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RESEARCH ARTICLE

MIST COMPUTING: A SOLUTION TO WATER WASTE IN INDUSTRY

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Abstract

Water leak detection systems provide immediate alertand accurate location allowing a leak to be found before moisture can damage any computers, electrical connections orother sensitive electronics if used by sensors and other emerging technologies such as Internet of Things (IOT) and Artificial Intelligence. In the research developed, the bibliographic reference was applied to the collection for the theme: leak detection system, withcomputer in fog, artificial intelligence. With the research, a prototype system was developed that after the tests carried out its objective of monitoring and collecting data from water flow peaks, thus creating a user consumption profile acionando an alert if there were anomalies for water containment operations.

Introduction:-

The efficient use of water by industry has become a challenge for companies since the creation of Law No. 9433/97 that governs the use of water resources, the manufacturing sector invests in reuse methods. According to the National Confederation of Industries (2017) approximately 2.3 million liters of river water are consumed for industrial use and mostly unused due to leaks due to the use of archaic pipes. Thus, the need for propostas that make water waste impossible is urgent, since it is a natural resource that becomes scarce. Faced with this problematic technology-based solutions can arise in order to monitor water consumption by detecting flows and deviations based on anestablished expenditure pattern.

In this context, there is the ability to produce effective and rapid results through water activity control and monitoring systems by issuing alerts when a leak occurs in the piping system. In view of this, the mprego of technologies that make it possible to inspect the water leak to avoid waste has become a significant problem. According to Fuad and Herman (2019) using sensors to monitor distribution networks is the most recommended method and easyto monitor water systems, these devices notify in real time any incidence and the algorithm predicts leaks before they occur.

When observing the need for rapid response in water containment procedures in an industrial environment, the choice of mist computing arises in order to bring part of the data processing closer to the real problem, thus allowing even systems that are occasionally offline or with low connectivity to run f-solutions independent ormas. Cloud computing has a centralized infrastructure with large processing and storage capacity, but is highly independent of internet connections. On the other, fog emerges as an extension of this technologywhich does not require high connectivity and offers results faster. According to Adel (2020) this network layer has the ability to handle applications that require instant data in addition to enhancing communication, privacy, and security.

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This article visa present a solution to improve the process of using water resources in the industry by reducing waste through the use of Artificial Intelligence with edge resources. Through a decentralized system with these resources and machine learningusing regression algorithms to identify deviations of pattern in order to detect possible water leaks, enabling the performance of retention operations.

Theoretical Frameworks

The bibliographic research of this article was subdivided into four topics: water waste in industry; artificial intelligence in industry; mist computing; water containment systems.

Water Waste In Industry

Industry is the set of all economic activities including companies, people and organizations involved in the production of goods and services for a given field. They are generally categorized by the goods and services they produce. This industry uses water in a variety of ways, including from the process of dis solutionof chemicals used in the production of manufactured products to the heating and cooling of machinery to prevent it from overheating. In this context there is waste due to the water flow that occurs mainly due to the use of old industrial piping.

Water is a crucial and widely misused natural resource, about a third of the world's water supply companies have losses of about 40% due to leaks (COELHO; GLORY; SEBASTIAN, 2020). Higher levelsof water waste are extensively associated with lost revenue, as well as increased stress in the aquatic ecosystem due to increased water extraction levels from lakes and rivers, reduced system reliability, and contribution to pipefailures. According to Eltek Appliance, in 2018, financial losses occurred to companies in various segments equivalent to more than 32 billion euros worldwide.

Monitoring consumption and timely detection of splashes and spills areessential to minimize the consequences of water leaks in companies. In addition to the economic and financial costs associated with water flows, there is a concern about safety mainly in industrial and manufacturing environments. This is evidin industries such as steel making, in which ovens are commonly used. Alabi et al. (2019) still points out that: Today, many countries in the world are facing various water challenges, and there is a need to adopt innovative technologies from Industry 4.0 in order to improve, manage and distribute water using 21st century intelligent technologies that are also known as disruptive technologies.

Artificial Intelligence In The Industry

Artificial Intelligence (AI) is a subfield of computer science and can be defined as a machine's ability to mimic human behavior. According to Ertel (2018), the most sufficient definition is that its function is to solve problems as close to human wisdom.

