SMART WATER FOUNTAINS

Introduction :

Today, more people around the world have pets than ever before. According to American Pet Products Association's survey in 2020, 67% of U.S. households own a pet which is about 84.9 million homes. This proportion has been increased by 20% in thirty years . Breakdown of the pet types, cats and dogs are the most popular animals, they contribute to about 80% of all pets. Same trend happens all over the world. On average, one in three households own a dog globally and about a quarter of households worldwide own a cat . Both cats and dogs prefer flowing water. A source of fresh clean running water can encourage pets to drink. Drinking a certain amount of water daily plays an important role in long-term health for pets, especially cats. As a result, a water fountain is essential to most households having cats or dogs as pets. However, we can not ensure the water quality when we are away from home for several days. It can happen when pets have finished all remaining water in the water fountain, or water has been polluted somehow by the pet. These can cause the pet to be unwilling to drink water from the fountain.

Our goal is to design a smart water fountain that can monitor the water quality and automatically replace water when polluted(not healthy) or running out. We will use sensors to measure the water quality. Common water quality measurement factors include temperature, Ph-value,

conductance, turbidity and hardness . Considering the pollution at home can only affect limited factors, we choose temperature, Ph-value and conductance to be the three properties used for calculating water quality in our water fountain. These data will be collected, calculated, and reflected to the user in terms of "Good", "Average" and
"Bad". The water fountain is also designed to self-filter the water every time when water is pumped through the submersible water pump.

PROBLEM:

Smart water fountains are becoming increasingly popular, both for pets and humans. They offer a number of advantages over traditional water fountains, such as:

- Convenience: Smart water fountains can be automated to refill themselves, meaning you don't have to worry about running out of water.
- Hygiene: Smart water fountains often have built-in filters that remove impurities from the water. This helps to keep the water clean and fresh for your pet or yourself.
- Monitoring: Some smart water fountains come with monitoring features that allow you to track your pet's water intake or detect any potential problems with the fountain.

However, smart water fountains are not without their problems. Some ofthe most common problems that people report include:

- Technical issues: Smart water fountains are complex machines, and they can sometimes experience technical problems. This can include things likethe pump failing, the filter not working properly, or the sensors not functioning correctly.
- Noise: Some smart water fountains can be quite noisy, especially if the pump is not well-designed. This can be a problem if the fountain is locatedin a bedroom or other quiet area.
- Cost: Smart water fountains are more expensive than traditional water fountains. However, the convenience and additional features may be worth the extra cost for some people.

Here are some specific examples of smart water fountain problems that people have reported:

- The fountain may leak water.
- The pump may not work properly, causing the water to flow too slowly or not at all.
- The filter may not remove all of the impurities from the water.
- The sensors may not function correctly, causing the fountain to turn on or off at the wrong time.
- The fountain may be too noisy.
- The fountain may be difficult to clean.

If you are considering buying a smart water fountain, it is important to be aware of the potential problems. Be sure to read reviews of different products before you buy, and choose a fountain from a reputable manufacturer.

If you do experience problems with your smart water fountain, the first thing you should do is try to troubleshoot the problem yourself. Check the manual for instructions on how to clean and maintain the fountain, and troubleshoot any common problems. If you are unable to fix the problem yourself, you may need to contact the manufacturer for assistance.

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DESIGN THINKING:

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Background:

There have been quite a lot of water fountain products on the market, while most of them have only filtration as an extra function besides providing running water. The size of the water fountain limits the capacity of the water source that most water fountains cannot store enough water for multiple pets to drink in several days.
Our water fountain can be connected to an extra water source that provides enough water for long-term usage. The link is adaptable to universal water bottles for convenience. The sufficient water source as well as automatic replacing and refilling function enable pet owners to leave home for several days without worrying about water supply for pets.

Physical Design:

Physical design in smart water fountains using the Internet of Things (IoT) can be used to create a more efficient, sustainable, and interactive experience for users. By collecting and analyzing data from sensors, smart water fountains can be programmed to optimize water flow, temperature, and other settings. This can help to reduce water waste and energy consumption, while also improving the quality of the water.

Some specific examples of how physical design can be used to improve smart water fountains include:

- **Using sensors to detect when someone is using the fountain and then automatically adjusting the water flow and temperature accordingly. This can help to save water and energy, while also ensuring that users have a comfortable experience.**
- **Using LED lights to create colorful and dynamic displays that can be programmed to change based on the time of day, the weather, or other factors. This can make the fountain more visually appealing and engaging for users.**
- **Using touchscreens or other interactive interfaces to allow users to control the fountain's settings, such as the water flow rate, temperature, and lighting. This can give users more control over their experience and make the fountain more fun to use.**
- **Using IoT to connect the fountain to a central network. This can allow the fountain to be monitored and managed remotely, and can also be used to collect data on water usage, energy consumption, and other metrics. This data can then be used to improve the efficiency and sustainability of the fountain, and to identify any potential problems.**

Overall, physical design can play a significant role in making smart water fountains more efficient, sustainable, and interactive. By carefully considering the needs of users and the capabilities of IoT technology, designers can create fountains that are both functional and fun to use.

Here are some additional thoughts on how physical design can be used to improve smart water fountains:

- **Use materials that are durable and easy to clean. This will help to ensure that the fountain remains in good condition and is easy to maintain.**
- **Design the fountain in a way that is accessible to people of all ages and abilities. This may include features such as ramps, handrails, and adjustable heights.**
- **Incorporate features that encourage users to interact with the fountain. This could include things like interactive games, puzzles, or educational displays.**
- **Make the fountain visually appealing and inviting. Use colors, shapes, and textures that are both eye-catching and calming.**

By following these tips, designers can create smart water fountains that are both functional and enjoyable to use.

Functional Requirements:

- **The smart water fountain must be able to dispense water at different temperatures (e.g., cold, room temperature, hot).**
- **The smart water fountain must be able to track water usage and filter life.**
- **The smart water fountain must be able to send alerts to users when water usage is high or when the filter needs to be replaced.**
- **The smart water fountain must be able to be controlled remotely using a mobile app or website.**

Non-Functional Requirements:

- The smart water fountain must be easy to use and maintain.
- The smart water fountain must be energy-efficient.
- The smart water fountain must be durable and reliable.
- The smart water fountain must be secure from unauthorized access.

IoT Requirements:

- The smart water fountain must be able to connect to the Internet of Things (IoT) platform.
- The smart water fountain must be able to send and receive data from the IoT platform.
- The smart water fountain must be able to be managed and controlled remotely using the IoT platform.

Additional Requirements:

- The smart water fountain may be equipped with additional features such as:
  - Water quality monitoring
  - UV sterilization
  - Carbon filtration
  - Ozone purification
  - Voice control
  - Touchscreen display

- **Payment options**

  The specific requirements for a smart water fountain will vary depending on the intended use and location of the fountain.
  For example, a smart water fountain for a public park may have different requirements than a smart water fountain for an office building.

