elaborate the logic operation of the physical device; choose the technology to be used for the development of the mobile application; prototyping the application interface; and integration of the mobile application.

4.1 STRUCTURE ELABORATION

The logic of the electronic device was divided into two parts: one responsible for its movement and the other responsible for collecting information. The finished device can be seen in Figure 4.

Figure 4: FishBoard prototype



4.1.1 Movement logic

The logic defined for the functional of the electronic device was a combination of servo motors with a ultrasonic sensor so it could dodge the obstacles in its course. This combination works through the following steps:

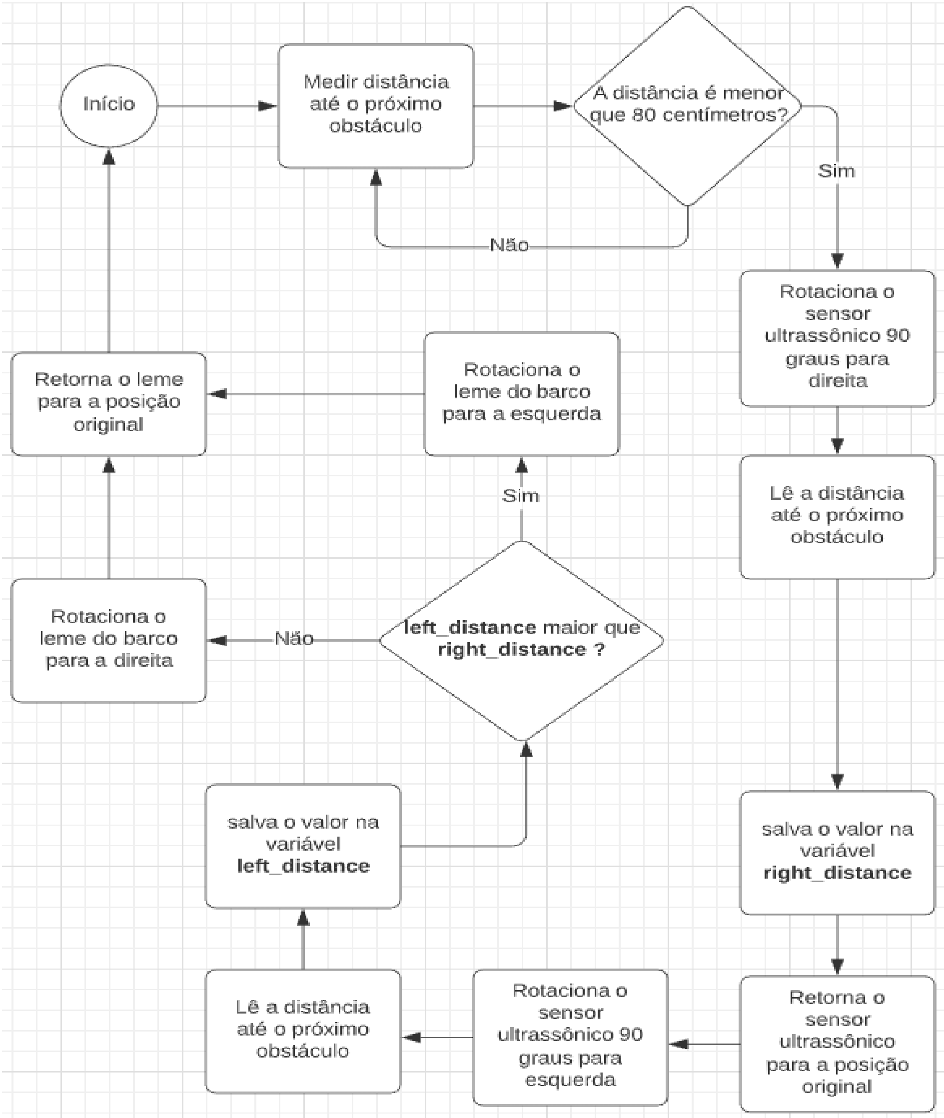
a) The ultrasonic sensor measures the distance every 5 seconds between the front of the device to the nearest obstacle, if that obstacle is less than 80cm away, the logic to switch the direction is activated;

b) To change the direction there is a servo motor under the ultrasonic sensor, which makes it possible to rotate it. From the moment the logic is activated, the servo motor rotates the ultrasonic sensor 90 degrees to the right, returns to its original position and then 90 degrees to the left, measuring the distance between the front of the device and the obstacles in both the sides; and

c) After the distances from the sides are measured, the algorithm causes the servo motor that controls the rudder to turn the boat in the direction in which the distance between the side and the obstacle was greater.

