SWAMP

SMART WATER MANAGEMENT PLATFORM

Project nº: 777112

WP2

D2.6 IoT Device for Water Management Specification

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Status – Version:	1.3
Date:	30 April 2019
Distribution – Confidentiality:	Public
Code:	777112-SWAMP – D2.6 IoT Device for Water Management Specification

RNP

European Commission

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8	Federal University of Pernambuco	UFPE	BR
9	LeverTech Tecnologia Sustentável	LEV	BR
10	Brazilian Agricultural Research Corporation	EMBR	BR

Document revision history

Date	Issue	Author/Editor/Contributor	Summary of main changes
10 Out 2018	1.0	Eric Grassl, Plinio T. Aquino Jr., Rodrigo Filev Maia	Initial specifications
29 Out 2018	1.1	Eric Grassl, Plinio T. Aquino Jr., Rodrigo Filev Maia, Kolehmainen Kari	Updated according to reviewers
22 April 2019	1.2	Eric Grassl, Plinio T. Aquino Jr.,	Updated according to reviewers
25 April 2019	1.3	Gilberto Souza, Rafael Gomes Alves, Rodrigo Filev Maia	Updated according to reviewers

Internal review history

Date	Reviewer	Summary of comments
22 October 2018	Kolehmainen Kari (VTT)	Accepted with minor changes
22 October 2018	João Henrique Kleinschmidt (UFABC)	Accepted with minor changes
29 April 2019	João Henrique Kleinschmidt (UFABC)	Minor comments and corrections in numbering of Figures/Tables
30 April 2019	Kari Kolehmainen (VTT)	Minor comments to the text and references to SWAMP context

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Executive Summary

SWAMP (Smart Water Management Platform) is a Europe-Brazil cooperation project aiming at developing IoT (Internet of Things) based methods and approaches for smart water management in precision irrigation domain and to pilot the approaches in four places, two pilots in Europe (Italy and Spain) and two pilots in Brazil. SWAMP aims at improving precision irrigation by increasing the awareness of the condition of the crop, by monitoring the field based on crop status (size, growing phase) and environment (e.g., weather forecast) and at adjusting the irrigation prescription map accordingly. The smart water management pilots aim at guaranteeing that technological components are flexible enough to adapt to different contexts and to be replicable in different locations and settings. The same underlying SWAMP platform can be customized to different pilots considering different countries, climate, soil, and crops.

This document proposes an initial specification of an aquatic device that it could be designed to be one of the device sensor to be applied in SWAMP project. Although SWAMP project will not develop this device (IoT Robot) according to project specification, the importance to specify such device resides in the recogtinition that water quality is a fundamental aspect of crop healthy, and there is a clear interface between water quality and irrigation. For example, in Guaspari pilot the presence of natural chemical elements such as calcium and iron may cause drip system clogginig.

The task 2.2 proposes the architecture and requirements of IoT Robot and this document presents the following content: the basic modules that composes the IoT Robot, sensors that may be relevant to both detect quality of water and device sensor orientation, and initial mechanical and electrical specification. The autonomy specification is based on ROBOFEI activities (a research project that design autonomous robots) and the IoT Robot will use the same set of algoritms briefly described in this document. The objective is the device be able to avoid obstacles, recognize watershed limits (margins) and be able to back to margin autonomously according to battery charge. Details about how such algorithms will be used in the IoT Robot is out of the scope of this document.

1 Introduction

This document contextualizes and specifies sensors that can be embedded in a robotic mechanism for water parameter measurements.

Recently, freshwater usage and pollution have come to a critical level, resulting in a probable lack of freshwater for food production, environment and urban use in the next decades. Furthermore, agriculture is responsible for 85% of freshwater consumption worldwide and, according to the US Census, the global population will grow to 9.2 billion in 2050. Thus, to preserve the current per capita supply, food production will have to increase approximately 50% and, as a result, it is expected an increase in freshwater demand in the next decades [1].

Optimizing water usage is important for future food supply security as well as financial profitability of farming. Where irrigation is needed, it is an expense that can be optimized to provide maximum yield for least amount of expense. Monitoring soil and crop parameters produce data that can be used for systematic optimization of water usage. The IoTRobot can contribute with high granularity data which can be also used along with other SWAMP devices' data for creating a digital twin of the soil and plant, enabling usage of advanced simulation and modeling of crops in deliverables 3.2

The user of poor-quality water can influence negatively food production resulting in great losses. There are many critical water quality parameters such as temperature, pH and salinity. For instance, crop growth can reduce when salinity is excessively high, and the water infiltration process can decrease when salinity is low. Furthermore, poor quality water can result in drought even though the soil appears wet. Hence, techniques for monitoring water quality have been extensively considered in literature [2].

Traditional methods of water monitoring demand laboratory analysis and water sampling, resulting in a probable late detection of water contamination and high costs. On the other hand, the measurement of water quality through physicochemical parameters can be executed in a fast, online, and low-cost way [3]. Thus, water quality monitoring techniques that measure water physicochemical parameters through low cost and off-the-shelf sensors are widely explored in the literature. Figure 1 shows an example of a water quality monitoring system proposed by [4].