Here are some examples of how IoT can be used to enhance the functionality of smart water fountains:

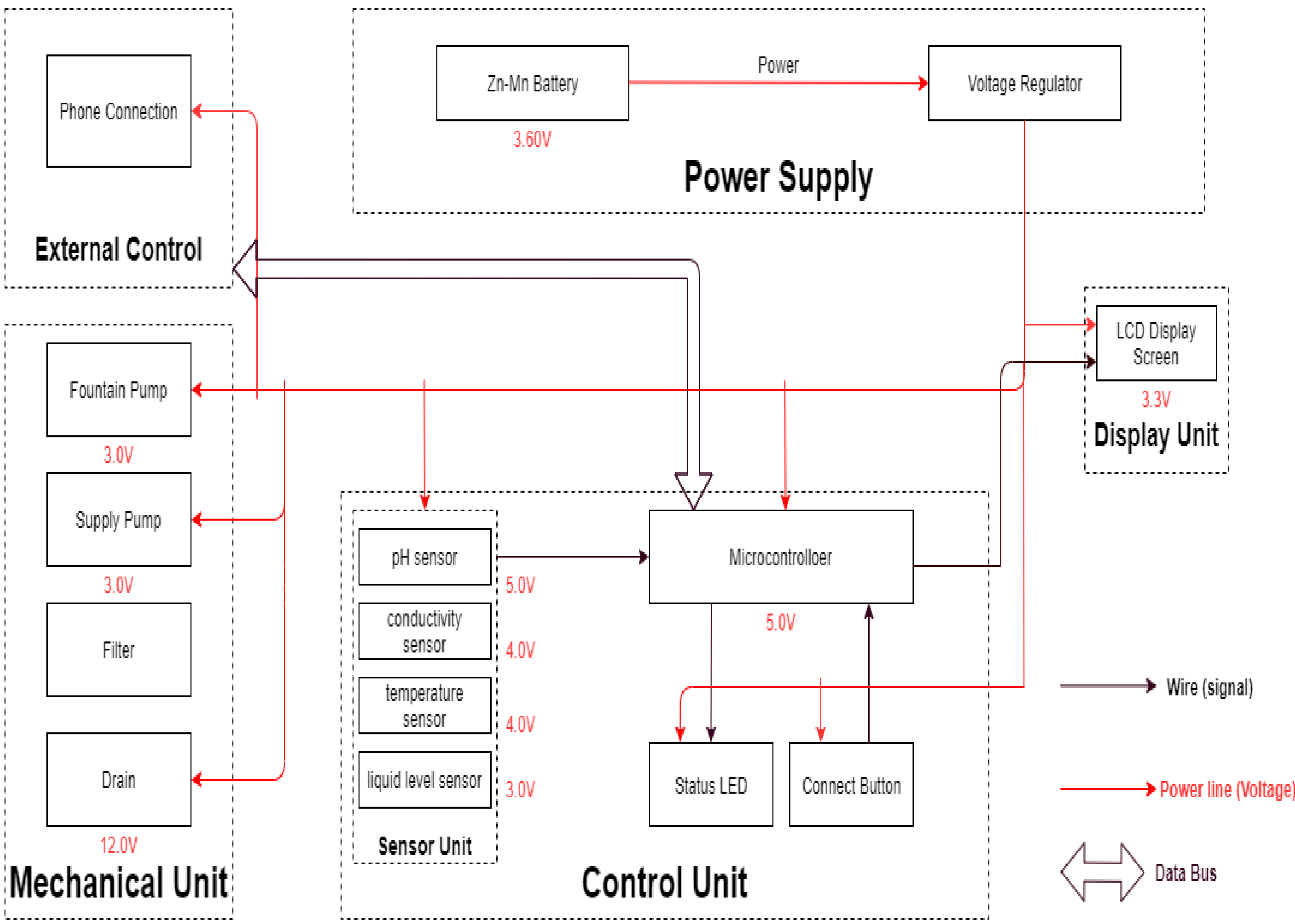
- **Water quality monitoring:** Smart water fountains can be equipped with sensors to monitor the water quality for contaminants such as bacteria, viruses, and chemicals. This data can be sent to the IoT platform and used to generate alerts to users if the water quality is not safe to drink.
- **UV sterilization:** UV sterilization is a highly effective method of disinfecting water without the use of chemicals. Smart water fountains can be equipped with UV sterilizers to ensure that the dispensed water is safe to drink.
- **Carbon filtration:** Carbon filtration can be used to remove impurities from water such as chlorine, taste, and odor. Smart water fountains can be equipped with carbon filters to improve the taste and quality of the dispensed water.

- **<u>Ozone purification:</u>** **Ozone is a powerful oxidizer that can be used to disinfect water and remove organic impurities. Smart water fountains can be equipped with ozone purification systems to ensure that the dispensed water is safe to drink and has a good taste.**
- **<u>Voice control:</u>** **Smart water fountains can be integrated with voice assistants such as Amazon Alexa and Google Assistant to allow users to control the fountain using voice commands. For example, a user could say "Alexa, dispense a glass of cold water" to get a glass of cold water from the fountain.**
- **<u>Touchscreen display:</u>** **Smart water fountains can be equipped with touchscreen displays to allow users to interact with the fountain and view information such as water usage, filter life, and water quality data.**
- **<u>Payment options:</u>** **Smart water fountains can be integrated with payment systems such as credit cards and mobile wallets to allow users to pay for water without having to carry cash.**

IoT can be used to make smart water fountains more convenient, efficient, and safe for users. By connecting smart water fountains to the IoT, facility managers can also gain valuable insights into water usage and patterns. This information can be used to improve water conservation efforts and reduce costs.

Design:

The block diagram below is a general design of our solution. We divide our design into four modules, including Power Supply, Control Unit, External Control, and Mechanical Unit. Details of each unit is presented in the diagram and described in the next section.



Block Diagram of Smart Water Fountain

Sensor Unit:

This block contains the four sensors. The data acquired from the sensors will be transmitted to the control unit. Control unit will then have some logic designed to send

corresponding signals to control other blocks of the water fountain. At the same time, the display screen on the water fountain will display the readings along with the determined water quality level and remaining water quantity.
For the PH-value sensor, temperature sensor and conductivity sensor, values will be retrieved and calculated to determine the overall water quality level. When poor water quality is determined, the water replacement procedures will take place. The weight sensor readings will be used to determine the amount of fresh water left in the water tank.

Temperature Sensor:

A water-proof temperature sensor is going to be used. Part number from sparkfun is: DS18B20 . This temperature sensor is compatible with a relatively wide range of power supply from 3.0V to 5.5V. The measured temperature ranges from -55 to +125 celsius degrees.
Between -10 to + 85 degrees, the accuracy is up to +-0.5 degrees. This sensor can fulfill all requirements needed for this project.

PH-sensor:

PH value is a valued indicator of water quality. This PH-sensor works with 5V voltage, which is also compatible with the temperature sensor. It can 6measure the PH value from 0 to 14 with an accuracy of +- 0.1 at the temperature of 25 degrees.