60 years after the emergence of AI in 1956 with John McCarthy finally the industry was able to unleash a fourth industrial revolution using this clever tool. Recently this technology has stood out, as advances have expanded thelimits of automation beyond the manual and operational activities that have already occurred since the first industrial revolution, while intellectual processes and tasks that are highly dependent on cognition have been left almost exclusively to humans who have been skilled. For Nascimento and Bellini (2018), even if computers are able to make difficult calculations and structured decisions, they are not as complex as dealing with abstract reasoning and optimistic scenarios - which still require the presence of the human agency.

Artificial Intelligence enables reliable processing and analysis of large and complex datasets throughout the lifecycle for better products, more efficient software, and optimized production. Systems that use this technologycan be applied in a variety of scenarios because they are designed to retrieve information about the operation, conditions, and performance of any task or environment that can be controlled remotely.

In recent years, several sectors of industry have adopted these systems, for example petrochemicals, automobiles, food, textile, metallurgical, mechanical, etc. Smart technologies such as AI also play a crucial role in sustainableglobal growth.

Mist Computing

Fog computing is a paradigm that extends computing and cloud services, similar to this mist provides data, computing, storage, and application services to end users. Thereare numerous organizations investing considerably in research such as Cisco.

Fog computing is more advanced and performing better than the cloud to handle high demand for user requests and emerging scenarios and using recourses from cutting-edge devices. According to Shakir et al. (2019), among the characteristics that highlight the mist can be cited:

1. Low inertia and edge area: Processing disposition to provide better administration to end clients at the edge of the network.
2. Geographic distribution: Application, purpose, and mist computing services are widely distributed.
3. Real-time interactions: Provides fast instant interaction services in the fog.
4. Heterogeneity: Mist computing supports heterogeneous devices and support nodes in a wide variety of environments.
5. Interoperability: Offers a wide range of services for fogdevices to be incorporated into streaming services.

With the fourth industrial revolution,it is noted that the costs of communication, computing and storage have decreased remarkably, which makes the integration of Artificial Intelligence and Mist Computing possible for economic application globally.

Water Containment Systems

A water leak detection system can respond instantly in certain integrated applications so that businesses can continue to operate without interruptions in service or need to go offline. These systems use sensor cables or through acoustic waves can monitor the environment in search of any water spillage that would otherwise go unnoticed. After detecting a problem, the system typically triggers an alarm in order to alert the engineering team so that workers can solve the problem efficiently and timely.

Critical areas that typically deploy water leak detection systems include data centers, server rooms, and production parks where service cannotbe disrupted. To prevent water waste in any environment containing water pipe structure, a leak detection system is required not only for sustainable purposes, but also for reducing operating costs.

The industrial sector, for example, needs to constantly monitor leaks and cannot afford failures in water leak detectors, so the market has increasingly invested in these systems and their accuracy to handle errors. A leak containment system is very important for water resource management (OLIVEIRA, 2018).

The growing need to adopt sustainable measures in any production sector has significantly increased the search for more accessiblesolutions to combat water waste. Leak detectors are easy to use and can be deployed in any pipe structure, including PVC pipes and polyvinyl chloride. Among the solutions one can mention: acús tica vibration leak sensor(geophone); flood sensor; cable leak sensor.

According to the Global Research and Markets (2022) report, during the COVID-19 crisis, the global market for water leak detection systems that was once estimated at $4.6 billionin 2022 is expected to reach $5.9 billion by 2026, growing at 5.8% during the review period. Active Leak Detector Systems, one of the segments analyzed in the report, is expected to grow up to 6% to reach $4.3billion by the end of the period. Currently, this segment accounts for a 30.9% share of the global market for water leak detection systems.

Materials And Methods:-

The section was subdivided into two topics: materials, presentingthe tools used in a succinct way; methods, explaining the stages of elaboration of the prototype.

Materials:-

For a better understanding of the tools used in the development of the prototype, the division between the hardware that reaches the physical level and the firmware, embedded software, will be performed.

