Introduction to IoT and Its Industrial Applications (CS698T)
Indian Institute of Technology Kanpur
Assignment 2

QUESTION 1

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1 Description

The objective is to design a smart agriculture system in which the water flow is controlled by servo motors based on the prediction of a Machine Learning algorithm. This algorithm uses the humidity and temperature values given by the sensor related to the individual servo, to predict the water flow. Additionally, the water flow is regulated during the daytime only.

2 Components

2.1 Development Board

1 Arduino Mega

2.2 Sensor Used

1 DHT22 - Digital Humidity and temperature sensors - 4
2 LDR - Light Dependent Resistor - 1

2.3 Display

1 LCD 16x2 I2C display - 1

2.4 Actuator

1 Servo motors - 4

2.5 Others

1 Power source
2 Jumper wires

3 Procedure

To design the given system, first place all the components on the canvas. Connect all the Vcc and Ground(GND) pins of the components to the available Vcc and Ground(GND) sockets respectively on the Arduino Mega board. Next, connect the SDA pins of DHT22 sensors to digital(PWM) sockets(mega:2-5). Allocate one socket to each sensor. Now, connect the PWM pins of servo motors each to one of the digital(PWM) sockets(mega:6-9). Connect SDA and SCL pins of LCD I2C display to the respective SDA(mega:20)and SCL(mega:21) pins on the Arduino Mega board. Finally, connect the LDR sensor pin to the Analog socket(mega: A0) on the board.

After making the connections, define the same in the sketch.ino file. Call the required methods in the setup function to run for once at the time of the bootstrap. The loop function, which runs continuously, checks the value of luminous intensity(lux) using the LDR sensor. During the daytime (i.e; lux more than 50) it takes the humidity and temperature values from the DHT22 sensor and predicts the required water flow using a machine learning algorithm. The proportional value of water flow is then used to control the servo motor position. Also, the water flow percentage is displayed on the LCD with respect to each servo. During the night(i.e; lux less than 50), the water flow is set to zero and all the servos are returned to their zero positions. Also, the LCD displays zero percentage.

4 Instruction

1. Run the simulation and wait for the simulation to load.
2. Set the LDR sensor value to more than 50 for daytime and less than 50 for night time simulations.
3. Set the required Humidity and temperature values for each of the four DHT22 sensors.
4. Observe the positions of the servo and water percentage displayed on the LCD.

5 Machine Learning Technique

The aim is to predict the amount of water flow (in percentage) sent through the motor. We need an ML model which takes Humidity and Temperature as input and predicts the water flow. It is one of the important requirements of our system. We tried different models and picked the best model based on metrics. This ML model is trained on the given sensor Dataset. To reduce the overhead of computation on the Board, we have performed the training phase of the ML models on the Cloud. And the optimal parameters are used on the Board.

6 Machine Learning Architecture

6.1 Neural Network

We trained a neural network containing One input layer, hidden layer one consisting of 8 neurons with activation as ReLu, Hidden layer two consisting of 2 neurons with activation as ReLu, and a final output layer with activation Sigmoid. We have used epoch=1000 with loss function as Mean square Error and Optimizer as Adam.

6.2 Random Forest

We used the ensemble learning technique to predict the water flow. For this, we have used 10 estimators with Gini Index as the split criterion.

6.3 Decision Tree

A decision tree with entropy as a split criterion has been used with max depth=10

6.4 Linear Regression

We trained a simple linear regression on the Dataset.

6.5 Support Vector Machine

We trained a simple linear regression on the dataset.

7 Evaluation

For evaluation of our ML models, we used Root Mean Square Error (RMSE).

$$RMSE(Y_{actual}, Y_{predict}) = \sqrt{\sum_{i=0}^{i=N} (y_{actual_i} - y_{predict_i})^2}$$

Dataset is split into training sets and validation set to perform the evaluation.
We observed, Random Forest produces the least RMSE value on the validation set. So we have chosen Random Forest as our working model in our system.

8 Libraries Need To Run Machine Learning Model

- Python 3.8
- Numpy
- Pandas
- Tensorflow
- Sklearn

9 Observation

1. Day and Night simulation is realized using the LDR sensor.
2. Water flow percentage is regulated according to Humidity and Temperature values.
3. Servo motor rotation is observed in proportion to the water flow.
4. The water flow percentage is being displayed on the LCD accordingly.

10 Link to Simulator

For getting into our project you can use the following link **Link To Project**

To solve our assignment we have used following references ref (a),ref (b)

References

Welcome to wokwi! — wokwi docs. https://docs.wokwi.com/, a. (Accessed on 11/03/2021).

Built-in examples — arduino. https://www.arduino.cc/en/Tutorial/BuiltInExamples, b. (Accessed on 11/03/2021).