Conductivity sensor:

Conductivity sensor is also part of the water quality assessment. The input voltage is from 3.0 to 5.0V. The error is small, +-5%F.S. The measurement value ranges from 0 to 20 ms/cm which is enough for water quality monitoring.

Liquid Level Sensor:

This sensor is responsible for reflecting how much freshwater is left in the water tank. When the water level is low, fresh water will be pumped to the water tank to ensure the water fountain keeps running with freshwater. This sensor is 0.5 Watts. For water level from 0 to 9 inches, the corresponding sensor outputs readings from 0 to 1.6. From that, the quantity of freshwater left can be determined.

Display unit:

Screen:

The screen will be used to display the readings from the sensors in a real-time manner. In addition, other necessary information will also be displayed. As described in the sensor part, the water quality and remaining water quantity will be displayed. The screen will be programmed so that it makes it easy for users to read information.
This 20*4 LCD display screen is going to be used to display the relevant information. After programming the screen, a conclusion of water quality(Good, Average, Poor) will be displayed along with the remaining water level.

Power Supply Unit:

Zn-Mn Battery:

The Zn-Mn battery must be able to continuously support the functioning of the circuit, display unit, and the mechanical unit.
Requirement: Commercial batteries will be used to maintain a continuous 3.60V power supply for at least 24 hours. If the chosen battery is not powerful enough, 120V power outlets will be considered.

Voltage regulator:

The integrated circuit will regulate the power supply for each module to maintain their functionality. This chip must be able to handle the maximum voltage supplied by the battery (3.60V ± 0.5V) while ensuring the voltage at each module does not exceed their limit.

Requirement: Must maintain thermal stability below 100°C.

Mechanical Unit:

Fountain Pump:

The fountain pump must maintain a continuous water supply through the fountain mechanism. The pump must work 24 hours a day, 7 days a week unless the user manually turns off the power supply.

Requirement 1: The fountain pump must lift a cylindrical water stream of diameter 6mm for a height of 400mm.

Requirement 2: The fountain pump must serve for a duration of 2 years without maintenance or replacement under heavy workload.

Requirement 3: The fountain pump should have an operational condition around 3V, 200mA.

Supply Pump:

The supply pump must function when a low water level alert is raised. While no water supply is requested, the pump must prevent water flow between the main supply and the fountain. **Requirement**: The supply pump should have an
operational condition around 3V, 200mA.

Filter:

The filter must maintain the water quality through controlling the pH value and conductivity of the water.

Requirement 1: The filter must have a cost less than $5 each for frequent replacement. Each new filter must serve a duration no less than 3 month.

Requirement 2: The filter must be designed for easy removal and installation, while the connection mechanism must have a low degenerate rate when submerged in water.

Drain:

The drain must be able to hold and release water in the fountain. When water in the fountain should be replaced, the faucet should automatically drain the fountain once instruction is received from the integrated circuit.

Control Unit:

This unit contains the control unit which does the following things:

• When the weight sensor reports a weight less than the minimum weight setting, the control unit will send an alert signal to the user and then control the water supply unit to refill the water fountain with a certain amount of water.

• Computes the water quality with data transferred from the three sensors in the water quality module and sends the result in terms of “Good”, “Average” or “Bad” to the user.

• If the water quality is “Bad”, the control unit will control the drain module to drain the water in the fountain and then control the water supply to refill.

• Water quality result is sent to the user with wireless connection and screen display as described above in the display unit.(unsure about keeping this function)

Risk Analysis:

Control Unit Block:

One of the most challenging points in this project is the precise control of the control unit between different blocks.

To react accurately and promptly based on the results from the sensors is the key. The control unit needs to accommodate the mechanical and the electrical part so that the pumps, draining system can work collaboratively smoothly. From acquiring the data from sensors, analyzing the data, communicating and displaying the data to users, and then sending signals to activate the corresponding actions(drain or add fresh water), these are all to be performed by the control unit. Thus, it is the block that brings the greatest risk.

We will divide all the overall control unit functions into three parts: data retrieving, data manipulation, data delivering.

Data retrieving is the logic used to read data from all sensors. Necessary algorithm is to be written to ensure successful and accurate data acquisition. Data manipulation is the process of calculating the water quality levels, and the formula to integrate all the data to produce a credible result. The data delivering is used to connect the control unit to the screen, displaying the necessary information as described above. This part will also be responsible for building the
connection between the water fountain and the users' phones through WIFI.

Mechanical Unit Block:

This is very challenging and extremely important. As most of the components will be exposed to water. Sensors, pumps, filters, draining system motors are all to be placed in the water tank. This means that we need to ensure no water can leak into the electrical-related mechanical parts. This puts pressure on the design and also the implementation. In addition, the motor-controlled valves used to drain the polluted water need to be firm when closed. Otherwise the fresh water will be leaking to the polluted water storage and the water consumption will be uncontrollable.

To achieve those points, we will make sure the designs are carefully implemented. The actual building process for the container should be proved before placing the electronic parts in.

Ethics and Safety:

I-1 of IEEE Code of Ethics:

Quoted from IEEE Code of Ethics: “To hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment.” We will carefully choose the materials used to build the container. Non-toxic are sure to be used. We will prefer using reusable materials. In addition to that, the users can choose to buy reusable bottles of water for the freshwater supply for the water fountain. Those universal water bottles are safe and reusable. Aspecial connector will be designed and the universal connection is to be used.After the water in the bottle is used up, this reusable bottle can be recycled and reused. This is the most environmentally-friendly solution and complies with the IEEE Code of Ethics #I-1. It not only improves the practicality, convenience, and reduces the future cost when using the water fountain.

II of IEEE Code Of Ethics:

Quoted from "II. To treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others." As mentioned in the 3.2, the mechanical unit involves electronic components that are physically placed in the water tank. The consequence can be serious if the leakproofness is not performed properly. To maintain a safe, convenient using experience, we will be responsible for testing and ensuring all containers meet the demand. These actions must be taken to ensure the safety of using the water fountain and protect the others.

I-6 of IEEE Code Of Ethics:

Quoted from "to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations."
All team members involved in the development of the water fountain have completed "Laboratory Safety training" and have gained required and necessary knowledge in dealing with emergency situations. In case of accidents, proper reaction will be made to ensure the safety of people and property to the largest extent.

Conclusion:

Incorporating predictive maintenance algorithms into smart water fountains isa promising way to reduce downtime and costs associated with equipment failures. By identifying potential malfunctions before they occur, facility managers can take corrective action and avoid costly disruptions to service.

In addition to the benefits listed above, predictive maintenance can also helpto:

- Improve the overall reliability of smart water fountains
- Extend the lifespan of smart water fountain equipment
- Reduce the need for emergency repairs
- Improve the safety and quality of drinking water

As the technology continues to develop, it is likely that predictive maintenance will become an increasingly important part of smart water fountain management.

