International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

System for Optimizing Water Usage

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Abstract: ***Water scarcity is an issue talked and discussed for many decades. Yet most of us are unaware about our contribution towards this ever increasing scarcity. Despite the presence of ample papers claiming optimal water usage details for various scenarios, none have been implemented to bring a positive change. Authors propose a implementable system capable of optimizing water usage in various scenarios.***

Keywords: IoT, Water Usage Modeling, Flow Rate Sensor, Predictive Analysis

1. Introduction

Reckless consumption of water has led to the current struggle for water resources. For decades, environmentalists have spoken about fresh water level reduction and extinction of same in the near future. There are ample amount of articles claiming water usage statistics under varying situations and formulated by researchers from varying backgrounds. Yet, not much effort has gone into using this data and reducing the excess water usage by the common man. Authors propose an application to address the above mentioned issue.

Human beings, being intellectual beings, require merely a nudge in the right direction to start thinking and acting towards it. With this principle in mind, the proposed system shows water usage statistics for a user and gives an insight into the non-optimized usage. The usage is optimized for a particular user, adjusting to one's habitat, thus giving a more personalized and accurate analysis rather than a general one.

Sections below elaborate on the system architecture and procedure used, the core of which treats the problem as a classification problem. It classifies water usage for each user as optimal or excess.

2. Proposed Product

A. System Work-Flow

Each water source will be connected to a sensor-transmitter circuit. The sensor detects the amount of water consumed through the particular source and sends the information to a central server with the help of an attached wireless communication module. Server analyzes the amount used and stores the usage details along with the transmitting device ID, uniquely mapped to a water source, in the database. This data can be accessed by the user at any point of time with the help of a web-application. Here the user can specify the required parameters and view and analyze the water usage statistics which helps the individual reduce their water consumption more consciously.

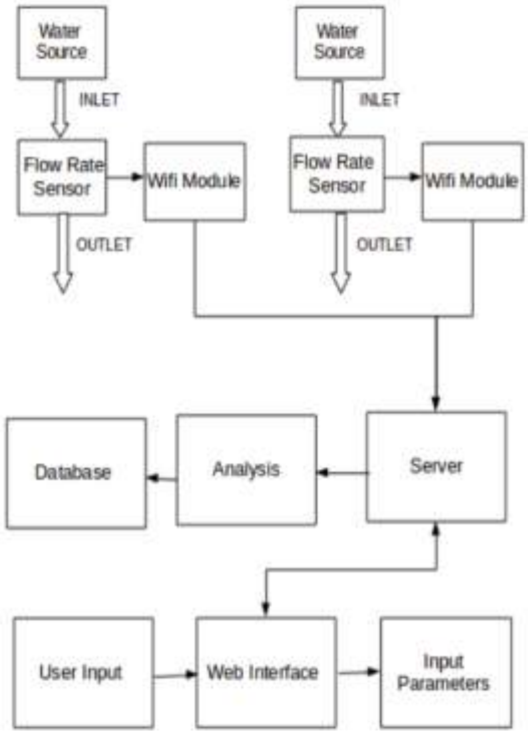

Figure 1: Workflow Diagram

2.2 Generic Plant Growth Model

Stability Parameters for Comparing Varities provides a predictive model for hybrid plant growth estimation.

The model is:
$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$
where,

- Y_{ij}, is the variety mean of ith variety at the jth environment.
- μ_i, is the i^{th} variety mean over all environments.

- β_i, is the regression coefficient that measures the response of the ith variety to varying component.
- I_j, is the environment index.

2.3 Optimal Water Usage Prediction Model

Authors suggest a similarity in prediction of water usage for varying environment (surroundings) and for a variety of activities.

The model is:

$$Y_{i\,j} = \mu_i + \beta_i I_j + \delta_{ij}$$

- $Y_{i\,j}$, is the mean of ith type of activity at the jth environment.
- μ_i, is the ith activity mean over all environments.
- β_i, is the regression coefficient that measures the response of the ith activity to varying component.
- I_j, is the environment index.