The steps described above are presented in the flowchart format in Figure 5:

Figure 5: Physical device flowchart



4.1.2 Data collection logic

The data collection logic resumes itself in a cycle of 10 seconds in which every cycle all sensors of the device (pH, water and air temperature, luminosity and air humidity) collect the data from that time and send them, via internet, to a cloud server, in a relational database (MySQL Server), where the data are registered along with the exact time it was harvested. The table structure used for data storage follows the model in Figure 6.

Figure 6: Database table sctructure

fish_data	
Pk	Id
	airtemp
	watertemp
	umidity
	ph
	luminosity
	CREATED_AT

4.2 TECHNOLOGY USED FOR THE DEVELOPMENT OF THE MOBILE APPLICATION

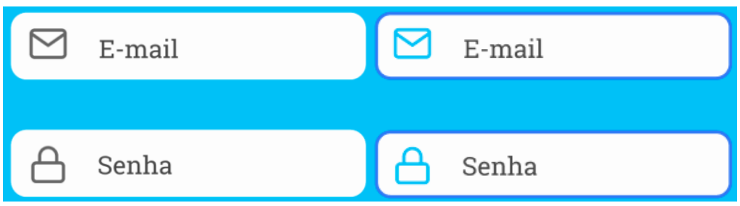
For the development of the mobile application, the React-Native library was chosen, which is a javascript library that allows the creation of multiple platforms applications from the same source code, in other words, it is possible to create an application that works on the Android system and the iOS system from a single code.The following describes how the application building activities were carried out in this library.

4.2.1 Application interface prototyping

For developing these applications the tasks were divided following the Scrum methodology, for the elaboration of four interface components : Text input, the text input, the button, the side menu and the graph component. These components are described below:

a) **Text input:** In this component the UX(user experience) technique was used, where in selecting the field, the borders and the icon change color to make it clear to the user which field he is in. The change can be seen in Figure 7.

Figure 7: FishBoard app text input

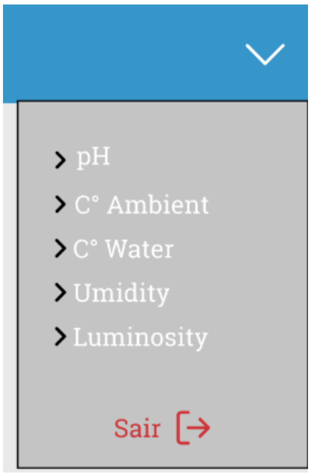


b) Button : This component uses the reduction of opacity from the UX technique when the user presses it, making it clear which button was used.The opacity reduction can be seen in Figure 8.

Figure 8: FishBoard app button

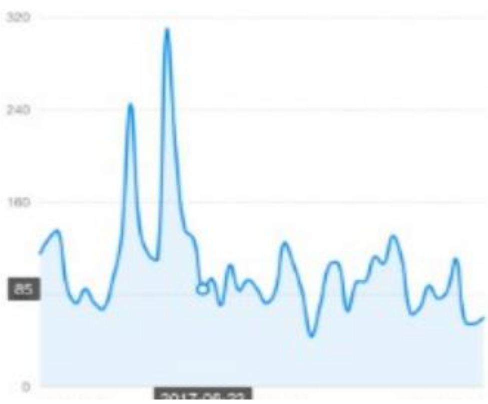
c) Side Menu: The side menu is a component developed with the responsibility of facilitating access to information for the user, providing the options of the graphics in the upper corner of the screen. The respective component can be seen in Figure 9.