FIGURE 1– A WATER QUALITY MEASUREMENT SYSTEM PROPOSED BY [4]

Therefore, this project aims to expand approaches such as [3], [4] and [5] in order to assist food producers to avoid losses due to poor-quality water and help them to achieve sustainable water usage. To reach this goal, a real-time and spatiotemporal water-quality monitoring system, denominated IoTRobot, will be created. It will be capable of measure physicochemical water-quality parameters and provide their location and time besides of providing services based on this data. Furthermore, the IoTRobot uses the concept of IoT (Internet of Things) since it combines people, processes, devices, and technology with sensors and actuators in a ubiquitous way [6]. Lastly, the IoTRobot must be able of moving in the water and avoid obstacles in an autonomous way since it is going to be used in water bodies such as rivers, lakes and ponds. To reach the autonomous locomotion, an embedded navigation system will be created and added to the IoTRobot. One requirement that engines used to control navigation just have power to correct navigation directions and make the device navigate in favor of the water current in a lake or in the channel. This requirement is important to identify the behavior of the water flow and to IoT Robot be autonomous to follow the presence of substances presented in the water that sensors are capable to detect [9].

2 Architecture

The IoTRobot's objective is to assist farmers to avoid unexpected losses due to poor water quality by providing a fast way to detect and react to contaminations or undesired water quality. In other words, its objective is to provide a real-time and spatiotemporal physiochemical water-quality system. To reach this objective, it is necessary the use of an embedded system that combines sensors, services, and communication with other devices. Thus, the next sections will describe the project's architecture.

The IoTRobot's architecture is divided in 3 layers and 5 modules. This division was made aiming an architecture where each module will have one responsibility and each layer will have one purpose. The next sections will focus on detailing this architecture.

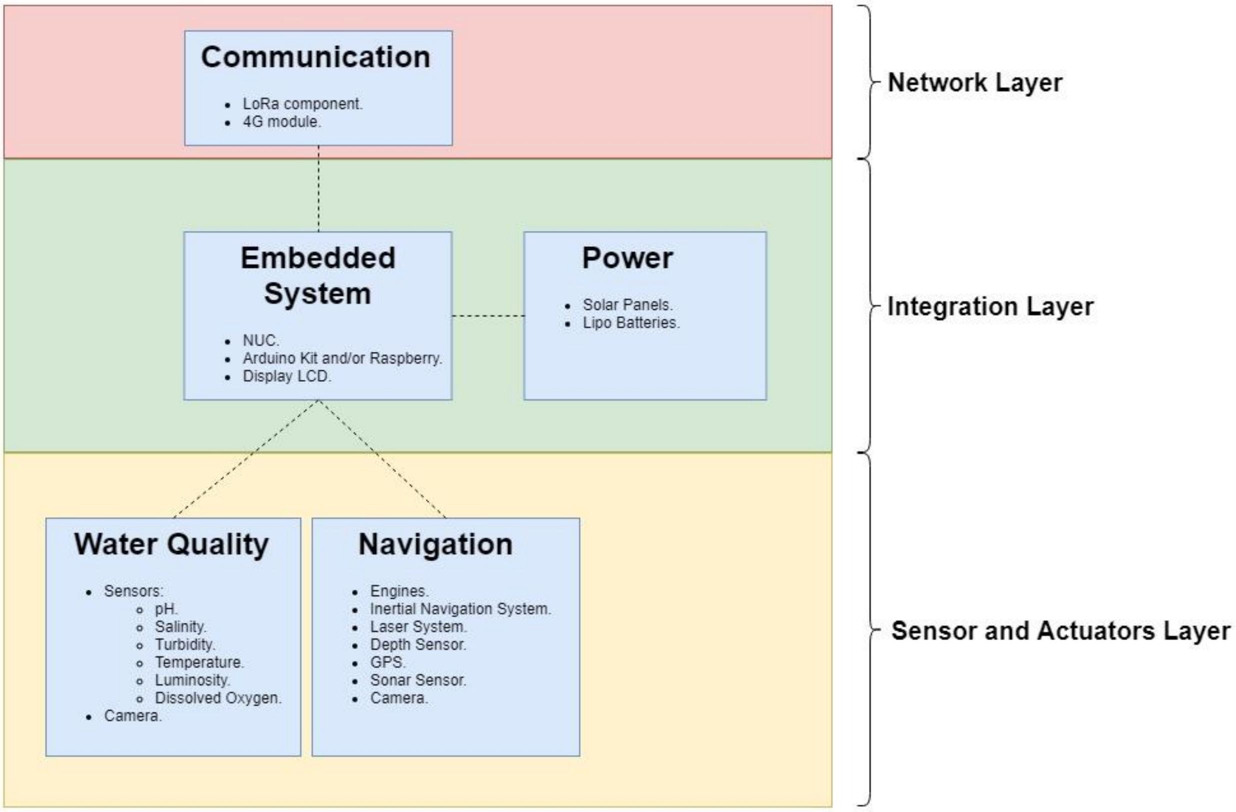

FIGURE 2– IOT ROBOT´S MODULES

The Architecture of the IoTRobot data collection system is similar to other SWAMP data collection systems deployed on the fields. Connection between Sensor and Actuator layer and Integration layer will be done by wired structure. Integration of contextual information is done on cloud service through network layer.

