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REVIEW ARTICLE

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Design and Fabrication of Smart Water Consumption Management System

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Abstract

Aartificial Iintelligence has found its way into almost everything that humans have built. Water Consumption Management is one such field that has recently been paving way for AI. This paper primarily focuses on the management of water consumption using AI. This technique analyses the domestic water utilization and helps one regulate the wastage by controlling the water supply during hours of least usage. It smartly tracks when the water consumption is high and automatically suggests when the water supply should be cut off to facilitate the distribution and efficient usage of available fresh water. The amount of optimal water usage is decided based on predicted rainfall for the following month, population of the particular area and real time water consumption. This technique provides personalized solutions for every household by taking into account number of family members, area of residence, etc. The functionality of this Smart Water Consumption Management system is extended by visualizing the data and providing important insights to the user. This can also be used in manufacturing industries, corporate offices and government offices.

ARTICLE HISTORY

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KEYWORDS

Artificial Intelligence; reduce wastage; IOT; drinking water

INTRODUCTION

India is facing major water crisis right now and it is estimated that by 2030 India will not have access to drinking water according to a report by the National Institution for Transforming India (NITI Aayog). This accelerated depletion of India's water table is primarily because of excessive consumption, water wastage along with introduction of toxins in fresh water bodies. In order to deal with this scenario, government is enforcing water cuts during specific hours throughout the day. These hours are planned by keeping general public's working hours in mind but since everyone don't follow the same lifestyle, people with unconventional work hours often face inconvenience because of this decree. People often have to stay up till late hours or wake up quite early to stack up water to use during cuts which often takes up a lot of time and is quite stressful and hectic as well. India has always been in need of a water consumption management system due to its ever expanding economy and population along with failing methodologies to address any of the current problem persisting in the particular field.

Integrating some existing methods with Machine Learning and IOT could be a leap forward in the right direction and provide solutions that can sort out the mass inconvenience caused by water cuts and depleting water quality due to the availability: consumption ratio being lower than what World Health Organization and other global authorities have prescribed.

LITERATURE SURVEY

Smart Water Grid

Olga Martyusheva. Colorado State University. Smart water grid has been equipped with a two way real-time network with smart sensors placed on site. Measurement and control devices have been placed that continuously monitor and detect problems in

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the water grid dynamically. Smart water meters are equipped in order to monitor some key parameters like water flow pressure, temperature, quality and consumption. Information gathered using the above metrics is transmitted directly to a control tower, which is responsible for transmitting the information to the local utility company.

Water Network based on experimental water distribution system

D.Camhya, D.Steffelbauera,M.Neumayerb, et al. Institute of Urban Water Management and Landscape Water Engineering, Graz University of Technology.

An experimental water distribution system has been proposed that is equipped as a smart water network comprised of various devices that can collect data and communicate, measure and control various parameters, display, manage and analyze data. Open SDM has been used in the proposed system to provide a complete remote control EWDS. Already existing detection algorithms can be evaluated along with the localization of leakages.

Using smart water meters for household water consumption feedback

A. L. Sønderlunda, J. R. Smitha*, C. Huttonb, Z. Kapelanc, et al.

Psychology, University of Exeter, Exeter. Department of Civil Engineering, University of Bristol. Centre for Water Systems, University of Exeter. Existing methods to conserve water are reviewed with existing evidence. Smart feedback method that curbs domestic energy use is being reviewed. Reductions in energy use is primarily credited to the provision of dynamic usage data ranging from 5% to 10% in domestic households. Various other technologies are also reviewed in brief throughout the paper.

Smart Meters, Smart Water, Smart Societies: The iWIDGET Project

D Savića, L. Vamvakeridou-Lyroudiaa, Z. Kapelana. Centre for Water Systems, College of Engineering, Mathematics and Physical Sciences, University of Exeter.

iWidget is an EU/FP7 funded ambitious project that started in 2012 and concluded in 2015. It aims to expand understanding smart metering technologies in order to develop efficient, robust and affordable methodologies to manage urban population's water demands across Europe. A set of decision support tools are built for its consumers so as to provide useful information about water and energy related consumption on a daily basis.

Smart water meter system for user-centric consumption measurement

Adnan.M, Council for scientific and industrial research A reliable relationship has been built between the utilities sector and the consumers using the proposed system. Visual application has been used for customers to be the primary beneficiaries of the system as the flays shall be detected in respect to the rendered service. Mesh networking among the meter nodes within the radius of 100 meters has been recursively developed. Data sent by the meter interface node is collected by the gateway. Pandora flexible monitoring system has been used as a monitoring application while a web based visual tool has been developed.