Figure 9: FishBoard app side menu



d) Chart: The visual component for displaying the data was obtained from a specific library for mobile applications developed with React-Native called Victory-native. A line graph provided by the library can be seen in Figure 10.

Figure 10: Fishboard app graphic



4.2.2 System integration

The integration of the physical device with the mobile software was done through an intermediary, which is the cloud service where the collected data was sent. The device makes requests in this cloud to save the data and the application makes requests to collect this data, thus populating the app with valid information.

5 EXPERIMENT APPLICATION

Field tests of the electronic device were carried out in a tilapia fish breeding tank in a Tilapia breeding fishery in the city of Valinhos, São Paulo, Brazil. To this end, several test scenarios were developed to validate the objectives presented in this work. To facilitate the visualization of the test scenarios, Table 2 was set up:

Table 2: Test case records

Id_	***Description***	***Expected objectives***	***Results found***
1	Validate pH sensor reading	It is expected to correctly measure the pH of the water	The pH sensor worked correctly
2	Validate reading of the water temperature sensor	Correct measurement of water temperature is expected	The water temperature sensor worked correctly
3	Validate reading of the ambient temperature sensor	Correct measurement of ambient temperature is expected	The Temperature Sensor worked correctly
4	Validate humidity sensor reading	It is expected to detect the relative humidity of the	The Humidity Sensor worked correctly
5	Validate reading of the brightness sensor	It is expected to validate the amount of lumens arriving at the device	The Brightness Sensor worked correctly
6	Validate the boat's locomotion	The boat is expected to move and avoid possible obstacles	The device managed to dodge obstacles

7	Validate your internet connection	The device is expected to be able to connect to the wi-fi network	The device was able to connect to the internet
8	Validate sending data to the cloud	Collected data is expected to be saved to the cloud	Data has been successfully sent to the cloud

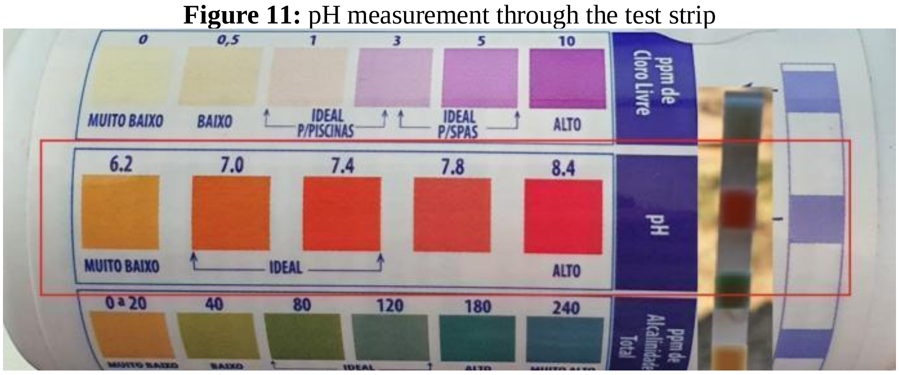
6 FIELD TESTS RESULTS

The tests results were, mostly, successful. All the sensors (pH, luminosity, humidity, and water and air temperature) responsible for reading environmental information work correctly and communicate with the internet, providing data in the cloud for later consultation.

The pH and luminosity measurements are data provided by analog sensors, so for the conversion of the collected data to a conventional unit, a comparison with parameters provided by the Adafruit library, responsible for the communication between the controller code and the sensors, is necessary. The luminosity sensor LDR (Light Dependent Resistor) measures correspond to a variation in its internal resistance, where the greater the resistance, the smaller the amount of light reaching its surface, so it is possible to visualize variations in the intensity of the light reaching the device.

The measurement of the pH sensor brings a number between 1200 and 2600 where the higher the number, the lower the pH. By parameter, the measure of 1780 approaches pH 7, a neutral measure, so it is observed that the water in the place where the tests were carried out was at a neutral pH considering an average of the measurements between 1600 and 1930 of the sensor, which is confirmed by the pH measurement through the test strip which can be seen in Figure 11.