2.1 Network Layer

The network layer is responsible for sending data through the network by sending and answering requests and it is composed by the communication module which is described in the next section. Network layer is connecting cloud system to the IoT embedded system.

2.2 Communication Module

The communication module aims to provide means to the system to access the network in order to receive and send requests. It is composed by a wireless network component using LoRaWAN protocol, WiFi and/or a 4G module which are described in Table 1:

Component	Description
LoRa	Long Range (LoRaWAN) is a wireless data communication protocol used for IoT devices.
4G module	Module that enables 4G communication technology to the system.
Wifi module	Wifi access module that can be used in cases where wifi communication is possible

TABLE 1 – IOTROBOT COMMUNICATION MODULES

These components will be tested in order to measure packet size, range and energy consumption. Thus, the best suitable component will be chosen and used in this module. Choice of right module depends on available infrastructure and communication bandwidth requirements.

2.3 Integration Layer

The Integration layer is responsible for collecting sensor data and respond to requests that come from the Network Layer. This layer is also responsible for managing the system's power consumption and navigation. It is composed by two modules that will be described in the sections below.

2.3.1 Embedded System Module

The Embedded System module is responsible for integrating the Water Quality and Navigation modules and manages the system's power consumption. Furthermore, the spatiotemporal information collected by the Navigation module will complement the water quality parameters information and it will be sent to the network. Also, the data collected by the Navigation system will be used to control the engines autonomously and to create maps of the underwater surface and borders of the water body. This module is composed by the following components in Table 2. The use of NUC and/or Raspberry must be evaluated since new versions of Raspberry Pi has processing power that would be enough to deal with all activities of IoT Robot. However, a study of available API from all system, as well as how to deal with multitasking must be investigated. For specification purposes this document takes into consideration only NUC for IoT Robot specification.

Component	Description
NUC[1]	Embedded computer responsible for integrating sensor data with the network environment.
Arduino Kit and/or Raspberry	They are used for sensor integration and to assist the NUC. They will be used as a comparison study of the embedded architecture on the water surface.
Display LCD 7 Touch Screen and smartphone	It serves as a feedback screen to display the system's information when it is on the field.

TABLE 2 – IOTROBOT PROCESSING UNIT

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[1] Next Unit of Computing (NUC) is a 4 x 4 inches (10.16 x 10.16 cm) personal computer designed by Intel.

Embedded system module from SWAMP plataform is responsible of collecting data from the sensors and relaying them to cloud service using facilities offered by network layer. Data that local gateway collects is measurements from soil and plant sensors, weather instruments, power module, etc.

2.3.2 Power Module

Since Water Quality monitoring is a critical operation, the IoTRobot should work for one business day (around 8 hours) with all sensors working and engines being used only for IoT Robot direction. Thus, the Power module should be able to provide and collect enough power aiming the IoTRobot's continuous functioning. Therefore, this module is composed by (Table 3):

Component	Description
Lipo/LiFePO4 Batteries	Lightweight batteries that keep the IoTRobot functioning at night or when there is not enough light to depend on solar panels.
Solar Panels	Generates power to keep the IoTRobot functioning and/or recharge its batteries.
Solar Charge Controller	MPPT Charge controller chargers batteries when solar array is producing power and provides regulated 12V drain from the batteries

TABLE 3 – IOTROBOT ENERGY SYSTEM COMPONENT

The Embedded System module can use the data collected from the luminosity sensor to switch between the power consumption strategies, which are listed below:

- Battery only: when there is not enough light to depend upon solar panels.
- Solar Panels only: when there is enough light to depend upon solar panels and the batteries are fully charged.
- Solar Panels while recharging batteries: when it is possible to depend upon solar panels and recharge the batteries at the same time.

If Solar charge controller is integrated into the system, it can take care of switching between battery and solar power according to the need. MPPT controller offers also detailed status information of the state of the solar power system (see deliverable D2.7 for solar panel virtual entity specification).

2.4 Sensors and Actuators Layer

The Sensors and Actuators Layer is composed by components that collect data of the environment and also components that act on the environment. Sensors will be used to collect data from the environment and this data will be sent to the Integration Layer. Furthermore, in this project, the actuators are components related to the equipment's locomotion and will act based on decisions made in the Integration Layer. This layer is composed by two modules which are described in the next sections.

