Smart Water Distribution System using Machine Learning and IoT

Aashika Perunkolam, Makshi P Baskaran, Sarrthak Tripathi, Om Prakash Sahu

Abstract: ***Water Management includes four major processes, namely, estimating the amount of water readily available to be distributed, the measurement of the quality of water, distribution of water to different sectors of the city based on the quality and finally to provide a platform to monitor this distribution from anywhere and by anyone. All these processes, are currently treated as separate modules, but the integration of these four models, enhances water conservation and creates a social awareness since the proposed cloud platform can be accessed by everyone, and they are made aware, in advance, about the quality and amount of water they are going to get for the week, so that they can use the water wisely. In this paper we discuss our new and improved proposed model which not only integrates the existing four modules but also optimizes the distribution path based on algorithms for the fastest coverage. This is turn provides a short and concise solution to water management which is more user friendly and can reach more people, hence spreading more awareness. The lack of coordination between the current quality measurement and distribution system calls for an integrated system. This system predicts the rainfall to prepare the system for the amount of softener required to soften the water which acquires calcium and magnesium as it makes its way into other natural rivers. This water management system can be setup both on a small scale and a large scale. The smaller water management system setup in villages can be interconnected to make a larger water management system that can be centrally controlled from cities which helps in ensuring water distribution even in the smallest towns and villages.***

Keywords: Forecasting, Knowledge Acquisition, Machine -Learning, Water Distribution Network.

I. INTRODUCTION

Water is one of the most important resources to sustain a living environment for mankind. However, due to our negligence research has proved that people are reaching a point where water may be equally expensive as mineral oil.

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Water resource management has become an increasingly important issue from innumerous angles such as development of water bodies for future and protection of available water bodies from further pollution. Without proper water management, it would be difficult to talk about food security, environmental stability and any kind of safe future for mankind. Across the world various factors such as demographic, economic, and technological trends have accelerated our ability to knowingly and unknowingly modify the environment we live in and that sustains us.

Humans are largely responsible for environmental changes and our actions are directly impacting the global environment. Water plays the most essential role in anything we produce, whether it be irrigational or industrial. There are no alternatives for it and while it is renewable there is only a finite amount of it left and we have to use it optimally. In this paper, we create a smart water management system using machine learning and incorporate IoT as well. We have divided the whole project into three modules. In the first module, we collect a dataset of rainfall in a particular area. We use machine learning techniques to predict the rainfall for the upcoming week in that area. In the next module, we route and redirect the water using Raspberry Pi. We further proceed to check the quality of the water received using turbidity sensors. And according to the water quality, we add a certain quantity of water softeners. Lastly, in the third module, all the data collected and processed is uploaded on the cloud. Through this model we are trying to provide a comprehensive and accurate solution, while reducing the time and resources for water management.

II. RELATED WORK

Several studies predicted rain fall using various machine learning models. One such study predicts the rainfall using Multiple Linear Regression for Indian Dataset. Rainfall prediction is important in an Agriculture prime country like India to support the respective industry. Lots of other models have also been implemented that predict the rainfall with a certain degree of uncertainty but this study tries to achieve improved precision when it comes to the same task [1]. Another study aims to predict the rainfall in a certain area along with devising a smart irrigation system for the watering of crops. The model suggests ways to reduce the wastage of water and minimize energy consumption so that the villages can utilize the extra resources when required. It also uses the geographical and meteorological information to suggest plantation of ideal crops to the farmers [2]. Kala's and Vaidyanathan's study aim to

predict rainfall using Artificial Neural Network, such as Feed Forward Neural Network model.