Hardware

For the development of the prototype, theESP 32 prototyping pla ca was used, as shown in Figure 1, through it it is possible to use Wi-Fi technology for communication with the central system in addition to recording programming routines integrating with sensors and peripherals.

Figure 1:- Plate Esp 32 WROOM-32 WIFI.

Source: Saravati, 2021

Tomeasure the water flow, the water flow sensor of 30 liters per minute was used, as shown in Figure 2, in order to analyze and send data to the main system about the leaks. Together two light LEDs were used to indicate whether the positive isconnected to the system and to indicate whether leaks are occurring.

Figure 2:- Water flow sensor 30 l/min.

Source: DHGate, 2020.

To finish the prototype at the physical level, a 3000 mAh battery was used to power the circuit como illustrates figure 3.

Figure 3:- 3000 mAh battery.

Source: DHGate, 2021.

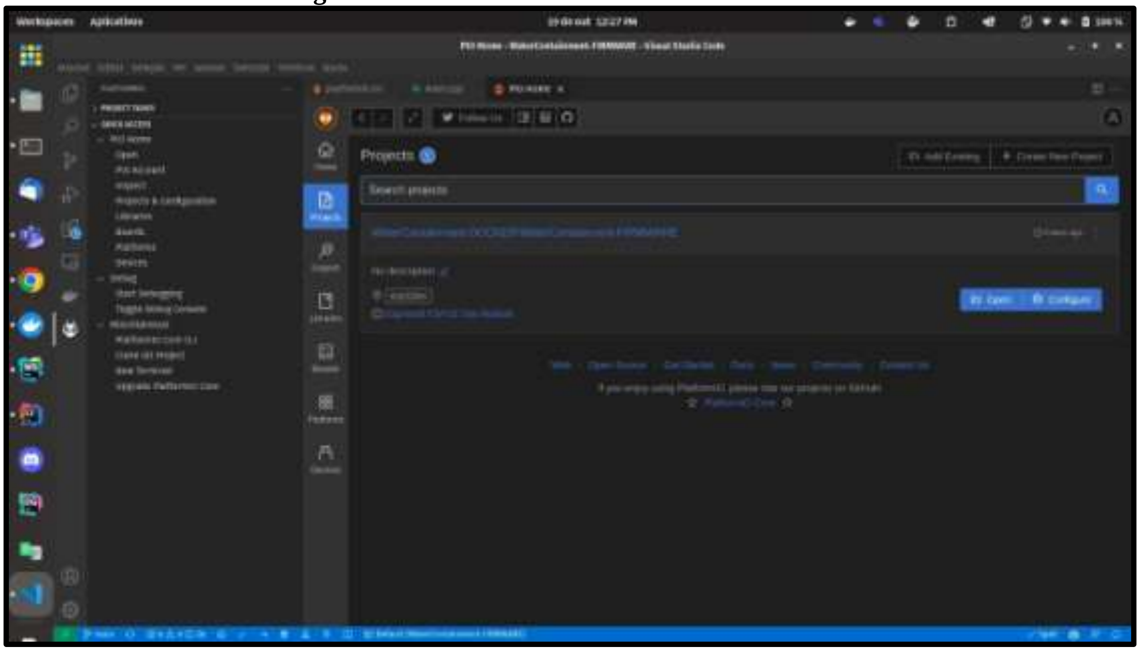
Software
To build the system, the PostgreSQL database was used and the Java language with Spring Boot framework was selected to receive, send, gravar and process this data. For the graphical interface, typescript integrated with React was used to create a web interaction field so that the prototype hardware data could be viewed by the user.

Methods:-
The development of the prototype was divided into three stages: elaboration of the prototype, development of the central system and data processing.

Prototyping
In the first stage, the selection of the materials to be used for hardware and firmware creation was made. The ESP 32 card was selected for prototyping and the water flow sensor 30 liters per minute, in addition to the definition of how the firmware would be encoded.

In firmware development, the Platformio platform was chosen in conjunction with Visual Studio Code code editor for coding as shown in Figure 4, this set supports ESP 32 card and dependency management.

Figure 4:- Use of Platformio in Visual Studio Code.



Source: Authors, 2022.