Figure 11: pH measurement through the test strip



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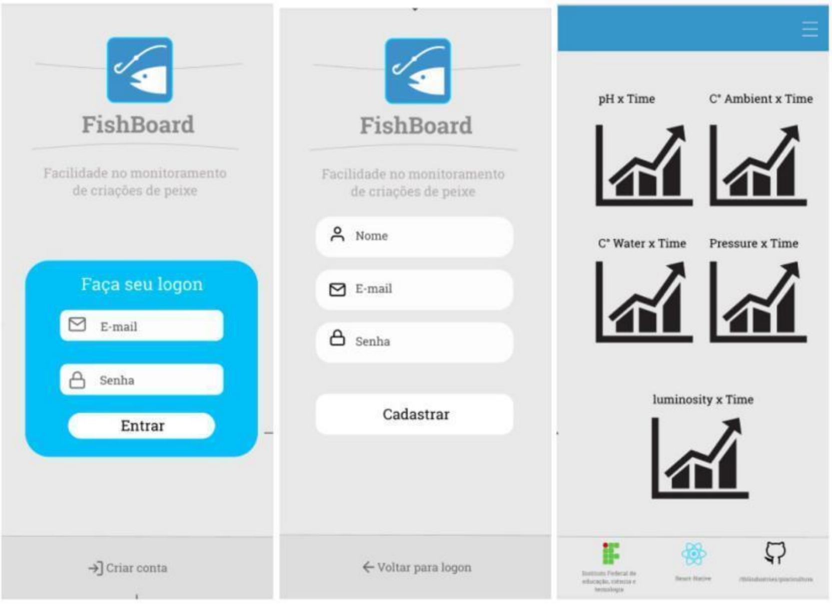
The sensor responsible for assisting the movement of the electronic device (ultrasonic sensor) has also been successful in its role, along with the sensors motors that control the rudder and the direction that points the ultrasonic sensor.

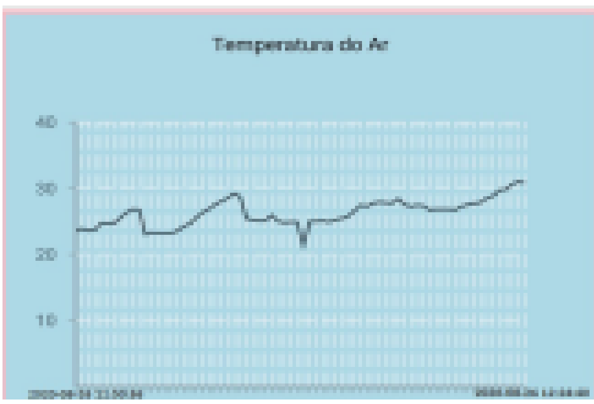
The app for the mobile device has also worked as expected. Its interface is presented in Figure 12.

