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INTERNET OF THINGS AND MATHEMATICS: THE WATER ECONOMY IN AGRICULTURE

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ABSTRACT

The Internet of Things (IoT) allows devices to exchange data in real time and actions to be performed through user programming. IoT applications have already been carried out in several areas, such as health, education, industry, within your own home. The purpose of this article is to present equipment that receives data from a plantation and irrigation is done according to the needs and conditions of the soil, saving water resources, generating savings for the producer.

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INTRODUCTION

We are witnessing the fourth industrial revolution, or as it is called in Europe, industry 4.0. The concept of the Internet of Things (IoT) is relatively simple, connecting all objects to the network so that you can control everything from anywhere on the planet. Gradually this idea has been taking shape in day-to-day. The simplest examples come from smart security cameras, passing lamps that can be controlled remotely and doorkeepers who choose to be serviced from anywhere in the world by a cell phone application. But, this is a story that is just beginning, our daily lives are already connected, it starts with the cell phone that doesn't leave our hands, and it's exactly that which makes us part of the IoT system. We are an IoT item, after all the cell phone allows a connection with all devices. Digital assistants make you connect to your home from anywhere in the world.

If in the 17th century we had the steam engine, now in this new milestone we have the integration of systems as characteristics, as stated by Perasso (2016). According to Schwab 2016, technology will revolutionize the way we live, including in work and relationships, for him it will be necessary to change paradigms to adapt to IoT. Some situations emerge from the IoT, such as the coffee maker preparing your coffee the moment you go into the shower, the refrigerator making the purchase of the products that are missing, the irrigation of your garden will not be turned on because the weather service has informed that there will be rain. According to Sinnapolu and Alawneh (2018), agribusiness has a good acceptance of IoT resources, and the proposal that aims to obtain data on meteorological conditions and soil moisture in crops for automated irrigation control making the activity more efficient considering that this industry has water as an essential resource for its existence.

Although there are large water reserves in Brazil, we cannot help thinking that we can face crises in this sector, whether due to the large quantity required for cultivation or the lack of administration, or the means for that of companies and family farming (Walbert, 2013). Therefore, it is necessary to develop mechanisms to manage the use of this resource in such a way that waste is minimized without prejudice to production.

Theoretical foundation: Why do we look for water on other planets? It is impossible to produce anything without water, without water there is no life. Brazil has about 12% of all fresh water in the world (Swaroop et al, 2019), but the distribution is uneven and we face scarcity. But, we are not treating water the way it deserves. 70% of the Earth is covered with water, but of this total 97% are seas and oceans, and 3% are freshwater distributed as follows: 4% air humidity, 7% in rivers and lakes, 18% groundwater and 71% polar ice caps. For Bannan et al (2017) with IoT even with the explosion of consumption in the 20th century by more than 680%, it is possible to avoid waste. Agriculture consumes 73%, 6% is domestic consumption and 21% is industry, responsible for half of exports, agribusiness participates with ¼ of our Gross Domestic Product (GDP). Iron ore exports reached a record 374 million tonnes in 2016.
Agriculture and livestock are accused of wasting water, mining would be responsible for dumping ore and damaging the springs. It is necessary to know the volume of water necessary for the production of a certain good, and for this management there is the IoT, as stated by Holdowsky et al (2015).

Brazil fits within the industrialized countries with an average consumption of 2,027m³ of water per inhabitant in a very steep year of the world average, which is 1,385m³. Now let's see some products: a cup of coffee 140 liters of water, 1 pair of shoes leather 8 thousand liters, and at the top of the list 1 kg of beef 16 thousand liters. When thinking about IoT as a project, according to Allhoff and Henschke (2018), we need the interconnection of sensor, internet, server, IoT application and mobile device as follows: The sensor is responsible for capturing data from the environment, the internet allows the sensor to send data to the server and also receive data from other servers or sensors, the server is the computer that can be located in the cloud or in the environment itself. The IoT application, on the other hand, is the program installed on the server responsible for interpreting and executing some activity with the received data, and the mobile device is the device by which the user can view information about the IoT application. The mobile device could also be a traditional computer or some other device that tells the user what is going on. For Kleina (2011), by 2020 the Internet of Things intended to have about 50 billion connected devices, that is, equipment exchanging information in real time about everything, today we have more than 80 billion connections, as shown by some examples in the work of Milovanovi and Bojkovic (2017). According to IBGE (2017), almost 1 billion and a half of the workforce in the world depends on water, and agriculture is responsible for 70% of this consumption, the misuse of scarcity and problems of access to water can harm economic growth In the next years. A reflection points out that ¾ of the jobs in the world depend directly or indirectly on this natural resource. If there is waste, there will be unemployment. The energy sector is responsible for 19% of the total water consumption, household needs and hospitals consume 10%, so the concern with managing water resources.