Household smart water metering in Spain: Insights from the experience of remotemeter reading in Alicante.

G.Hug March, Alvaro Morote, David Sauri. Internet Interdisciplinary Institute (IN3), Universitat Oberta de Catalunya, Interuniversity Institute of Geography, University of Alicante, Departament de Geografia, Universitat Autònoma de Barcelona.

Registration, data systematization about consumption and billing, supply of sewerage networks, etc. has prompted a strong interaction culture among the departments and people of the company that has been replicated in local municipalities. The mart metering programme dates back to the late twentieth century as AMAEM began its experimenting with remote meter readings in 1995 in Vistahermosa. Initial technology collected data by manoeuvring it by a car or by a worker.

A Novel Smart Water-Meter based on IoT and Smartphone App for City Distribution Management

M Suresh, U. Muthukumar, Jacob Chandapillai, 2017 IEEE Region 10 Symposium.

Smart water metering systems were proposed for thirld world countries with vivid investments in growing infrastructure and population due to uncontrolled population expansion. The approach employed has used simple Internet of Things concept along with an interactive android app. Various water leakages, logging in complaints and utility monitoring are the signature features of this CRBM.

***An Analysis of Domestic Water Consumption in* Jaipur, India**

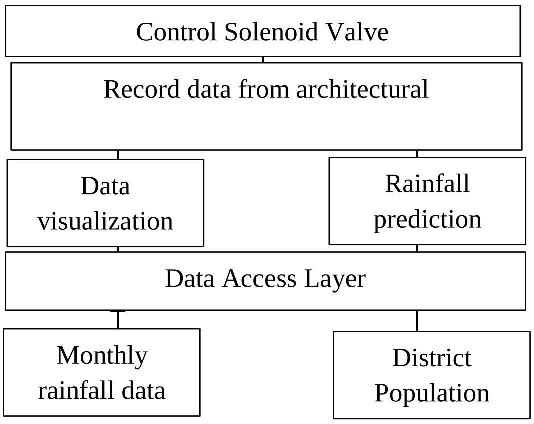
Seyed M. K. Sadr, Fayyaz Ali Memon, Arpit Jain, Shilpa Gulati, Andrew P. Duncan, Wa'el Hussein, Dragan A. Savić and David Butler, Centre for Water Systems, University of Exeter, Exeter, EX4 4QF, UK.

Department of Civil Engineering, Malaviya National Institute of Technology.
It has been compiled as a result of answers received by answering 60 questions from a specialized questionnaire. It is formulated in a way such that it covers details of all the basic household usage .The compiled data received using cluster analysis and one-way analysis of variance inferred that for standalone household was 183 litres/person/day while for an apartment, it was 215 litres/person/day

PROPOSED WORK

It is proposed to build a smart consumption management system that can be used to conserve water efficiently by integrating the concepts of machine learning with conservation techniques. Amount of rainfall received by a particular landlocked district in a state is considered to be an indicator of approximate water availability over there. The predicted rainfall along with population of the particular area is used as parameters to set the amount of optimal water that should be used on an average over the entire month. The value can be modified based on number of members in the household. Once the amount of water flowing through the water flow sensor exceeds the calculated value, the valve is shut hence inhibiting the user from using any more water. It is also proposed to compare various machine learning algorithms along with performing data visualization in order to provide essential insights to the user. The insights obtained can be thus used to also choose between the models as the amount of data increases as different models respond differently to the amount of data available. It is also proposed to place the valve along with the water flow sensor in a particular arrangement to facilitate counting the number of pulses and the open and shut mechanism of the valve. With the help of proposed work previous shortcomings of real time monitoring have been resolved.

Architecture Flow Diagram



Abbreviations and Acronyms
1. CI = Consumption Index
2. APd = Available water per day
3. RpPd = Required pulses per day

Units Pulses- Represents the amount of water passing through the water flow sensor.
Liter/day- Represents the amount of water that has flown in liters per day.