2.4.1 Water Quality Module

The Water Quality module's goal is to execute the real-time water quality monitoring through measuring physicochemical parameters. It uses cheap and off-the-shelf sensors to measure these parameters which are listed below and described according to [7]:

Parameter	Description
Water pH	The pH indicates if a solution is basic or acidic. The substance can cause a chemical burn in case it is too acidic or too basic.
Water Turbidity	Turbidity indicates how light is scattered and absorbed by particles and molecules. It can result in increases of water temperature because it can promote microorganism's growth and convert light into heat.
Water Salinity	It is the amount of salt in a water body. It determines what organisms will live in that environment. Salinity is inversely proportional to the dissolved oxygen.
Water Temperature	The water temperature is related to other parameters such as turbidity and dissolved oxygen and can be used along with other sensors data to analyze the water quality.
Water Dissolved Oxygen	It is the amount of oxygen that is dissolved in a given medium. It is a key factor for marine life and it is determined by water volume, flow, temperature, and types of organisms living in it.
Luminosity	Indicates the amount of light in an environment.
Air humidity	Air humidity is taken by weather instruments located with the gateway system
Air temperature	Air temperature information is gathered by soil sensors as well as weather instruments.
Air pressure	Air pressure is gathered by weather instruments.
Wind speed	Windspeed is gathered by weather instruments on the location of the gateway
Wind direction	Windspeed is gathered by weather instruments on the location of the gateway

TABLE 4 – IOT ROBOT WATER QUALITY SENSORS

Furthermore, this module will also capture camera images that will be stored in the system together with all sensor information, so they can be used as a part of data analytics solution . Lastly, the data collected will be sent to the Integration Layer that will be responsible for further processing.

2.4.2 Navigation Module

The Navigation module aims to provide autonomous locomotion and spatiotemporal measurements to the IoTRobot. Thus, this module's purpose is to complement the Water Quality data by providing spatiotemporal information about those measurements and enable smart locomotion in water bodies where avoiding obstacles such as rocks and branches may be necessary. The list below shows this module's components and their purposes:

Component	Description
Engines	A set of engines used for locomotion in water bodies.
Inertial Navigation System	It helps the IoTRobot to have stable navigation in water bodies.
Laser System	It maps the underwater surface and the borders of a water body. It is also used to detect collisions.
Depth Sensor	It is used to avoid obstacles that might prevent locomotion such as branches and rocks. It also maps the depth of water bodies.
GPS	Provides the IoTRobot's location and enables the system to collect spatial-temporal data.
Sonar Sensor	It is integrated with the laser system and it is used to map obstacles on the water surface.
Camera	As specified for the Water Quality model in Section 2.4.1.

TABLE 5 – IOT ROBOT SENSORS FOR NAVIGATION

3 IoT Robot Specification

This is a first specification of the principal components, the communication and data transfer between the IoT robot and SWAMP Platform.

3.1 IoT Robot diagram blocks

The Figure 3 illustrates the connection between navigation sensors and the NUC device. NUC is a powerful system compared to Arduino and it will be used to control the navigation and it will run all algorithms to provide autonomy and communication.

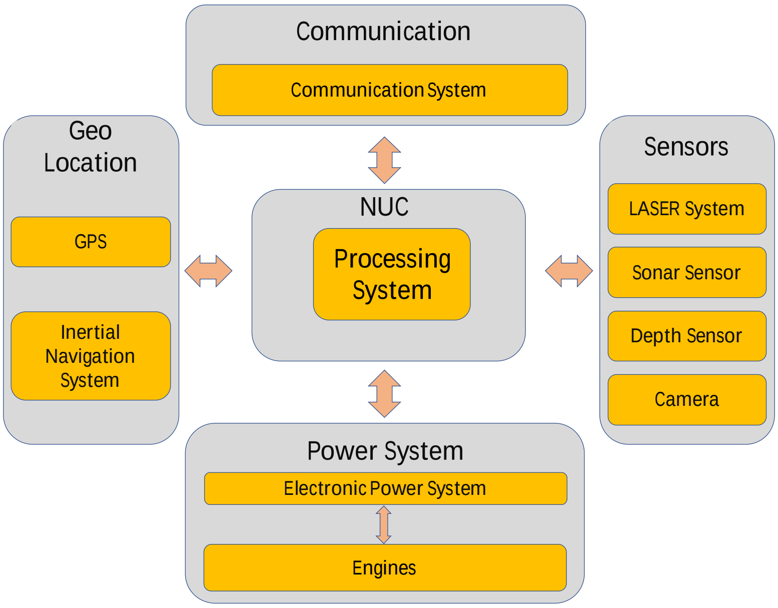

FIGURE 3 – DIAGRAM OF NAVIGATION MODULES

The interface between main modules (Geo Location, Communication, Sensors and Power Supply) will be via serial interfaces. The Power supply is out of the scope of this document because it is the module to control and provide energy to the engines.