Agriculture is the main source of employment in developing countries and is responsible for about 70% of water consumption, paradoxically it is the main source of pollution. Thus, it is a relationship of dependence and degradation because the water used in the agricultural environment has contact with contaminants such as pesticides. Sharma et al (2019) says that by developing smarter innovation processes, products, factories and value chains, companies can increase revenues and decrease costs, sometimes both at the same time. With the technology, it is possible to interconnect sensors responsible for capturing data on temperature, soil moisture, water level, mineral salts and other data automatically, eliminating the need for labor to perform these collections (Chaudhuri, 2018).

If we consider the small farmers who are primarily responsible for filling our fairs with food, they are the ones who least have access to technology due to the high cost of acquisition and maintenance, thus preventing the acquisition of sophisticated equipment that help in the productivity of these farmers, as stated Bernardi and Inamasu (2014).
Irrigation deserves continuous improvement, and a device that manages soil moisture, temperature, rainfall forecast, and water level in the reservoirs would serve to control the release or not of water in a given plantation.

METHODOLOGY

We realized the need to develop inexpensive and simple to install equipment to allow small farmers to have automated irrigation activity to improve productivity in this process. The irrigation techniques were studied taking into account the planting of coriander, this vegetable has a quick ripening and allows to easily evaluate the benefits of having a device for this purpose like the one developed.
The project was developed from the following activities:

- Study of the most efficient irrigation methods according to the crop;
- Study of the coriander needs for the best ripening;
- Survey of the technological requirements necessary for the management of water resources;
- Development of the device responsible for obtaining data on the cultivation environment;
- Development of the software responsible for managing the device;
- Report of water consumption without and with the use of the device.

We found squirt as an efficient irrigation method for our study and the following components were used in the creation of the device:

The software was developed for the web platform with Python version 3.5 for the reason that it is a language widely used in the scope of artificial intelligence, a resource that in the future may be part of this equipment and also because it has great support for controlling the components required in the project.

RESULTS AND DISCUSSION

With the device installed in an area of 60cm x 60cm where coriander seedlings were planted, it generated a gain in harvest time and a reduction in water use compared to the same scenario where the device was not installed, that is, the irrigation occurred manually.

Table 1. Components used in the development of the device

Component	Amount	Post
Soil moisture sensor hygrometer	4	Detect ground moisture
Rain sensor module	1	Detect rain
Flowmeter sensor YF-S501 1-30L / min Flow	1	Accounting for water flow
GPS module + antenna	1	Get the exact coordinates of the device installation
DHT11 temperature and humidity sensor	1	Detect thermal temperature
Raspberry Pi 3 Model B	1	Store the software developed and process the data
Solenoid valve	1	Release the water

The table below shows the values obtained with this experience. Reduction in harvest time was possible because the device worked between 7 am and 4 pm respecting the ideal conditions for growing coriander, so with the device the automated irrigation occurred at intervals so that the soil remained moist, but not soaked, this allowed a faster maturation when compared to manual irrigation where the water was applied only once. On the 16th day we had the coriander ready for sale and consumption, and in manual irrigation the process took 23 days.

Table 2. Amount of water used in cultivation

DAY / IRRIGATION (LITERS)	AUTOMATED	MANUAL
1	4,7	2.8
2	4,8	3,1
3	4,8	3,6
4	5,2	3,2
5	4,9	2,6
6	5,1	3
7	4,5	2,9
8	5,2	3,5
9	5,4	3,9
10	5,3	4,2
11	4,5	4,1
12	4,8	4,6
13	4,3	4,8
14	5,8	5,1
15	5,1	4,5
16	5,5	4,9
17	-	5,1
18	-	4,7
19	-	5,2
20	-	5,3
21	-	5,6
22	-	5,5
23	-	5,7
TOTAL	79,9	97,9

Water consumption was 22.5% when compared to manual irrigation. In irrigation without the device it was not possible to know how much had been spent on water even with a timed time, as the water pressure varied. Manual irrigation was performed once daily so that data closer to the small farmer's routine could be obtained. Another important point to note is that the device evaluated the soil moisture and thermal temperature to then release the water.

Consideration

A agriculture associated with food production was the activity that allowed sedentary life for more than 10,000 years, so the emergence and flourishing of the first civilizations occurred on the banks of rivers. The relationship between agriculture, water and soil is indisputable, but 70% of the water used on the planet is in agriculture, and this use brings waste and pollution. We conclude the effectiveness of an automated system with IoT in agriculture for the management of water resources. The objective of reducing water waste was achieved without negatively affecting cultivation. This same project can be improved to be applied in other types of crops, in addition to being valid to apply artificial intelligence so that the machine has the capacity to develop new patterns and then leverage the potential of the developed device. Therefore, this equipment can be widely used in agriculture, contributing to the sustainability of the business and adding cost reduction for farmers, leading them to a management that before the IoT was not possible. The social relevance of this work shows how much technology can and should improve our lives by transforming impossible tasks into possible ones and improving those where human precision is not enough.

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