Equations

1. Consumption index is calculated by dividing the predicted value of rainfall by the population of the distract.

CI = predicted rain / population (1)

2. Water availability per day is calculated by dividing consumption index by 0.5 and multiplying it by The average water consumption in India (200 liters)

APd= (CI/0.5) *200 (2)

3. Required pulses per day is given by multiplying Apd by 10800(7.5*60*24)

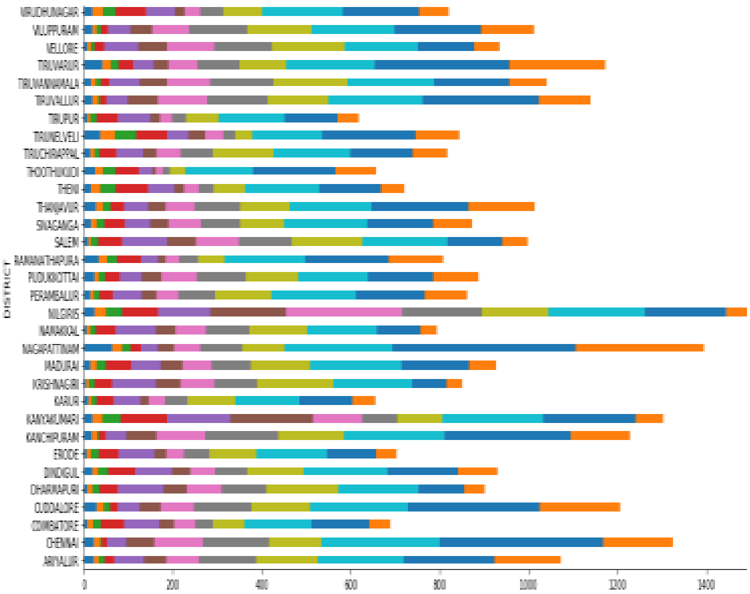
RpPd=APd*7.5*60*24 (3)

IMPLEMENTATION

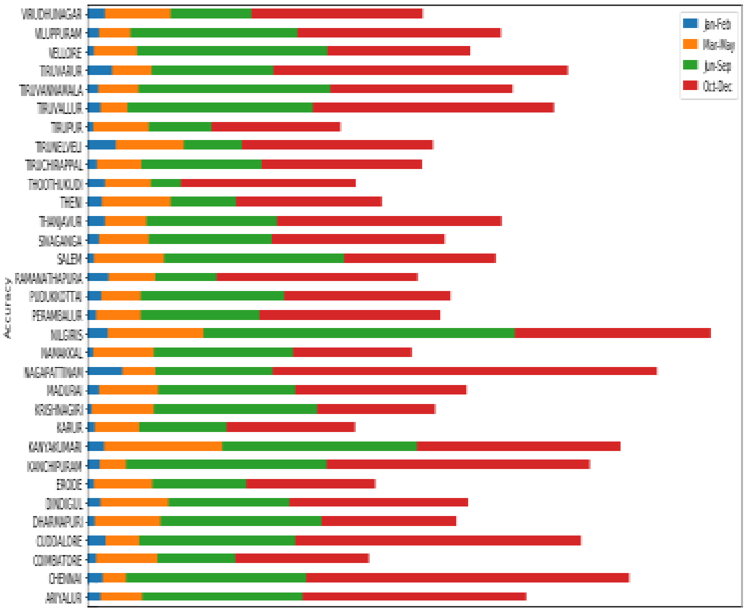
Smart water consumption Management system makes an intensive use of machine learning throughout its implementation. The programming software used for this study was 'Spyder v 3.3.0' because of its compatibility with raspberry pi 3 model B and various libraries in Machine learning. Various supervised machine learning algorithms were used on a data-set containing rainfall data of all the districts in India. The algorithm which led to maximum testing accuracy was chosen. Random Forest Algorithm with a training accuracy of 98% and testing accuracy of 78.5% was employed. The data was also visualized to show the relationship between various attributes of the data -set. Using the equation (1) the consumption index is found out, which is essential to determine the ratio of rainfall and population. Equation (2) is used to find the optimal water to be used per day by one person In the second equation CI is divided by 0.5 as that has been found out to be the maximum value of CI and multiplied by 200 because that is the average water that is consumed by an average Indian per day. In equation (3) the pulses that are required are calculated using the standard formula. A Raspberry pi 3 model B is used for implementation of this smart water consumption management system. A water flow sensor is connected to the raspberry pi which is responsible for monitoring the amount of water that is passing through it. Once the amount of water passed through the water flow sensor crosses the threshold value which is required pulses per day found in equation (3) a four channel relay which is also connected to the GPIO pins of the raspberry pi 3 model B is activated. The four channel relay is responsible for controlling a solenoid valve which is connected to it. The mentioned valve works with the help of an external power supply as the power from the pi is not enough.

RESULT

Data visualization is performed for providing an insight into the data and the result is as follows.