The model is based on self-adaptive mechanism and creates a function between the historical data to make predictions. The model aims at improving the accuracy from the already present various prediction models [3]. Another study is based on the rate of rainfall in earlier years as per different yields seasons like Rabi, Kharif, Zaid and predicts the precipitation in future seasons. The study also measures the various categories of data by linear regression strategy in measurements for successful understanding of agriculture in India [4]. Arif Ul-Islam created a project in which he used two motors to control the flow of water. One motor was controlled by the Arduino Uno to fill up the tank using ground water while the other is controlled via the desktop to control the water flow to the users. However, the project does not involve any water level sensors and requires the user to manually control the flow of water, this can be improved by implementing sensors and upgrading the program [5]. In a study conducted by Indranil Banerjee, et al, various sensors were used to estimate the agricultural land and environment and this data was sent to the cloud for processing. Accordingly, the water is supplied to the plant as and when needed. This project highlights the benefits of using an IoT (Internet of Things) based system [6]. Another study conducted by Dumtiru Vaju, et al., uses a two-step thorough water treatment procedure. In the first stage, electrolysis is performed while in the second stage electromagnetic water softening is performed. Finally, a UV-ray disinfection is also used. This study provides an economic and ecological treatment process with no pollutant factors and significant results [7]. A study by M. Suresh, offers a new and improved approach for water meter-reading which is more economical and efficient. Using IoT techniques, the authorities as well as the end-to-end users can access the data and readings. This overcomes many issues like data-tampering and proposes ideas to deal with connectivity issues [8]. In another study by Arun. M, water is recycled and then distributed for irrigation purposes. The real time data is forwarded to the user and regular updates are sent. Arduino based irrigation is used for conserving water and using it more efficiently [9]. In Srihari's study, Intelligent Water Distribution and Management System using Internet of Things, a web interface collects the sensors value and controls the water control valve to provide adequate and equal water to each user. A pH sensor is also used to measure the quality of the water before supplying it to the user. This study, however, does not provide solutions when the quality or pH of the water is not consumable [10]. In a paper written by M.S. Bennet Praba, et al., we observe a real time application of IoT. Similar to the above research paper, the water flow is monitored via mobile applications. Issues related to the water flow is updated in the cloud and complaints can be raised directly [11].In this study by Rizqi Putri Nourma Budiarti, et al., a raspberry pi is used to interface the data collected by the sensors which measures the quality of the surface water and then can be monitored real-time in the cloud using IoT. By adding and updating the program we can utilize Big Data Analysis to further categorize the quality of water receive [12]. In a study conducted by Christine Joy T. Dinio, et al., an Arduino and a DS3231 Real Time Clock is used to develop a schedule to segregate different water sources. A flow control is also used to improve efficiency [13].

III. PRELIMINARIES

We use machine learning for rainfall prediction. One of the most critical aspects of using machine learning is that we are using time series data. The time series data can be analyzed using the following algorithms.

A. Moving Average Model:

The moving average model is probably the easiest way to deal with the time series model. Even though it is basic, this model may be shockingly acceptable, and it speaks to a decent beginning stage. The moving average can be utilized to distinguish intriguing patterns with regards to the information. We can characterize a window to apply the moving average model to smooth the time arrangement and feature various patterns. The moving-average model is essentially a finite impulse response filter applied to white noise, with some additional interpretation placed on it. The role of the random shocks in the MA model differs from their role in the autoregressive (AR) model in two ways.

B. Exponential Smoothing

Exponential smoothing utilizes a comparable rationale to moving normal, yet this time, an alternate diminishing weight is appointed to every perceptron. As we move forward, less significance is given to each perceptron.

C. Double Exponential Smoothing

Double exponential smoothing is utilized when there is a pattern in the time series data. All things considered, we utilize this procedure, which is basically a recursive utilization of exponential smoothing.

IV. METHODOLOGY

A. Moving Average Model for Rainfall Prediction

The fresh dataset was acquired from IMD Pune. The dataset used is for the time duration from 01/06/2019 to 31/01/2020. The parameters for the dataset are as follows:

1.Temperature 2. Relative Humidity 3. Pressure 4. Precipitation Amount 5. Total Cloud Cover 6. Low Mid and High Cloud Cover 7. Wind Speed and Direction 8. Wind Gusts 9. Sunshine Duration 10. Solar Radiation.