To communicate with the device, the PubSubClient library was used , which uses the MQTT communication protocol, through it it is possible to send and receive data quickly and with low energy consumption, ideal for IOT (Internet of Things) devices.

The reading of the data of the water flow sensor is done continuously, but the data is only sent if the water flow is greater than zero, so the Wi-Fi/Bluetooth module is turned off until there is data to be sent so that the energy is saved. The device has two LEDsindicated res: the red to indicate that anomalies are occurring in the water consumption as possible leaks; the blue to indicate that the device is sending data via MQTT.

Development Of The Central System

In the second step it was decided the details related to the system at the level of application development as: which protocol the firmware would use to communicate with the main system and in which language would be developed.

The central system consists of four workingparts and the joint m: Mosquitto as broken MQTT and PostgreSQL as a database; in the back end with a Rest API built in Java and Spring Boot framework; the front end as the means by which the user can have access to system data. In the construction of the system was used the broken MQTT which will be responsible for mediating the communication of the devices, there is a list of listeners / emitters separated by topics.

The developed API has as one of its functions to write in the topic Broken sensors, "listen" to all messages coming from hardware devices and store the data in the database. Other roles played by it can be cited the exposure of the data stored and processed to be consumed by the user or other systems through a Rest API. The interface construction was developed in TypeScript and React, where there is communication with the API showing the data processed in a readable way to the user through a web interface, which presents information through line charts and speedometer.

Data Processing

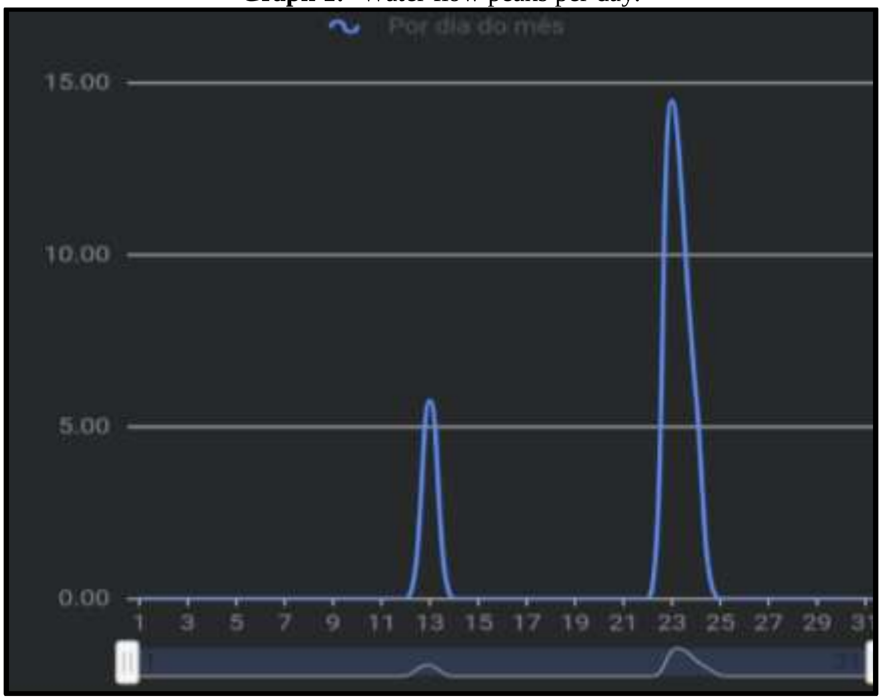
In the third stage, the data was processed and processed by minutes, hours and day, being possible to define a consumption profile and finally identify possible leaks. Through data collection, the mean water flow was performed according to the time variables, with this was defined the average consumption profile.

Therefore the data is shown to the user through the web interface so that he can track intertively his water consumption. At time intervals the central system provides the average of the maximum values in the ALERT LEAK topic where this value is stored on the device and it processes them in real time by triggering a leak alert if it encounters any abnormality. It is necessary to emphasize that the prototyping scenario used was domestic, but it is possible to adapt to the industrial environment.

Results:-

Through the data generated by the device when installed in a domestic residenceit was possible to create a water consumption profile, the data were cataloged following the filters: minutes, hours, daily and monthly. Based on the water expenditure pattern, the mean water flow was analyzed, as shown in graph 1, thus machine learning was used to predict the amount of consumption considered normal to be used.