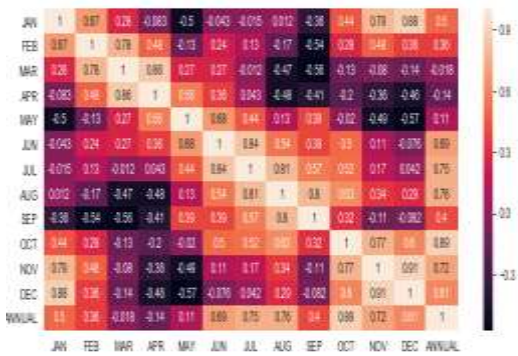


The above figure shows the amount of rainfall received during different months across the districts of Tamil Nadu. The Nilgris had been found with the maximum rate of precipitation. The district of Chennai received substantial rainfall too, especially in the months of October and November.



The above figure demonstrates amount of rainfall that was received across the districts of Tamil Nadu, when it is segregated in slots of months.

Heat-map(1 & 2)

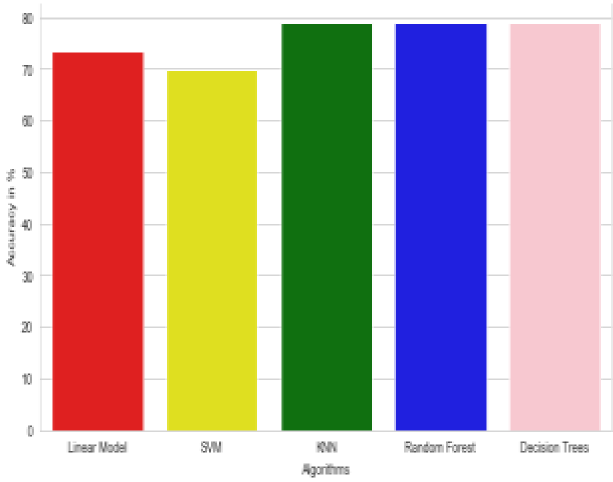


These are heat maps that conveniently visualize the rainfall data for the user. The different colours of the heat map depict the amount of precipitation. Various supervised Machine Learning algorithms are run on the data-set and their accuracy is calculated. The algorithms had been chosen in order to predict the rainfall received by the particular district. The testing accuracy have been taken into consideration due to its direct effect on forecasting.

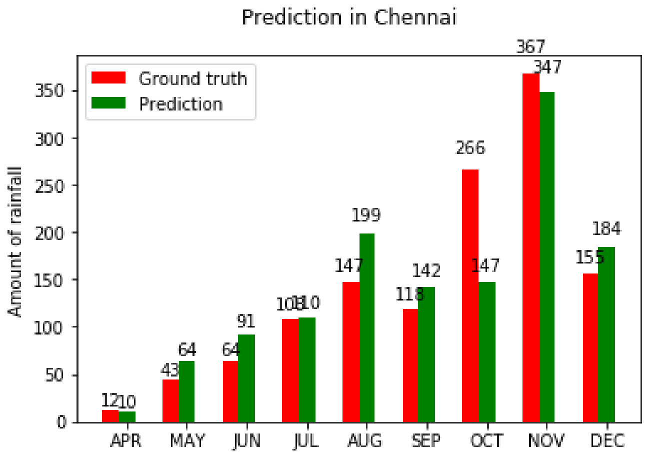
Accuracy Table

ML model	Testing Accuracy(%)
Linear Model	73.45
SVM	69.8
KNN	78.1
Random Forest	78.65
Decision Tree	76.27

Accuracy Bar Graph



Based on the table above Random Forest was used to move forward as it had the testing accuracy of 78.661% and training accuracy of 96.5%.
For this particular scenario two Machine Learning models have been used. The data set is initially run through a KNN model and the run through the Random Forest model for better accuracy.
Using other models in combination with KNN model could be explored in order to receive better results.



The optimal water to be consumed was found out using equation (2) and its values was 112.18 litters.
The required pulses per day are calculated using equation (3) and are 1211555.1725 pulses.
Once the water flow sensor records pulses more than or equal to RpPd it activates the 4 channel relay and the valve is closed.

Results Discussion

The smart water consumption management system should be used by various water resource distribution departments or companies for effectively and optimally managing the scarce resource based on its availability. The components of this smart water consumption management system can be customized to cater for the specific needs of individual customer. The accuracy of results can be further increased by using a CNN model but keeping in my mind the long operation hours for the pi Random Forest was chosen. The value for RpPd can be obtained for any district across India and the rainfall value for the coming month can be predicted using the rainfall data of last three months.

CONCLUSION

It can be concluded from the paper that by integrating machine learning with water consumption management techniques, they can be made more efficient and appealing to the masses. This paper tackles the problem of long water cuts by introducing the concept of personalized water cuts and also demonstrates adjustment to special needs that may arise. The major challenge that the paper faces is in some special cases rainfall is itself not accurate in determining approximate water availability and hence the results could be misleading.

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