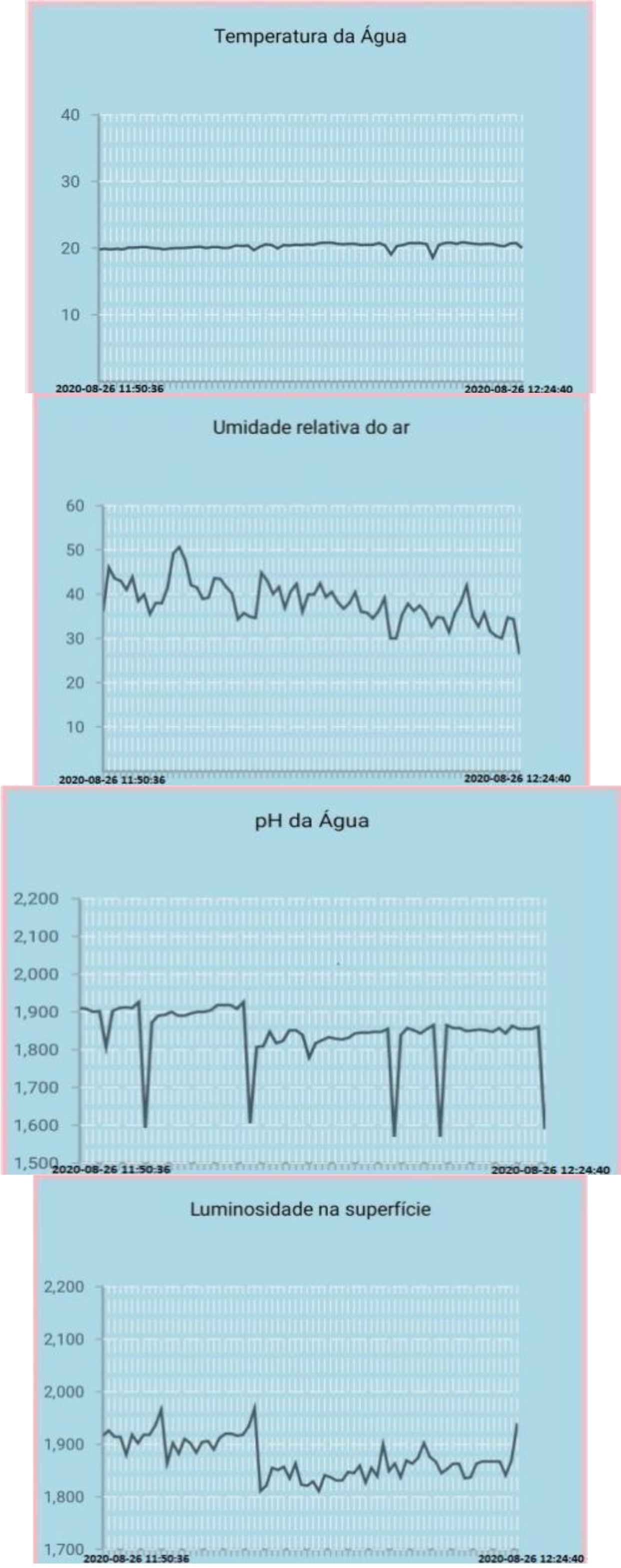
Figure 12: Android application interfaces



In addition, it was possible to consult the data saved in the cloud through the app, showing them in line charts as shown in Figure 13.

Figure 13: Graphics generated by the app





The graphs in Figure 13 are described below in the order of its appearance:

a) **Air temperature chart:** represents the graphic that measures temperature in Celsius °C (Y axis) of the air in the environment over time (X axis). In the Y axis we have the value in ° C and in the X axis we have the time when this value was measured.

b) **Water temperature chart:** represents the measurement of the water temperature in Celsius °C (Y axis) over time (X axis). In the Y axis we have the value in ° C and in the X axis we have the time when this value was measured.

c) **Relative air humidity chart:** represents the measurement of the relative humidity of the environment in% (Y axis) over time (X axis). On the Y axis we have the relative humidity value in% and on the X axis we have the time when this value was measured.

d) **Water pH chart:** represents the measurement of the water pH graph (Y axis) over time (X axis). On the Y axis we have the pH value measured by the analog sensor and on the X axis we have the time at which this value was measured. Some of the variations of the graph occur because the water bodies do not always have the same pH, so this value may vary depending on the location where the measurement is made and a palpable result can be obtained by averaging the measured values.

e) **Luminosity on the surface chart:** represents the graph of measurement of the luminous intensity on the surface (Y axis) over time (X axis).On the Y axis we have the luminosity value measured by the analog sensor and on the X axis we have the time when this value was measured. Some of the variations that can be observed in the graph occurred because certain places, in the test environment, had a lower incidence of light due to shadows caused by obstacles at the place.

7 FINAL CONSIDERATIONS

Throughout the development of this project, there were many expectations that failed as well as many that worked. The strategy adopted to ensure that the proposal of the work was fulfilled was to separate the problems and solve them at the last instance, thus being able to advance all the other parts.