Graph 1:- Water flow peaks per day.



Source: Authors, 2022.

In graph 1 the values in the vertical indicate the amount of liters consumed per minute and horizontally the days of the corresponding month, after observing consumption in the house, it was analyzed that between 21 and 25 October there was an increase in consumption, reachapproximately 14 liters per minute. It is concluded that there is a pattern where the days when the feature is widely used mostly comprise weekends when users spend more time at home.

Because it is a device powered by a battery of 3000 mAh the Wi-Fi communication module and the connection to the broken is disconnected until the water flow is detected, thus saving around 80mAh ~ 90mAh and enabling the device to operateand for longer without the need for charging. Since the device is not always connected to the broken it is not possible to perform water containment operations from the central system and with this it was necessary to bring part of the processing to the edge.

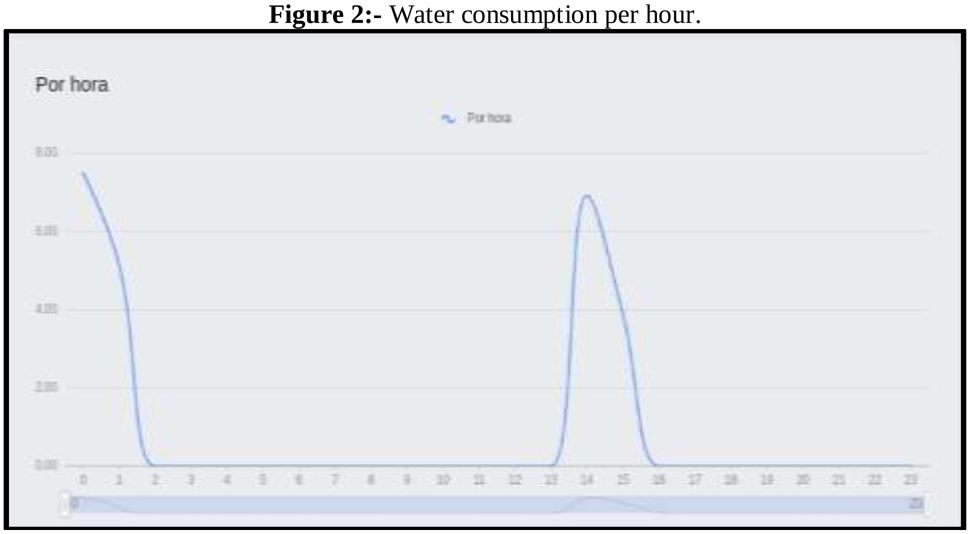
Through the Web system, the user can access his/her consumption profile and check the periods of higher water consumption and have access to his/her last recorded flow, as shown in Figure 5, assisting in controlling the waste of both water and financial resources.

Figure 5:- Web Application.

Source: Authors, 2022

Figure 5 shows the value at the exact moment when the water flow was recorded on the day corresponding to the exact moment when the profile is created the systemcan enter an ideal consumption range for that time and if the consumption exceeds the expected will be issued an irregularity alert through the speedometer.

Figure 2:- Water consumption per hour.



Source: Authors, 2022

Graph 2 shows that users consumed a significant volume of water between 1:00 p.m. and 4:00 p.m. Over the time when the system understands that it is feeding the database, the user's consumption profile will be adhering to the new data and with this you can obtain a more accurate dimension.

Final Considerations

The article presented a solution proposal for the problem of water waste in the industry bringing a system based on artificial intelligence in edge capable of creating a standardprofile at the ravés of machine learning. In this application it was possible to deliver to the user the amount of water wasted following the average of liters per minute showing an alert if there are abnormalities in the water flow so that a containment system is usedpreventively.

According to El-Zahab and Zayed (2019) in the 21st century, leak detection research has obtained numerous publications and contributions with the increased importance of water conservation and scarcity and the emergence of new technologies that are capable of facilitating and automating the leak detection process. The field of leak detection is growing in relation to technological uses, as several new technologies are being continuously used to explore aspects capable of presenting more accurate results. The field is expected to grow further as the need increases in the production sectors.

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