.To load and preprocess smart water fountain data in the IoT,we can use thefollowing steps:

- ☐ **Connect the smart water fountain to the internet**: Thiscan be done using a variety of methods, such as Ethernet, Wi-Fi, or cellular data.
- ☐ **Identify the data streams:** Once the smart water fountain is connected to the internet, we need to identify the data streams that we want to collect. This may include data such as water flow, temperature, and water quality.
- ☐ **Store the data**: Once we have identified the data streams,we need to store the data in a central location. This can bedone using a cloud-based database or an on-premises database.

- ☐ **Preprocess the data:** Once the data has been stored, we need to preprocess it before it can be used for analysis. Thismay involve cleaning the data, normalizing the data, and transforming the data.

Once the data has been preprocessed, we can use it to trainmachine learning models to perform various tasks, such as:

- ☐ Predicting water demand
- ☐ Identifying potential problems
- ☐ Providing personalized recommendations

Here are some specific examples of how smart waterfountain data can be used in the IoT:

- ☐ A water fountain company could use smart water fountain data to identify areas where there is high demand for water fountains and install new fountains in those areas.
- ☐ A water fountain company could also use smart water fountain data to identify water fountains that are not being used very often and remove them from service.
- ☐ A smart water fountain could be used to track a user's waterintake and send them notifications if they are not drinking enough water.
- ☐ A smart water fountain could also be used to recommend theoptimal water settings for each user, based on their individual preferences.

Smart water fountains are a valuable source of data that canbe used to improve the efficiency, safety, and convenience ofwater fountains for everyone. By using the IoT to collect andanalyze data from smart water fountains, we can gain a better understanding of how water is being used and make necessary adjustments to improve the water system.

Data preprocessing:

Some common data preprocessing tasks in IoT include:

- ☐ **Cleaning the data:** This involves removing errors and inconsistencies in the data. For example, we might removeduplicate data points or fill in missing values.
- ☐ **Normalizing the data:** This involves scaling the data so that all values are on the same scale. This makes it easier to compare and analyze different data points.
- ☐ **Transforming the data:** This involves converting the data into a format that is more suitable for our analysis. For example, we might convert timestamps into a consistent format or convert categorical variables into numerical variables.

Data preprocessing is an important step in any IoT project. By properly preprocessing the data, we can ensure that ouranalysis and machine learning models are accurate and reliable.

Here are some specific examples of how data preprocessingis used in IoT:

- ☐A smart water fountain company might use data preprocessing to clean and normalize data about water usage and preferences. This data could then be used to traina machine learning model to predict water demand.
- ☐A smart city might use data preprocessing to clean and normalize data from traffic sensors and other devices. This data could then be used to train a machine learning model tooptimize traffic flow.
- ☐A smart factory might use data preprocessing to clean and normalize data from industrial sensors and equipment. This data could then be used to train a machine learning model topredict maintenance needs and prevent downtime.

Data preprocessing is an essential step in any IoT project that aims to extract valuable insights from the data collectedfrom IoT devices.

☐ Five major steps of data preprocessing:

- ☐**Data cleaning:** Removing duplicate data points from the smart water fountain data can help to ensure that the data isaccurate and reliable.
- ☐**Data normalization:** Normalizing the smart water fountain data can make it easier to compare and analyze different data points, such as water flow rates and water temperatures.

- **Data transformation:** Converting timestamps in the smart water fountain data to a consistent format can make it easierto analyze the data over time.
- **Data feature engineering:** Creating a new feature from the smart water fountain data that represents the average waterflow rate over the past hour can be more predictive of futurewater demand than the current water flow rate.

By preprocessing the smart water fountain data, we can ensure that our analysis and machine learning models are accurate and reliable. This can help us to improve the efficiency, safety, and convenience of smart water fountainsfor everyone.

Program:

```
import pandas as pd

# Load the data
df = pd.read_csv('data.csv')

# Clean the datadf =
df.dropna()
df = df.drop_duplicates()

# Normalize the data
from sklearn.preprocessing importStandardScaler
scaler = StandardScaler()
df_scaled = scaler.fit_transform(df)
```

```
# Transform the data
# For example, convert categorical variables into numerical variables
df_transformed = pd.get_dummies(df_scaled)

# Save the preprocessed data

df_transformed.to_csv('data_preprocessed.csv', index=False)
```

Importance of loading and preprocessingthe dtaset:

- ☐ **To improve the accuracy of machine learning models:** Machine learning models are trained on data, and the quality of the data has a direct impact on the accuracy ofthe models. By loading and preprocessing the data carefully,we can ensure that the models are trained on accurate and reliable data, which will lead to better predictions.
- ☐**To reduce the time and resources required to train machine learning models:** Preprocessing the data can helpto reduce the time and resources required to train machine learning models. For example, by normalizing the data, we can ensure that all features are on the same scale, which can make the training process more efficient.
- ☐To **prevent overfitting:** Overfitting occurs when a machine learning model learns the training data too well and is unable to generalize to new data. Preprocessing the data can

help to prevent overfitting by removing noise from the dataand making the data more representative of the real world.

- ☐**To improve the interpretability of machine learning models:** Interpretability is the ability to understand why a machine learning model makes the predictions that it does.Preprocessing the data can help to improve the interpretability of machine learning models by making the data more structured and easier to understand.

Here are some specific examples of how loading and preprocessing a dataset of smart water fountains in the IoTcan be beneficial:

- ☐**Predicting water demand:** By loading and preprocessing a dataset of smart water fountain data, we can train a machinelearning model to predict water demand. This information can be used to optimize the operation of the water fountainsand ensure that there is always enough water available.
- ☐**Identifying potential problems**: By loading and preprocessing a dataset of smart water fountain data, we cantrain a machine learning model to identify potential problems, such as leaks or water quality issues. This information can be used to prevent problems from occurringand save money on maintenance costs.
- ☐**Providing personalized recommendations:** By loading and preprocessing a dataset of smart water fountain data, we can train a machine learning model to provide personalized recommendations to users. For example, the model could recommend the optimal water temperature and

flow rate for each user, based on their individualpreferences.

Challenges involed in loading and preprocessing a smart water fountainsdataset:

There are a number of challenges involved in loading and preprocessing a smart water fountains dataset. Some of themost common challenges include:

- ☐ **Data quality:** Smart water fountains can generate a large volume of data, but the quality of the data can vary depending on the type of sensors used and the environmental conditions in which the fountains are located. It is important to clean the data to remove any errors or inconsistencies.
- ☐ **Data format**: Smart water fountains can generate data in avariety of formats, such as CSV, JSON, and XML. It is important to convert the data into a consistent format so that it can be easily loaded and processed.
- ☐ **Data volume:** Smart water fountains can generate a large volume of data, which can be challenging to load and process. It is important to use efficient data processing algorithms and scalable infrastructure.
- ☐ **Missing values**: Smart water fountains may not be able to generate data for all of the sensors all of the time. This can lead to missing values in the dataset. It is important to

handle missing values in a way that does not bias the resultsof the analysis.

- ☐**Outliers**: Smart water fountains may generate data that is outside of the expected range. This can be caused by sensor malfunctions or other environmental factors. It is importantto identify and remove outliers from the dataset before performing any analysis.