2.4 Relationship mapping between Classification model and Efficient water usage

According to A Survey of household domestic water consumption patterns in rural semi-arid village, India and

The Malvern And Mansfield Studies Of Domestic Water Usage, there exist a number of environmental factors influencing the water consumption per activity, which can be incorporated into the classification model, hence enabling it to predict an Optimal Water Usage Model. Broadly, environments that impact water consumption activities are as follows:

- Classification of socio-economic groups.
- Dependency of Seasonal Variation

2.4.1 Classification of socio-economic groups

The recorded annual income data of households was classified in five socio-economic classes based on annual income of the households. According to Survey of household domestic water consumption patterns in rural semi-arid village, India, over a plethora of factors that determine the socio-economic background of families household assets score is preferred, rather than annual income, for classifying households in various socio-economic categories.

2.4.2 Dependency of Seasonal Variation

According to The Malvern and Mansfield Studies of Domestic Water Usage, the effect of the variation in Seasonal pattern resulted in the consumers altering their usage in general. This was attributed to comply to conservation pressures applied towards them, following the variation.

2.5 Analysis of Water Usage

This section elaborates on parameter specification for the predictive optimal model. The values for the user are predicted on the basis of observed classifying model. The measured usage data is obtained by the hardware setup, which is compared with that of optimal predicted model values.

The comparison model is:

$$|X_p| - |X_i| <= T_P$$

where,

- X_p, is the usage data from predictive classifying model per activity.
- X_i, is the obtained data from sources per activity.
- T_p, is the threshold determined by the predictive classification model. The wastage or usage is calculated using the above model.

3. Implementation Details

3.1 Components Used

This section expands on the components used, their specifications and the interaction among the different components.

3.1.1 NodeMCU WiFi Module

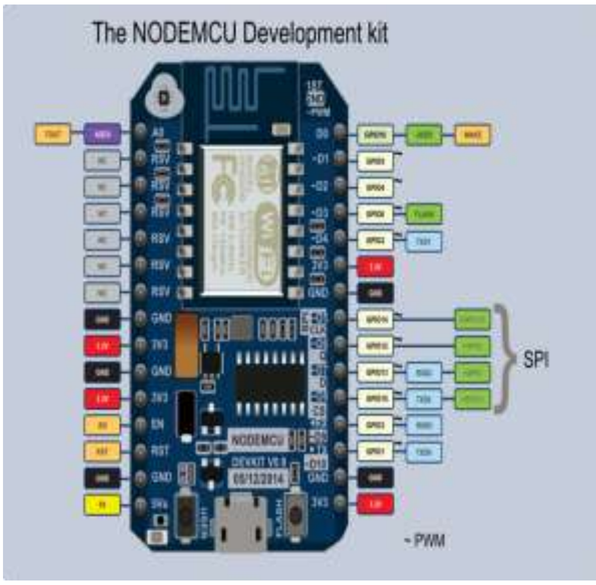

Figure 2: NODEMCU Pin Configuration

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi System on a Chip, and hardware which is based on the ESP-12 module. The term NodeMCU refers to the firmware rather than the development kits. The ESP8266 is a Wi-Fi chip which is embedded into the NodeMCU. The ESP8266 chip supports IEEE 802.11 b/g/n Wi-Fi, and uses 64KiB of instruction RAM, and 96KiB of data RAM. Here, the NodeMCU module performs certain key functions. It connects to the pre-defined Access Point and establishes a connection to the Central Server. Once a connection is established, it sends the data from the flow rate sensor to the Central Server.

3.1.2 YF-S201 Flow-Rate Sensor

The YF-S201 Flow-Rate Sensor is a device which is used to measure the water flow. This sensor sits in line with the water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic Hall Effect sensor that outputs an electrical pulse with every revolution. The Hall Effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. The pulse signal is a simple square wave. We use the following formula to obtain a numeric value of the flow rate in Litres per minute according to the following formula:

Pulse frequency (Hz) / 7.5 = Flow Rate

This gives us the flow rate of the water in L/min format. Using the above equation, we calculate the rate of water flowing through a pipe, as well as the total amount of water flow through the pipe.