One of the biggest difficulties of the project was regarding the amount of analog inputs available on the ESP-2866, the microcontroller chosen for this project. The fact that the microcontroller has only one analog input and the project needed three was a problem, thus, a method of expanding the inputs was needed. It was searched and tested two ways of expanding them, the first one failed, it was a multiplexer module Cd74hc4067, which used the same analog port but with a chip that changed the port connection based on the bits that were sent to the module. This module didn't work because there were too many noises between the electric connections, causing an invalid measurement. The second way, a successful one, was the use of an ADS1115 analog to digital signal converter module, which performed the analog readings, converted them to digital readings and sent these measurements to digital microcontroller ports.

Another great difficulty of the project was to find a free and updated graphic library that would work with React-Native since most of them were out of date and needed some kind of intermediation between the code and the application. The library that solved this problem was Victory Native, which works with data visualization for mobile applications and served the purpose of the project perfectly.

Despite negative expectations for the physical structure of the device, field tests revealed the opposite, it was expected that some type of leakage would occur between the bottom of the Styrofoam box and its interior, however it did not occur, a weight imbalance was also expected, causing the need to use stones or metal plates to level the structure, which also did not occur.

The sensor responsible for assisting in locomotion of the electronic device (ultrasonic sensor) has also successfully performed its role in conjunction with the servo motors that control the rudder and the direction that the ultrasonic sensor points. Improvements in the logic of operation of this set (servomotors and ultrasonic sensor) are necessary and possible in order to make the device able to cover a larger measurement area and to be able to deflect nearby obstacles more effectively. Therefore, what was developed for the project, in terms of locomotion, was considered a success, but there are possibilities to improve what has been done. Future updates for this project are palpable. With more field tests, it is possible to work on the code so that the movements are more efficient, and with the addition of more sensors to the locomotion set, it is possible to further investigate the precision and efficiency of the route covered by the electronic device.

The device's data collection set successfully performed its role, all values were properly measured and sent to a cloud structure. Another possible improvement is the addition of new sensors in the data collection part, which would make it possible to establish relationships between more variables and expand the area of research on this topic.

The next stages of development of this project add to the the work the analysis of the collected data, considering that after the collection of a large mass, it will be possible to apply algorithms of artificial intelligence and treatment of the information, making it possible to establish relations between the variables and connecting these variables with the quality of the final product.

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REFERENCES

[1] SAMBUICHI, R. H. R; CONSTANTINO DE OLIVEIRA, M. A. ; MOREIRA DA SILVA, de A. P.; LUEDEMANN, G. A sustentabilidade ambiental da agropecuária brasileira: Impactos, políticas públicas e desafios, Instituto de Pesquisa Econômica Aplicada (IPEA), n. 1782, p.7-36, Brasília, 2012.

[2] MEADOWS, D. et al. The limits of growth. Universe Books. Nova York, 1972.

[3] MASSHRUHÁ, S. M. F. S.; Leite, M. A. de A. AGRO 4.0 – RUMO À AGRICULTURA DIGITAL. 2.ed. São Paulo: Centro Paula Souza, 2017.

[4] DAVET, Patrícia et al. Ciência de Contexto na IoT: Uma Contribuição à Pesquisa Agropecuária. In: SEMINÁRIO INTEGRADO DE SOFTWARE E HARDWARE (SEMISH), 43.

[5] Coleção SENAR. Piscicultura: fundamentos da produção de peixes. SENAR – Brasília, 2017.

[6] Li, Z., Yang, C., Ding, N., Bogdan, S. and Ge, T., 2012. Robust adaptive motion control for underwater remotely operated vehicles with velocity constraints. International Journal of Control, Automation and Systems, V. 10, pp. 421–429.

[7] M. H. Rohit, S. Barua, I. Akter, S. M. M. Karim, S. Akter and M. M. Lutfe Elahi, "IOT Based Submersible ROV for Pisciculture," 2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), New Delhi, India, 2019, pp. 1-6, doi: 10.1109/RO-MAN46459.2019.8956441.

[8] EMBRAPA. Manual de qualidade da água para aquicultura. 2019. Disponível em: https://www.embrapa.br/documents/1354377/1743436/Manual+Qualidade+%C3%81gua+Aquicultura.pdf/674c0a9a-2844-43e2-9462-04fddd387529?version=1.0. Acessoem: 7 mar. 2020.

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