How to overcome the challenges of loading and preprocessing a smart waterfountain dataset:

To overcome the challenges involved in loading and preprocessing a smart water fountains dataset, you can trythe following tips:

☐ **Data quality:**

- ☐**Use a variety of data quality checks:** This could include checking for duplicate data, missing values, and inconsistencies in the data types.
- ☐**Use a data validation framework**: A data validation framework can help you to automate the data quality checksand ensure that the data is meeting your standards.
- ☐**Use a data quality monitoring tool:** A data quality monitoring tool can help you to continuously monitor the data quality and identify any problems that arise.

☐ Data format:

☐ **Use a standard data format**: A standard data format, such as CSV or JSON, will make it easier to load and process the data.

☐ **Convert the data to a standard data format:** If the data is not in a standard data format, you can use a data conversiontool to convert it to a standard format.

☐ **Use a data wrangling tool:** A data wrangling tool can help you to clean and transform the data into a format that is suitable for your analysis.

☐ Data volume:

❖ **Use a scalable data processing platform**: A scalable data processing platform, such as a cloud-based platform, can help you to process large volumes of data efficiently.

❖ Use distributed data processing **algorithms**: Distributed data processing algorithms can help you to process large volumes of data by distributingthe workload across multiple machine.

☐ Missing values:

☐ **Use a missing value imputation technique:** There are a number of missing value imputation techniques that can beused to fill in missing values in a dataset. One common approach is to impute the missing values with the mean or median value of the feature.

- ☐ **Use a machine learning algorithm to impute the missingvalues:** Machine learning algorithms can be used to impute missing values by learning from the relationships between the different features in the dataset.
- ☐ **Remove data points with missing values**: If the number ofmissing values is high or if the missing values are concentrated in certain features, it may be necessary to remove data points with missing values.

- ☐ **Outliers:**

- ☐ **Identify outliers using statistical methods**: There are anumber of statistical methods that can be used to identifyoutliers in a dataset. One common approach is to use the interquartile range (IQR) method.
- ☐ **Remove outliers from the dataset:** Once the outliers havebeen identified, they can be removed from the dataset.
- ☐ **Use a machine learning algorithm to detect and removeoutliers:** Machine learning algorithms can be used to detectand remove outliers by learning from the relationships between the different features in the dataset.

Loading the dataset:

To load the dataset in smart water fountains, you can followthese steps:

- ☐ **Identify the source of the data**: The data can be collected from a variety of sources, such as the smart water fountainitself, a cloud-based database, or a local file system.
- ☐ **Choose a data format:** The data can be stored in a variety of formats, such as CSV, JSON, or XML. Choose a format that is easy to load and process.
- ☐ **Load the data into a data processing environment:** Onceyou have chosen a data format, you can load the data into a data processing environment, such as a spreadsheet program or a programming language environment such as Python or R.
- ☐ **Clean the data**: Once the data is loaded, you need to clean itto remove any errors or inconsistencies. This may involve removing duplicate data points, filling in missing values, andcorrecting errors in the data.
- ☐ **Normalize the data:** Normalizing the data will make it easier to compare and analyze different data points. This involves scaling the data so that all values are on the samescale.
- ☐ **Transform the data:** You may need to transform the data into a format that is more suitable for your analysis. For example, you may need to convert categorical variables intonumerical variables or create new features from existing features.
- ☐ **Save the preprocessed data**: Once the data has been cleaned, normalized, and transformed, you can save it to a file or database. This will make it easier to access and use thedata in the future.

Program:

```
import pandas as pd

# Load the data from a CSV filedf =
pd.read_csv('smart_water_fountain_data.csv'
)

# Clean the datadf =
df.dropna()
df = df.drop_duplicates()

# Normalize the data
from sklearn.preprocessing importStandardScaler
scaler = StandardScaler()
df_scaled  =  scaler.fit_transform(df)

# Transform the data
# For example, convert categorical variables into numerical variables
df_transformed = pd.get_dummies(df_scaled)

# Save the preprocessed data df_transformed.to_csv('smart_water_fountain
_data_preprocessed.csv', index=False)
```

Data set:

- Water quality monitoring analysis:

The quality of rooftop rainwater can be affected by the localenvironment, roof material, and regular cleaning/maintenance. To further understand the water'sdiverse properties, we collected and examined 15 rainfall samples from the roofs of different buildings across the area.Samples have been analyzed immediately or within 24 h ofbeing collected. Sterilized glass vials have been used tocollect samples, subsequently transported, and kept in afreezer. The study results showed that the water samplesreduced levels of chlorine anion and significant cations such as magnesium and calcium. This water meets all the requirements for safe consumption, including pH and electrical conductivity. As a result, the study's findings suggest installing a basic filtration system to catch roof sediments before they reach the storage tank and enhancing stormwater quality analysis by 98.7%.

➢ Analyses of stormwater quality:

Number of Consumers	SWFG	DHW	IoT-SWM
10	52	65	78.5
20	54.5	67	84
30	55	64	79
40	58	70.8	81
50	50.1	61.3	94
60	56	63.7	85.7
70	59	66	97.1
80	57	68.4	87
90	53	69	92
100	52.8	62	98.7

➢ Efficiency ratio:

Water efficiency measures the amount of water required for a given operation and the volume of water used or delivered to decrease water waste. Water efficiency differs from conserving water because it focuses on minimizing waste rather than restricting usage, which seems different from water conservation. Planning, producing, distributing, and maintaining the most effective use of water resources are all aspects of water resource management. In the ideal scenario,water resource management planning should include all competing uses and demands for water and be allocated equally to meet all needs. In light of these important factors, an IoT-SWM-based smart water management system design has been given. This design uses machine learning-based predictions to increase the smart management system's efficacy further. By comparison, the suggested strategy improves efficiency by 95.1%. It is essential to have a watermanagement program or plan to ensure that Legionella andother waterborne pathogens are not allowed to flourish andspread in the water systems of residential buildings. In addition, it has been proposed as future work to develop an Internet of Things (IoT)-based architecture for a smart water management system that incorporates all these crucial features and uses IoT-based predictions to boost its efficacy.

Number of Consumers	SWFG	DHW	IoT-SWM
10	58	60	75
20	45	73	78.9
30	52.4	66	90
40	60.8	75.9	87
50	59	77	92
60	65	69	88
70	55	76	91
80	50.9	71	87
90	52	77	80
100	56	60.8	95.1

- **Analyzing water demand ratio:**

Demand is measured by the amount of water needed to meetthe demands of the consumer population. Due to climate change, freshwater resources are expected to decline in many parts of SA. Human population growth, and changes in land usage and energy production, are other influences. The water's dissolved elements were examined using chemical methods, including the number of suspended particles and the pH value. Population expansion is the primary driver of water demand growth. An increase in water required accompanies a rise in economic prosperity. Smart cities and campuses need a water management system. There has beena notable uptick in the deployment of IoT devices for use in water management. The issues with assessing water quality have been resolved by the availability of cheap sensors linked to IoT devices. This article thoroughly analyzes the current state of smart water management systems and describes the core elements of IoT–based water management platforms. This is due to various factors, including increased agricultural and industrial use, residential use, and concealed virtual water. The suggested approach enhances water demand analysis by 93.6 % compared to the previous methods.