3.1.3 Central Server

The server, as is the usual case, acts as the central backbone connecting all parts of the system. Author's use a Node.js server running a framework known as express on top of it. It directly handles requests from circuits measuring the water usage level and processes them and stores it in the MySQL Database. The server also accepts requests from users, as well as the initial parameters required to analyze the usage in the correct way for a specific user.

3.2 Interaction among Components

This section expands on the hardware setup and programming aspect of the circuit. The hardware setup includes the connection of the Flow-Rate Sensor to the NodeMCU circuit. NodeMCU programming involves setting up the module, connecting to the Central Server and sending obtained data values to the server.

3.2.1 NodeMCU-Flow-Rate Sensor Circuit

The flow rate sensor has 3 pins that are connected to the NodeMCU. Those pins are ground, Vcc and Hall Effect output pin. The steps involved in this setup are as follows,

- The black wire (ground) of the flow rate sensor is connected to the ground pin of the NodeMCU.
- The red wire (Vcc) of the flow rate sensor is connected to the 3.3V pin of the NodeMCU.
- The yellow wire (output) of the flow rate sensor is connected to pin D2 of the NodeMCU.
- The NodeMCU is connected to a 5V battery as its power source.
- One end of the pipe is given as input to the flow rate sensor, and the output point of the flow rate sensor is given to the other end of the pipe.

3.2.2 NodeMCU Programming

The NodeMCU is programmed using the Arduino IDE. The Arduino IDE requires the board used and the port being used to be mentioned. The NodeMCU board is loaded and the appropriate port is selected. Now the board is ready to be programmed.

3.2.2.1 Connecting to the Internet

The first step in setting up the NodeMCU module is to connect to the Internet. We accomplish this by using certain predefined libraries. We use the WiFiClient and ESP8266 libraries which have the APIs to connect to a host connection. This is done in the following steps:

- First, the Baud Rate is specified by the function Serial.begin(). This is done to set the rate at which data appears at the Serial Monitor. The preferred value is 115200, but other predefined values are acceptable.
- Now, the API AddAP() is used to specify the SSID as well as the passwords used to connect to the Access Point. It takes two arguments, namely the SSID of the access point and the password.
- The AddAP() function is coded in such a way that it runs until a connection is established. A maximum limit is set on the number of attempts. If a connection is not established within the set limit, an error is sent to the console.
- Once a connection is established, an acknowledgment is sent to the console.

If the above steps are followed correctly, a connection to the Access Point is set-up.

3.3 User Interaction

When the system is installed, the user is asked to specify various parameters regarding his surroundings that affect water usage levels and help in determining the optimal water usage for various activities that occur. These, for example, may include parameters like number of people living, area of the establishment, number of vehicles owned, and would then go into further details regarding the type of equipments to location and climate of the place. After this is achieved, the system measures the data and processes it and analyzes the usage to be optimal or excess based on these parameters specified by the user and shows them a comparison of it with the actual usage. Figure 3 shows a minimalistic graph that is observed by a user for a particular activity performed and analyzed by the system. Here, the water usage during the activity Washing Clothes is measured and shown over the duration of five days. The user is able to see the daily trends and realize when the usage has gone above optimal, and if so, and what might have been done to reduce it.

4. Future Scope

With the ever increasing need for sustainable development and control in usage of natural resources, water being the most important of all, there arises a dire need to develop smart automated systems which could help us use resources with more precaution and discretion. The proposed system could prove to be a stepping stone in this direction.

Figure 3: Sample Actual VS Optimal Graph

It could be easily further enhanced to perform various other tasks, some of them as follows:

- Detecting Water Leaks
- Detecting overflowing of water
- Automated Closing of taps
- Realization of optimal set of activities in case of water supply subject to constraints

5. Conclusion

Current work establishes a simple, cheap, yet effective IoT based system for classifying Water Usage as Optimal or excess. A user is able to specify his/her use case and receives analysis accordingly. With the help of this product, human beings can consciously increase their efforts in order to save water and reduce wastage due to them.

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Author Profile

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