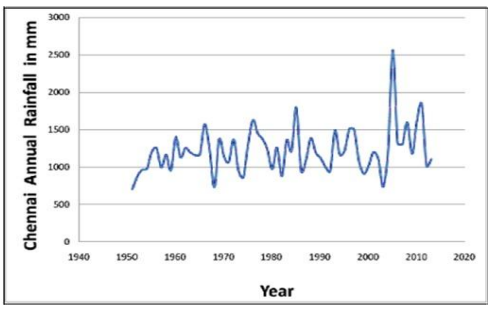


Fig 1. Moving Average Model of Rainfall Prediction

B. Measurement of Quality of Water

The quality of water is largely determined by a quantity known as 'Hardness of Water'. Water is often classified into soft and hard water. The former containing relatively fewer minerals, whereas the latter is rich in minerals such as Magnesium and Calcium.

This classification can be done by determining a quantity known as pH of water, which is essentially the hydrogen ion concertation in water. Pure water has a pH of 7, whereas hard water usually has a pH of 8.5 or above.

Since different industries require water with differing pH values, our model aims to soften hard water to suit all applications before distributing the water to the city.

C. Breakdown of the uses of pH in various Industries

Water that is meant for human consumption, in direct form or otherwise, needs to be maintained at a certain pH level. Water that has a high pH value, i.e. basic water, tastes bitter and leaves pipes and appliances caked with deposits. Whereas, if the water is acidic in nature and has a low pH, it corrodes metal. Most industries require water to be maintained at a particular pH level and keep checking on it periodically. Some of the industries that check the pH level include, Wastewater treatment - In this process, heavy metals, organic compounds and toxic substances are removed while the pH levels are balanced using appropriate chemicals; at each phase the pH levels need to be monitored before it is sent for further treatment to ensure pure, safe water at the end of the cleaning procedure. Aquaculture – In this industry it is important to keep the aquatic creatures alive and safe for consumption, hence the pH levels have to monitored regularly. Ideally the fishes thrive in pH levels 6.5-9.0. Another important industry is Food & Beverage – it is important to maintain a proper pH level in this industry as all of it is used for human consumption and any imbalance can have serious repercussions to the health. Pool and Spa water - also needs to be monitored on a daily basis to determine the quantity of sterilizing agents that need to be added to maintain a safe environment. Aquariums and Fish Tanks - also need to be proactively monitored to keep fishes and other aquatic creatures alive along with sustaining a clean and hygienic environment for them. Research - water plays a key role in numerous research projects. Each experiment will have exclusive requirements to ensure high accuracy results. Researchers also need to maintain the pH level to be able to repeat each experiment with the same level of accuracy. Hydroponics, the practice of growing plants in a nutrient-enriched water-based solution, requires a keen monitoring of the pH levels. If there is too much fluctuation, the plants can die quickly. Hence it is of the utmost importance to maintain a suitable pH level. In conclusion, any industry that requires water keeps a tab on the water quality characteristics, including the pH levels, to guarantee safety and compliance.

D. Testing of pH of Water

In this model the pH sensor along with a circuit driver and Arduino is used to measure the pH value of the incoming water before distribution takes place.

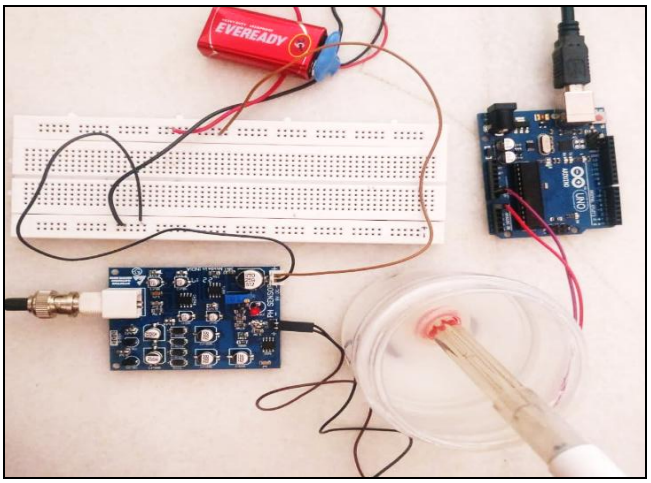


Fig 2. pH testing module Setup

The pH sensor is initially calibrated using different solutions like milk, coffee, water, soapy liquid. After this, it is we dip the probe in the required solution and find out the pH value of the rain water we received.