Number of Consumers	SWFG	DHW	IoT-SWM
10	55	70	74.5
20	43.5	63	78
30	59	76	84
40	60	65	89
50	52	78	79
60	55	69	85
70	58.9	77	91
80	51	71	94
90	59	73.8	87
100	53	65	93.6

➢ Leakage detection ratio:

A leak detection device that uses acoustics distinguishes between the noises of leaks and the usual flow of water through the distribution system to find them. Sound waves are used to place a tiny flex on the pipe walls to determine the real strength of the wall. Detection of a leak in a system is done using leak detection methods. In a wide variety of applications, the procedures are used to seal tanks that contain some substance. Several detecting techniques can becharacterized depending on whether the LDC is positioned inside or outside. Real-time water monitoring is an essential feature of any intelligent water management system. Water leaks and overflows can be spotted in real time with the help of monitoring equipment. Keeping up with real-time data demands a constant data connection anda lot of juice. The Internet of Things has drastically altered how we do research and make predictions. Internet of Things (IoT) can be integrated into a water management system to forecast the amount of water needed by a smart house or campus at various times of the day and throughoutthe year. The same method can be used to meet the water needs of the campus’s numerous structures. Similarly, studying and anticipating how things like a wet season may affect water quality is possible.

Number of Consumers	SWFG	DHW	IoT-SWM
10	46.3	65.9	76.8
20	55	71	87
30	47	73	82.6
40	49.9	65	90.2
50	53	60.9	79
60	57	64	86
70	45.1	72	94
80	51	71	84
90	58	78	86.9
100	60	79.7	97.5

➢ Analyzing non-revenue water ratio:

Non-revenue water (NRW) has been generated and is lost before reaching the end consumer. Losses can be both actual and perceived (via leaks, sometimes referred to as physical losses). When pipes leak or break, NRW can result in inadequate operations and maintenance, lack of leakage management, and poor quality of subsurface infrastructure.
NRW can originate from business losses due to under registration of client meters, data processing problems, illicitconnections, and theft. Unbillable authorized consumption, such as water used by utilities for operations, water used in firefighting, and water provided for free to specific consumergroups, is another reason for NRW. Developing countries' public water utilities can benefit greatly from reducing their NRW. The water level in the tank or reservoir was evaluated using water level monitoring equipment. Many factors, including pH, total dissolved solids (TDS), dissolved oxygen

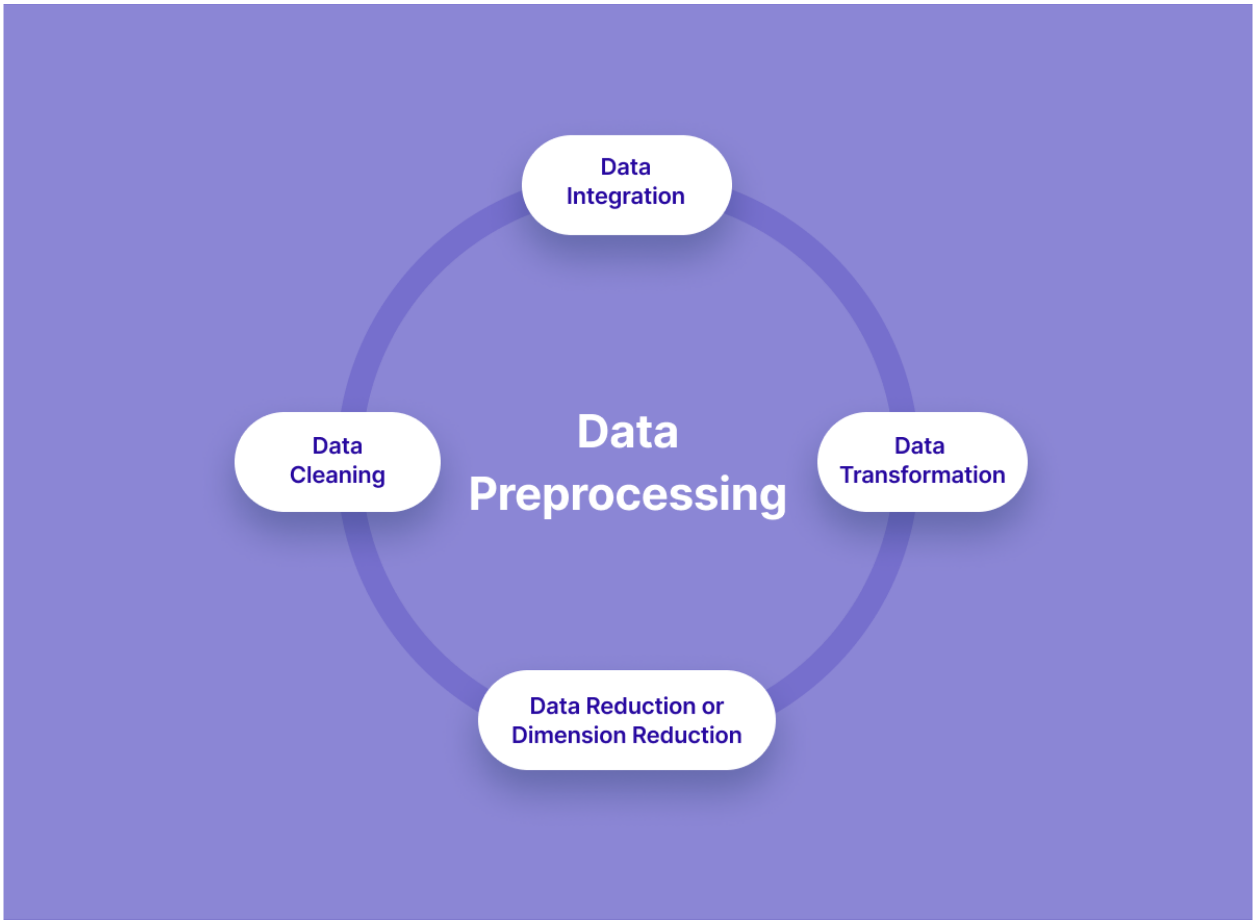
(DO), and others, were measured by water quality monitoring systems. All methods for gauging water quality looked at the pH value as an indicator of quality. Besides pH and dissolved oxygen, temperature, conductivity, and turbidity are frequently measured while checking water quality. There used to be problems with assessing water quality, but now we have cheap sensors that can be linked toIoT devices; thus, the problem is solved. All current smart water management systems were surveyed, and the key elements of the Internet of Things (IoT)-based water management were identified. Important characteristics
such as water level, pH, clarity, salinity, etc., were selectedfor measurement, and all current systems were evaluated.The model for calculating the water loss due to leaks was trained and validated using the IoT-SWM approach. The fastest IoT-SWM produced maximum non-revenue water.