The Figure 4 illustrates the water quality sensors connected to Arduino. The connections between sensors and Arduino are done by GPIO interfaces of analogic interface (one interface). Arduino collects data and does not suffer interference of NUC processing. After colleting data Arduino can send data to NUC by a serial interface.

3.2 First mechanical specification for IoT Robot

The IoT Robot robot is classified as autonomous surface vehicle (ASV). For the initial mechanical specification the IoT Robot will be named as ASV. Desa et al [14] presents the design for a small autonomous surface vehicle for color remote sensing that can be used as a first model for the IoT robot. The authors specifies their ASV by using the main properties such as the towing resistance (axial drag that the vehicle has in while in water), propulsion (supplied from the waterjet propellers) and endurance (duration for the battery to supply the electrical needs of both motors and sensors).

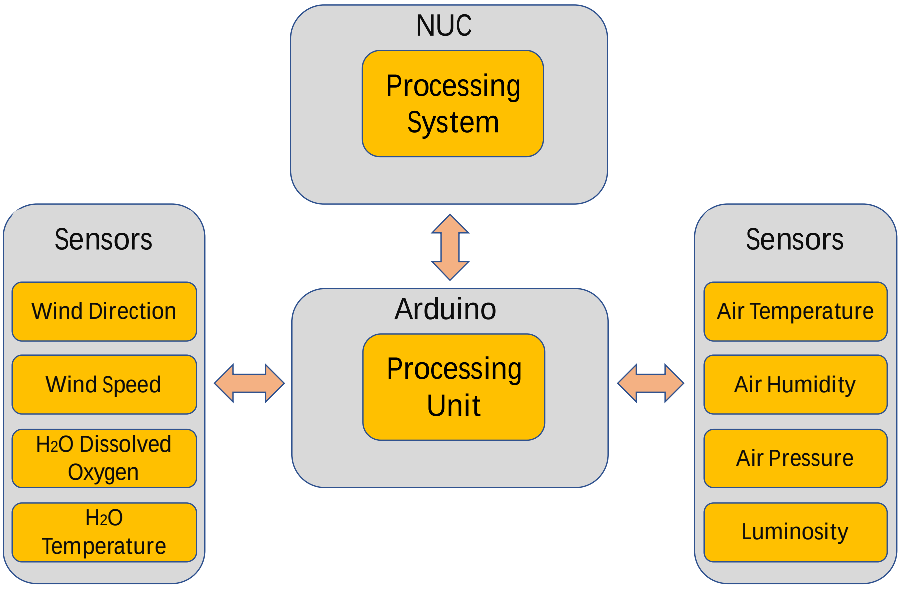

FIGURE 4– DIAGRAM OF WATER QUALITY SENSORS

By using the ASV model presented by Desa and the model ESM30 made from a manufacturer called Oceanα [15] as a baseline it is possible to asses two design categories: one for a cylinder hull and other for a catamaran style. It is important to notice that both models have different design characteristics and sensors associated with them so for a first design specification it is necessary to understand the differences between the designs in order to better understand the design characteristics for each model.

First, the Desa model is an ASV composed by a cylindrical hull attached to a metallic structured where the propellers are as can be seen in Figure 5. This hull contains the battery bank, the electronics, embedded controllers and the inertial measurement unit.

FIGURE 5 - DESA ASV MODEL

The Oceanα ESM30 model is a catamaran style ASV where the electronics elements are housed in the top portion and the propeller is located in the back of the ASV as can be seen in Figure 6. This ASV is capable of not only measuring water properties such as temperature, pH, conductivity, turbidity and other but it can also collects 4x1,8 litters samples from depths ranging from 0.3 to 0.5 meters which allows for a better quality assessment water quality in laboratory if needed.

FIGURE 6- OCEAN ASV MODEL

By using this, two models as an inspiration to the initial IoT robot design it is proposed the following properties for the IoT robot as presented in Table 6:

Features	Desa	ESM30	IoT robot first specification
Length	1400 mm	1150 mm	1265 mm
Height	360 mm	430 mm	475 mm
Width	360 mm	750 mm	825 mm
Total Weight	95.5 kg	31 Kg	40 Kg
Speed	1,4 m/s	1.5 m/s	1,4 m/s
Battery Endurance	7h @ 1.5A	3 hours	8 hours

TABLE 6 – ASV 'S AND IOT ROBOT PROPERTIES FOR EACH DESIGN MODEL

The IoT robot is most going to be based in the ESM30 design since this model has mostly the same sensor characteristics as the IoT robot. The dimensions for the IoT robot are based on the ESM30 model but increased a little bit in order to accommodate more devices as well as a bigger battery that should be able to last for 8 hours of operation.

The velocity for the IoT robot was defined as a 1,4 m/s since its usage is mostly going to be in lakes and rivers closed to the farm water input and as such does not need to have high velocity in order to transverse large water bodies quickly. The weight was estimated based on the ESM30 model but increased by a margin since a bigger battery and more devices are going to be used in the IoT robot.