E. Differential Softening of Water

As seen previously, the pH of hard water needs to be brought down to suitable values depending on the use of the industry. Usually industries use Brine tanks for the softening of water but for demonstration purposes we use a softening liquid in our model. We take an input in the Arduino, for example, 1 for Food and Beverage industry, 2 for Aquaculture industry and so on. We attach a SG90 Tower Pro DC motor to the lid of the softener. When 1 is entered, since we need a pH of 5.3, we need to a relatively more amount of softener so we rotate the motor by 90 degrees clockwise and drop only that much softener into the water, wait for 3 seconds and rotate it back by 90 degrees in the anticlockwise direction. If 2 is entered, we rotate the motor by 30 degrees clockwise and drop only that much softener into the water, wait for 3 seconds and rotate it back by 30 degrees in the anticlockwise direction

Fig 3. Motor at 90° of softener for Food and Beverage Industry

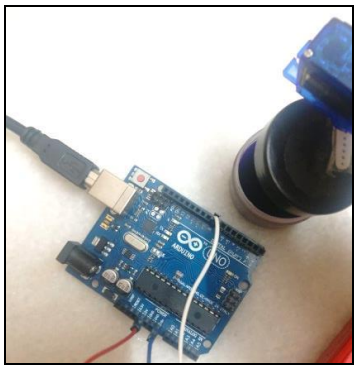


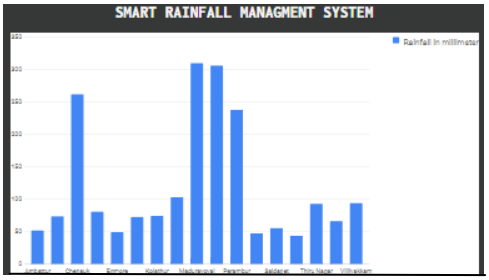
Fig 4. Motor at 60° of softener for Aquaculture Industry

F. Routing of Water

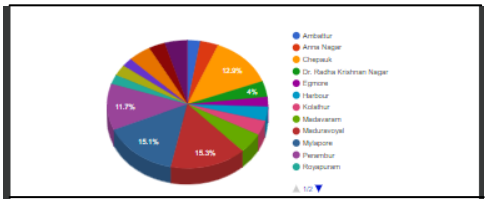
The rainfall prediction values are imported into the Raspberry Pi after which water to be distributed to different sectors of the industry is calculated using a preset algorithm. For demonstration purposes we have used a dc motor to control the valves. Opening of the valves is determined by the angles of the motor.

G. IoT Interface

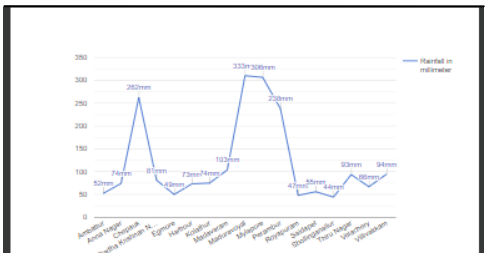
In this IoT development we used the raspberry pi 3, model type B. The embedded system is employed as a knowledge processing center whereas the Raspbian operating system has been modified and an addition of watermond application is employed to retrieve data and transmit water quality data from the sensor, which is then processed such that the data are often stored within the local database temporarily using SQLite and MQTT protocols for the method of sending data to a bigdata server. We made use of the Heroku platform to create a single page application as shown in figure 5a, 5b, 5c.



5 a) Rainfall Prediction in mm



5 b) Water Distribution in all areas of



5 c) Rainfall Distribution in all areas of Chennai

V. RESULTS AND DISCUSSION

A. Rainfall Prediction

The rainfall predicted over the past six months can be found in the table below.