Number of Consumers	SWFG	DHW	IoT-SWM
10	61	76	89
20	75	82	84
30	65	88	90.4
40	73	79	88
50	64	75	82
60	70	83	95
70	68	78	89
80	60	86	90
90	71	89.4	91
100	54	81	98.4

Some common data preprocessing tasks include:

- ☐ **Data cleaning:** This involves identifying and correcting errors or inconsistencies in the data. For example, we mightremove duplicate data points, fill in missing values, and correct typos and inconsistencies in the data.
- ☐ **Data integration**: This involves combining data frommultiple sources to create a unified dataset.
- ☐ **Data normalization:** This involves scaling the data so thatall values are on the same scale. This makes it easier to compare and analyze different data points.
- ☐ **Data transformation:** This involves converting the data intoa format that is more suitable for our analysis. For example, we might convert timestamps into a consistent format or convert categorical variables into numerical variables.
- ☐ **Data reduction:** This involves reducing the size of the dataset while preserving the important information. Thiscan be done using techniques such as dimensionality reduction and feature selection.

Data preprocessing is an important step in any data science project. By properly preprocessing the data, we can ensure that our analysis and machine learning models are accurateand reliable.



Conclusion:

Loading and preprocessing a dataset of smart water fountains is an important step for improving the accuracy, efficiency, and interpretability of machine learning models. By taking the time to load and preprocess the data carefully,we can ensure that our machine learning models are trainedon the best possible data, which will lead to better results.

There are a number of challenges involved in loading and preprocessing a smart water fountains dataset, such as dataquality, data format, data volume, missing values, and outliers. However, there are a number of steps that can betaken to overcome these challenges.

By following the tips and techniques discussed in this article,you can load and preprocess a smart water fountains datasetin a way that is suitable for machine learning. This will help you to prepare the data for analysis and ensure that you are getting the most out of your results.

Here are some additional tips for loading and preprocessinga smart water fountains dataset:

- ☐ Use a domain expert: If you have access to a domain expert,they can help you to understand the data and identify any potential problems.
- ☐ Use a data science platform: A data science platform can provide you with the tools and resources you need to load,preprocess, and analyze your data.
- ☐ Document your code: Documenting your code will help youto keep track of the steps you took to load and preprocess the data. This will also make it easier to reproduce your results in the future.

Loading and preprocessing a smart water fountains dataset can be a challenging task, but it is an important step for preparing the data for machine learning. By following the tips and techniques above, you can overcome the challengesand ensure that you are getting the most out of your analysis.

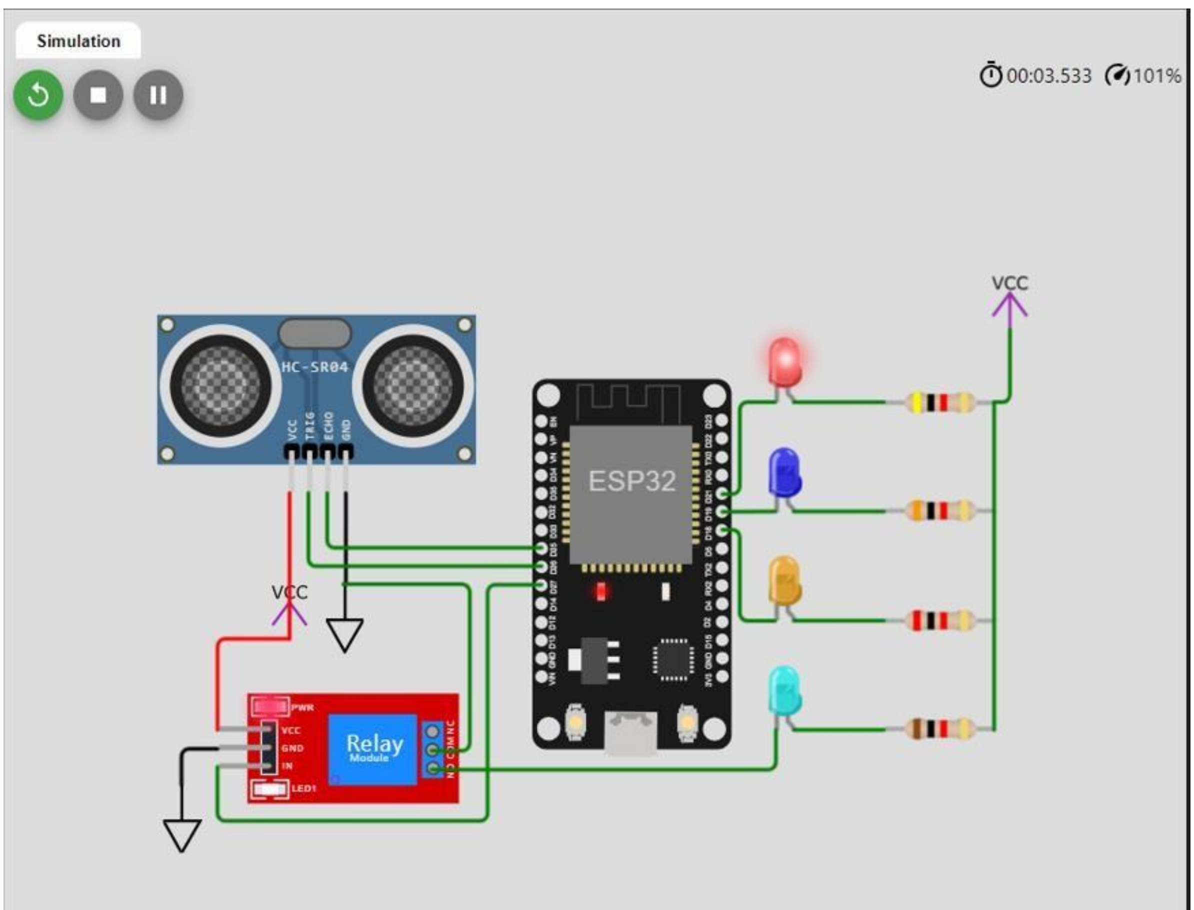
Codes:

```
#define PIN_TRIG 26
#define PIN_ECHO 25
#define LOWLED 18
#define MIDLED 19
#define HIGHLED 21
#define MOTOR 27
unsigned int
level=0;

void setup() {

 pinMode(LOWLED,
 OUTPUT);
 pinMode(MIDLED,
 OUTPUT);
 pinMode(HIGHLED,
 OUTPUT);
 pinMode(MOTOR,
 OUTPUT);
 digitalWrite(LOWLED,
 HIGH);
 digitalWrite(MIDLED,
 HIGH);
 digitalWrite(HIGHLED,
 HIGH);
 digitalWrite(MOTOR,
 LOW);

 Serial.begin(115200);
 pinMode(PIN_TRIG,
 OUTPUT);
 pinMode(PIN_ECHO,
 INPUT);
}

void loop() {
 // Start a new measurement:


 digitalWrite(PIN_TRIG,
```

```
HIGH);
delayMicroseconds(10);
digitalWrite(PIN_TRIG,
LOW);

// Read the result:
int duration = pulseIn(PIN_ECHO, HIGH);
Serial.print("Distance in CM: ");
Serial.println(duration / 58);
Serial.print("Distance in inches: ");
Serial.println(duration / 148);

level = (duration /

10);if(level < 100)
{
 digitalWrite(LOWLED,
 LOW);
 digitalWrite(MOTOR,
 HIGH);
 digitalWrite(HIGHLED,
 HIGH);
 digitalWrite(MIDLED,
 HIGH);
}

else if ((level > 200 ) && (level < 400))
{
 digitalWrite(LOWLED,
 HIGH);
 digitalWrite(HIGHLED,
 HIGH);
 digitalWrite(MIDLED,
 LOW);
}

else if (level >= 400 )
{
 digitalWrite(HIGHLED,
 LOW);
 digitalWrite(MIDLED,
 HIGH);
 digitalWrite(LOWLED,
```