These specific components for the IoT robot should be better defined in and electrical mechanical project that should contain the specifications, calculations and drawings for each component as well as a proper electrical and mechanical drawings for the whole robot.

3.3 Limits of the IoT Robot autonomy

The autonomy of a device may include a series of requirements and algorithms to fit such requirements. The IoT Robot has the initial set of requirements to determine its level of autonomy:

- IoT Robot should monitor the entire body of water to detect variations of quality.
- The IoT Robot must deviate from obstacles present in the body of water, both those on the surface and those that are submerged and that may cause damage to the helmet
- The IoT Robot should determine the boundaries of the watershed and correlate with GPS references in order to determine the dimensions of the area of interest to be analyzed.
- The IoT Robot must calculate the battery autonomy and back to the margin when battery becomes critical.
- The IoT Robot must read all data from sensors, store them locally and transmit them to the platform

There are several algorithms to promote such level of autonomy. The Deep Neural Networks (DNN) [10] is one possible algorithm to detect and learn watershed or channel margins. In [11] several kinds of algorithms are proposed to control autonomous aquatic vehicles, including DNN and Reinforcement Learning (RL), among others. However, due to the indeterminism related to the shape of watershed and variability of pilots the future implementation of IoT Robot will evaluate the use of fuzzy systems to relate expert knowledge with sensor measurements in order to promote the IoT Robot autonomy.

3.4 Possible data interface between IoT Robot and SWAMP platform

The interface between IoT Robot and SWAMP platform would be similar to drone interface with the platform as depicted in deliverable 2.7 [12]. The IoT Robot may be represented as a Virtual Entity in the SWAMP platform, which constrains the information about device status. This is going to be used to present to the farmer information about the IoT Robot that might be in its interest however this entity is not going to be used for the data that the device gets from the water as well as for the data from control system. An example about how such virtual entity could be deployed in the platform is depicted in Table 7.

Attribute Name	Attribute Type	Description	Constraint
Name	Normative References: https://schema.org/name	Name given to the IoT Robot	Optional
location	geo:json	Position of the IoT Robot in WGS-84 coordiante systemm	Mandatory
status	String	Status of the IoT Robot: off, on, armed, active, disarmed	Mandatory
horVelocity	Number	Horizontal velocity of the IoT Robot in meters per second	Mandatory
homeLocation	geo:json	Coordinates of home location of the IoT Robot.	Mandatory
batteryCapacity	Number	Indicates IoT Robot 's battery level in percentage	Mandatory
firmware	string/number	Indicates the firmaware version	Mandatory
manufacturer	String	Indicates IoT Robot's manufacturer	Mandatory
mission	String	Indicates if the IoT Robot is in a mission and the number for that mission	Mandatory

TABLE 7 – IOT ROBOT VIRTUAL ENTITY

A initial specification of IoT Robot virtual entity as depicted in Table 7. To organize data collected by IoT Robot it would be defined a virtual entity based on the IoT Robot virtual entity approach depicted in D2.7 and a specification about how to be deployed is depicted in deliverable 2.1 [13]. An example about how such virtual entity could be deployed in the platform is depicted in Table 8.

Attribute Name	Attribute Type	Description	Constraint
location	geo:json	Location of the IoT Robot (farm location) Representation by a GeoJSON geometry. (https://tools.ietf.org/html/rfc7946)	Mandatory
dateRetrieved	DateTime	The date and time the data was retrieved by the IoT Robot system	Mandatory
Firmware	Text	Version of software release	Optional
Manufacturer	Text	What company develops such probe	Optional
numberOfSensors	Number	Indicates the number of sensors in this IoT Robot	Mandatory
H2OTemp	Number	Temperature of the water measured in Celsius degrees	Mandatory
H2ODissO2	Number	Amount of measured oxygen in the water in mg/L	Mandatory
Luminosity	Number	Luminosity of the evironment	Mandatory
AirTemp	Number	Air temperature measured (Celsius degreees)	Optional
AirHum	Number	Air humidity measured	Optional
AirPres	Number	Air pressure measured in mmHg	Optional
WindSpeed	Number	Wind speed measuredin km/h	Optional
WindDirec	Number	Direction of wind (in degree)	Optional
H2OBodyDepth	Number	Dept of the body of water in a specific GPS coordinates in meters	Optional

TABLE 8 – IOT ROBOT DATA VIRTUAL ENTITY

4 Use Case

The IoTRobot can be used in many scenarios where water quality management is needed and where the is a high risk of contamination. Some of its functionalities are:

- Detection of water contamination in real-time.
- Mapping of underwater surfaces.
- Measure the depth of water bodies in real-time.
- Navigate through the water body.
- Provide localization in real-time.

The next section focusses on describing a use case for the IoTRobot where these functionalities will help food produces to achieve better water quality and usage. This scenarios are applicable only in the case of IoT Robot would be developed in SWAMP project. The considerations of this section may be applied for future exploitations and expansion of the project scope.