Table 1. Rainfall Prediction values

Jan	12.16174531
Feb	21.93578817
Mar	36.35945135
Apr	63.43136177
May	90.57470057
Jun	224.9171905
Jul	323.3359283
Aug	222.6941797
Sep	179.2126682
Oct	70.51140787
Nov	18.2265942
Dec	7.697738095

B. Quality of Water

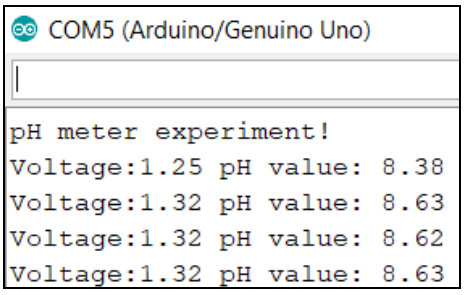


Fig 6. pH of Hard Water

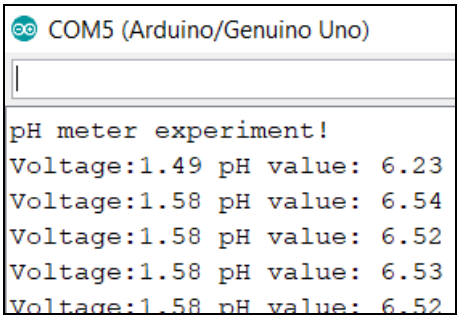


Fig 7. pH of Softened Water

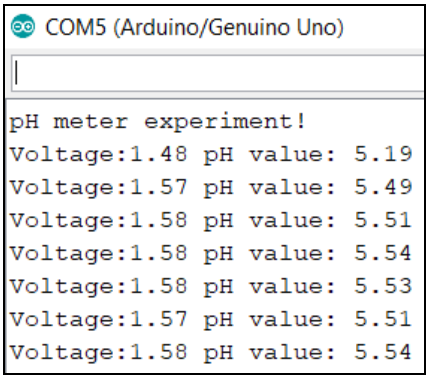


Fig 8. pH of softened water for Food & Beverage Industry

From A) it is observed that June, July, August and September experience the most rainfall. During these months amount of water softener required would be more.
From B) it is observed that Hard water has a pH value of around 8, softened water has pH value around 6.

Table 2. Comparison between past work and proposed work

Past Work	Proposed Work
Artificial neural networks have been used to predict rainfall [3].	The moving average model used is less complex and gives almost the same results.
In previous, water management systems, if the pH of water measured was not consumable, no action was taken to rectify this [10].	This system not only measures the pH of water but also adds the required amount of softener to suit that sector of the city or town that it is being distributed to.

VI. CONCLUSION

More purification techniques can be added to this Water management system like UV purification. The details in the IoT interface can be converted into a mobile app for easier access to data. A system of raising automatic complaints when a certain sector of the city or town does not receive good quality of water can also be integrated into the mobile app.
Water Softening is an important factor of a water management system as the pH value of water not only affects the end point customer but can also damage the pipes which carry this water. An IoT interface plays an important role in bringing social awareness among people and heightens their conscience regarding the conservation of water. These factors have been considered while constructing this water management system, thereby making it a water measurement, purification and distribution system to an extent.

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Om Prakash Sahu, from Bhilai, India and was born in 1982, received the B.E. degree in electronics and telecommunication in 2005 and the M-tech. with specialization on instrumentation and control system in 2008 from the University of CSVT, Bhilai, India and he completed his PhD at National institute of technology Rourkela, India in 2017. And he completed Postdoc at Ritsumeikan University, Japan along with collaboration of Mitsubishi Electric and NEDO, Japan 2019. Currently he is Sr. Assistant Prof in VIT, Chennai Tamil Nadu, India. He has published more than 26 technical research papers and two patents at National and International levels. His areas of research interest include Sensor integration, Automatic industrial robotics, Control system and Instrumentation, Vision feedback system, Point clouds and Robot operating system.