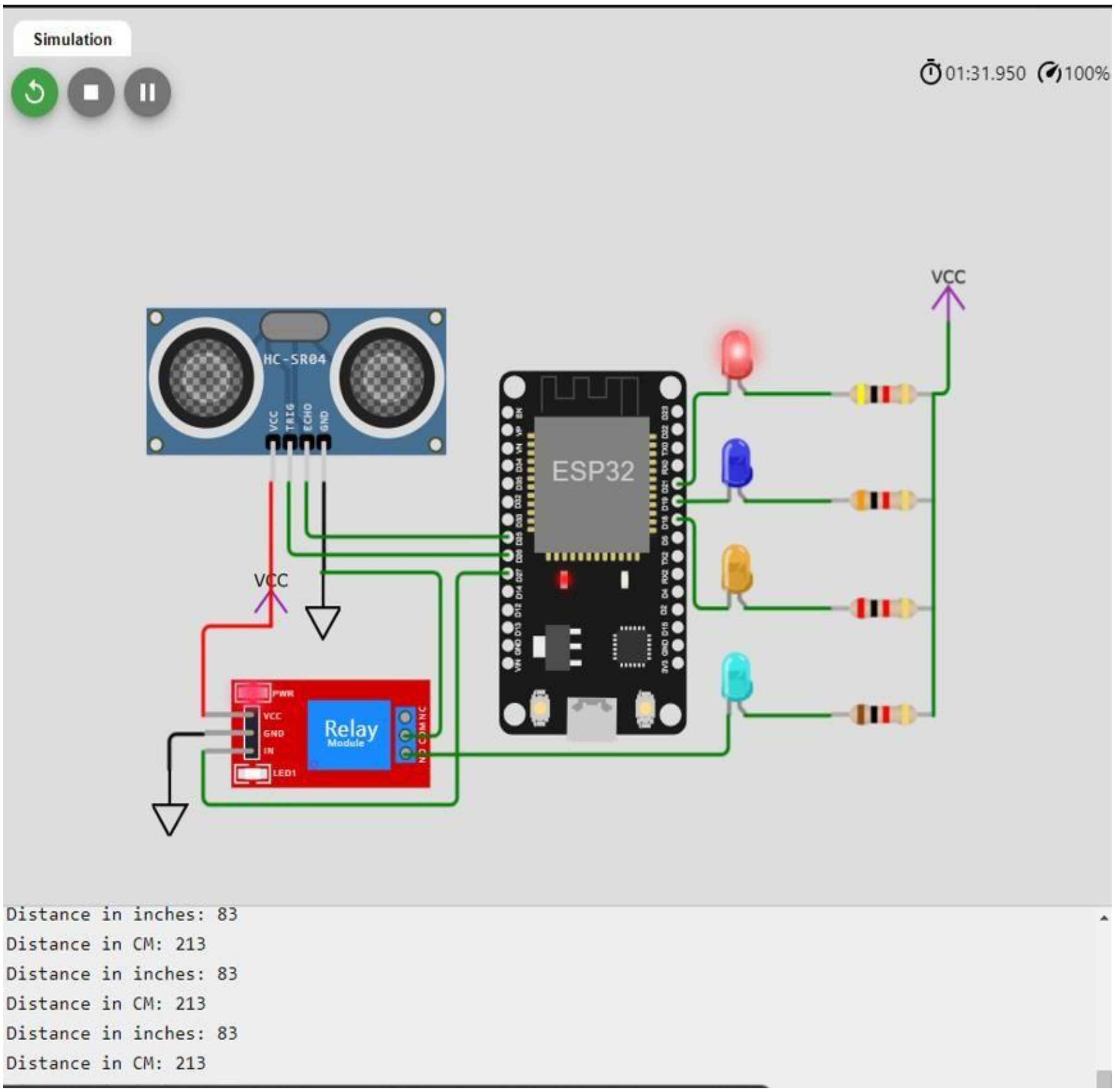
```
    HIGH);
    digitalWrite(MOTOR,
    LOW);
  }
  delay(1000);
}
```

Output:




```
entry 0x400805dc
Distance in CM: 281
Distance in inches: 110
Distance in CM: 281
Distance in inches: 110
Distance in CM: 281
```

Output:


Simulation
01:31.950
100%
VCC
HC-SR04
VCC
TRIG
ECHO
GND
ESP32
VCC
Relay
Module
Distance in inches: 83
Distance in CM: 213
Distance in inches: 83
Distance in CM: 213
Distance in inches: 83
Distance in CM: 213

COMMERCIALLY AVAILABLE WATER QUALITY SENSORS AND THE MEASURING PARAMETER

Sensor	Water quality parameter	Source
Spectro::lyser	Turbidity, temperature, pressure, colour, dissolved ions, UV254	Broeke(2005)[9]
SmartCoast	pH, dissolved oxygen(DO), conductivity, temperature, turbidity, phosphate, water level	O'Flyrm et al., 2007[10]
Kapta 3000 AC4	Chlorine, temperature, pressure, conductivity	Mcdougle et al., 2012[11]
Smart water(Libelium)	pH, dissolved oxygen(DO), conductivity, temperature, oxidation-reduction potential(ORP), turbidit y, dissolved ions	Libelium(2014)[12]
Lab-on-chip	Any specific bio-chemical	Tsopela et al., 2016[13]
I::scan	Colour, turbidity, UV254	S::can(2017)[8]

Harvesting technique	Advantages	Disadvantages
Piezo-electric	High efficiency, easy to design, No need of external voltage source	Small leakage of charge due to polarization
Electromagnetic	Reliable, No need of external voltage source	Size bigger compared to other methods, low voltage load
Thermoelectric	Lightweight, Reliable	Difficult to design due to maintain optimal thermal conduction coefficient, low power generated

Result:

As IoT is growing every day with new technologies involved, new challenges arise. The IoT has encouraged people to connect to devices using the internet and the increase in the use of IoT devices motivated people to use smart technologies.