4.1 Pilot: Smart Water Distribution (Reggio Emilia, Italy – CBEC)

The Consorzio di Bonifica Emilia Centrale (CBEC) is a reclamation consortium of the Emilia-Romagna Region in Northern Italy, responsible for the irrigation and water drainage of an area of nearly 3,130 km2 where most water required for irrigation is withdrawn from the Po river (Figure 7). The water is distributed to the farms by an intricate irrigation infrastructure composed of more than 3,580 km of canals, more than 200 small streams, six draining plants, and 72 pump stations with an overall capacity of 416 cubic meters per second.

FIGURE 7 - WATER DISTRIBUTION MANAGEMENT PILOT: OPEN EARTH CANAL (LEFT), MANUAL OPERATION (CENTER) AND WATER INTAKE (RIGHT)

The supply and irrigation network consists of open channels on the ground. Relevant widths characterize the main canals and therefore their filling for the irrigation season involves the use of substantial water volumes that are not always recoverable for irrigation purposes. Water losses are due to infiltration through canal banks and bottom, as well as to the management of the irrigation network that requires the filling of long canal stretches and several minor streams to accommodate farmer needs. Furthermore, the irrigation network also acts as drainage network for the cultivated areas.

The IoTRobot could be a useful device to assist in the CBEC water management by providing means to map the underground surface, achieve a better understanding of a water body’s behavior, and measure important information such as water quality parameters, depth and flow. First, water contamination could be detected in a certain area of the canal and measures could be taken quickly to avoid eventual spread of it. Second, the depth of the canal could be measured in many regions and a drought can be foreseen. Third, the GPS information provided can be used to analyze the water flow and behavior in the canals. Lastly, the data collected can be stored in the SWAMP platform and other SWAMP applications can use it in order to achieve better water management.

4.2 Pilot: Variable Rate Irrigation (MATOPIBA, Brazil)

The MATOPIBA region (Figure 8) encompasses the Brazilian states of Maranhão (MA), Tocantins (TO), Piauí (PI) and Bahia (BA), and is one of the most critical irrigated agricultural frontiers in the country, located in the *cerrado*, a savannah climate subtype. Irrigation is mostly performed by thousands of center pivots, each one with an average size of 100 hectares.

FIGURE 8 - CENTER-PIVOT IRRIGATION PILOT: LOCATION OF THE PILOT SITE (LEFT) AND CENTER PIVOT IRRIGATION FOR SOYBEAN CROP (RIGHT)

The soybean production in the region reached about 5.5 million tons in 2016 in a total cultivated area of about 1.52 million hectares. Despite those significant numbers, the production losses are estimated in 40% of the crop due to drought occurred during the 2015/16 season. The production from many properties was only 30 sacks per hectare, while an average of 58 sacks was expected. With irrigation and investments in soil fertility, some producers expect that this number can reach 80 sacks. Although irrigation is an alternative, its expansion depends on technologies that improve operating costs and promote sustainability. For example, a red flag was lifted in 2015/16 and imposed double charges to the energy used in irrigation. The increase represents a cost of seven sacks per hectare against three and a half sacks with a typical energy charging.

The IoTRobot could be used to assist MATOBIPA water management by providing a better understanding about the water body used for irrigation and measuring important water quality parameters. First, the information collected could be used in order to prevent farmers against a possible drought such as the drought occurred during the 2016/16 season. Second, water quality parameters can be used to avoid the use of poor-quality water which can have a negative impact in food production and water usage. Lastly, the data collected can be stored in the SWAMP platform and other SWAMP applications can use it in order to achieve better water management.

4.3 Pilot: Guaspari

Guaspari farm is a fifty hectares property located in Espírito Santo do Pinhal municipality, Northeast of São Paulo state. The region has a temperate climate and during the winter the thermal amplitude, insolation and low precipitation indices are similar to the European winery regions. The growing area altitude ranges from 600m to 1300m and the soils are developed from granite rock, with good drainage, which is especially suitable for grapes destined to produce high-quality wines. There is a total of 4 plots, 2 at a lower altitude (around 600 meters) and 2 at higher altitude (around 1200 meters). Each plot will be considered a management zone in the SWAMP platform.

The irrigation system in Guaspari consists of a private water reservoir and an automated network of pumping and valves, and drip irrigation tubing with 50cm spaced emitters. It includes water meters capable of reporting to SWAMP cloud with a simple interface to be adapted. The irrigation system is permanent.

Irrigation will be controlled by the current automated system using conventional methods during the first two growing seasons after the pilot installation. During this time all data and information obtained with SWAMP platform may generate irrigation recommendations just to compare to the usual methods. Along the third growing season SWAMP platform will provide water need estimation by a soil moisture sensing and forecasting approach. This result is expected to be downloaded to the existing controller to irrigate the pilot plots accordingly.

The IoTRobot could be used to assist Guaspari water management as the same way as MATOPIBA, i.e.by providing a better understanding about the water body used for irrigation and measuring important water quality parameters. The information collected could be used in order to prevent farmers against a possible, and water quality parameters can be used to avoid the use of poor-quality water which can have a negative impact in food production and water usage. As the same as MATOPIBA, the data collected can be stored in the SWAMP platform and other SWAMP applications can use it in order to achieve better water management.

5 Challenges

The IoTRobot will be responsible for monitor the water quality of water bodies used in food production processes such as rivers, lakes and ponds. It will move on the surface of those water bodies aiming to make spatiotemporal measurements. Thus, it must be capable of collecting physicochemical parameter of the water, providing real-time location, autonomous navigation and efficient power consumption. Based on these requirements, the next sections explain the challenges that will be faced.

5.1.1 Sensors Maintenance

Although the off-the-shelf sensors offer a cheap and real-time approach to water-quality monitoring, they may require frequent maintenance that can result in higher costs. Therefore, a maintenance technique will be studied to prevent this scenario where the harsh conditions of the environment forces the frequent maintenance of the equipment. Thus, it is expected that the system gives a warning when there is a chance that the sensors' data is being modified. This could happen in scenarios such as:

- The sensors are covered by sludge or mud.
- Some sensors have been damaged.
- Some sensors need adjustments.

5.1.2 Environmental Conditions

The IoTRobot will be used in uncontrolled environments such as rivers, lakes, and ponds. Therefore, it must be able to resist tough conditions in those environments such as high humidity and velocity of water flow. Hence, the IoTRobot's metal components must be protected against issues such as corrosion caused by the high humidity, water infiltration and impacts resulted from a fast water flow.

5.1.3 Power Management

The IoTRobot should keep functioning as much time as possible. The power management should be able to keep it working even in dark days where there is not enough light to depend on solar panels. Thus, power strategies such as sleeping schedule will be applied to minimize the chances of the system run out of power. Some challenging scenarios where the power management strategies should work on are:

- Places where there's few daylights such as in northern countries.
- Bodies of water where there is a lot of obstacles, which will result in an increase in power consumption since the navigation system will be more active.

5.1.4 Navigation

Navigation should be autonomous, energy efficient and it should be able to track the best routes to collect the water sample. This task can be performed by an existing system where the sampling locations are indicated by a researcher or farmer in an interface such as the system in Figure 9. Also, this route could be integrated in the SWAMP platform and the platform could redefine it based in other sensors data analysis.

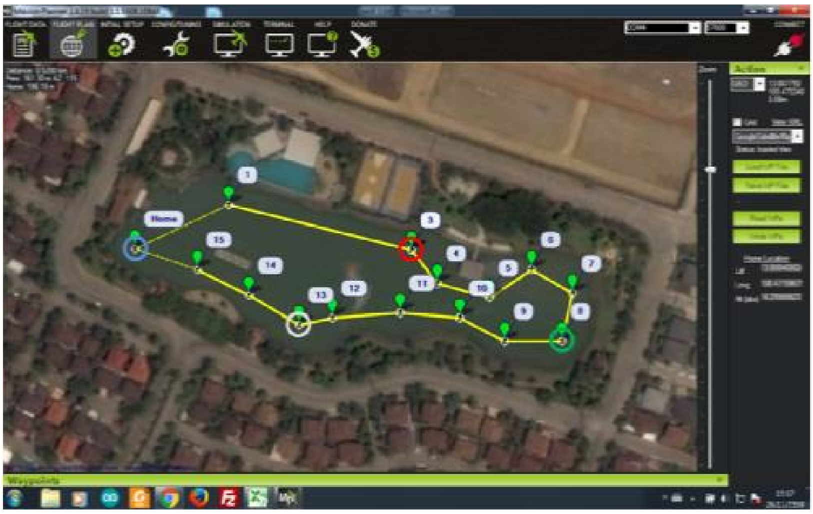

FIGURE 9 - AN EXAMPLE OF NAVIGATION SYSTEM WHERE SAMPLING LOCATIONS ARE DEFINED AND A ROUTE IS TRACED USED IN [8]

5.1.5 Obstacle Detection

Since the IoT Robot will navigate in uncontrolled environment, it should be able to avoid obstacles such as rocks and branches. The literature review done as base for this specification indicates that obstacle avoidance can be achieved with the use of laser systems or sonar sensors, although the last one is not suitable if you need high accuracy. Due to its complexity, the obstacle detection system can not be specified in detail yet and further studies are needed in order to do so.

6 Summary

This document describes the initial specification of the IoTRobot and describes its architecture in detail, a use case, and challenges that must be considered during its development.

The IoTRobot presents a real-time and spatiotemporal approach to measure water quality by using low cost and off-the-shelf sensors besides of using the IoT concept to integrate collected data with the SWAMP platform. Its goal is to help food producers to achieve better water usage and avoid unexpected losses due to poor quality water and contamination.

The specific components for the IoT robot should be better defined in and electrical mechanical project that should contain the specifications, calculations and drawings for each component as well as a proper electrical and mechanical drawings for the whole robot.

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