Solar Energy Based Smart Highway with Energy Prediction using Machine Learning

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***Abstract*—IoT-based Smart Street Light systems are one of the key infrastructures of a smart highway and are important for safe driving and safety of the pedestrians. The increase in new highways and the introduction of electric vehicles account for high energy consumption and thus a significant cost to the utilities. Smart street light is a mixture of enabling control and monitoring, transforming these systems into quick-witted and energy-efficient systems, ensuring huge savings in the consumption of power. This paper presents the automation of smart street lights, charging stations for electric vehicles working on the renewable energy source, solar energy. Machine Learning model LSTM-RNN is used to compare predicted and resulting power consumption.**

Keywords: Solar Energy, Consumption of Energy, Node MCU(ESP8266), Machine Learning, LSTM-RNN.

I. Introduction

Global civilization can be categorized into what's known as Kardeshev Scale. This scale measures and categorizes civilization according to its level of technological advancements based on the amount of energy it is able to use. It is scaled from 1 to 3. Currently, we as a civilization don't even reach type-1 civilization. This is because we don't use all forms of energy available on Earth. We use wood, coal, oil but there's a lot more. We should replace fossil fuels with renewable energy sources since they're limited and unsustainable. Renewable energy sources like sunlight, wind and water are so accessible for our energy needs that one day we might no longer need to pay for our power bill.

Our Smart Highway Model consists of smart street lights and charging stations. Smart street lights will be automatically turned ON during the night at low intensity if no vehicle is available on the highway. If the vehicles are passing by smart street lights will increase their intensity. Since technology has been revolutionizing and within a few period of time, fuel engine vehicles will be replaced by electric vehicles. Looking for a global perspective, charging stations should be available at particular intervals on highways. Our whole model will be working on a renewable energy source, solar energy. For maintenance of Smart Street lights and charging stations, we must have to keep a track of how much amount of energy is being consumed - for this purpose machine learning is used.

II. Literature Survey

The forecasting performance of ML algorithms is better and superior as compared to the smart persistence (SP) method.[1] A comparison was done among ML methods such as SVM, RF, DT, MLP and LSTM regarding MAE and RMSE. Ac- cording to the results, the performance of LSTM was better than that of other algorithms.[2] The work was combining Deep Learning Technology and the time correlation principle to tackle the deficiencies of conventional AI modeling. Re- sults verified the performance of the LSTM-RNN model and TCM method and effectiveness of the PDPP framework are accurate.[3]

The paper suggests the combination of lab testing power output under seasonal and hourly conditions during the year. The advantage of the proposed testing is that a comparative energy output and performance could be obtained in a short period of time.[4] Photovoltaic cells must operate in openspace to capture solar radiation and be continuously exposed to meteorological phenomena. The effects of some of these phenomena can lead to degradation of photovoltaic panel efficiency or operation. Solar power energy prediction that is suitable for the application in solar-powered IoT systems scores is more than 20 better than the current state of the art for IoT energy prediction.[5] The work in this paper is combining Deep Learning Technology and time correlation principle to

tackle the deficiencies of conventional AI modeling. Results verified performance of LSTM –RNN model and TCM method and effectiveness of PDPP framework is accurate.[6]

This paper implies the various uses of smart sensors tocreate a smart environment around us. The Paper studies analysis of different sensor applications.[7] The use of ma- chine learning offers a very accurate model, load balancingfor renewable energy systems can be improved which canhelp in increasing the penetration of renewable energy in the power systems which is highly desirable.[8] The electricity generated by the solar energy harvesting module is stored in the energy storage module, which can supply power to the electrical facilities on highways.[9]

III. Proposed Work

This section will briefly explain the software, hardware, architecture and working of the proposed work. We intend to move completely towards using renewable energy resources because what if we use non-renewable energy resources to their extent. Solar panels are those devices that are usedto absorb the sun's rays and convert them into electricity or heat. A solar panel is a collection of solar (or photovoltaic) cells, which can be used to generate electricity through the photovoltaic effect. These cells are arranged in a grid-likepattern on the surface of solar panels.

Parameters	Values
Length	34.5 cm
Width	21.5 cm
No. of cells	36 cells
Output Voltage	8 V
Solar Power	5 Watt
Current	0.2778 A
Efficiency	67.5 A

Table-1 : Specifications of Solar Panel

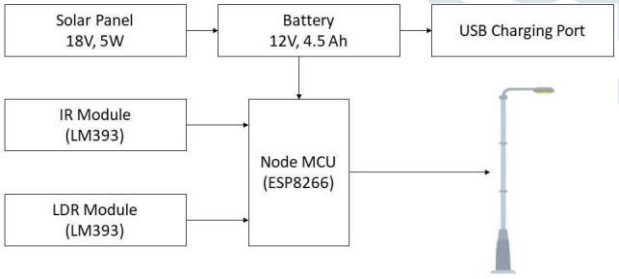

Figure-1 : Block Diagram of Smart Highway

Node MCU is used as a microcontroller unit in the proposed work. Solar Panel used is of 18V, 5W voltage and pow er respectively. It is made up of monocrystalline material. This panel will absorb solar energy and will generate electricity which it will pass on to the energy storage unit that is the battery. The battery will store and pass it to the system to operate. IR Sensor will detect the presence of the vehicle. LDR Sensor will automatically turn ON when the night falls and turn OFF when the sun rises on smart street lights. The power which is stored in the energy storage unit will provide power for Charging Stations.

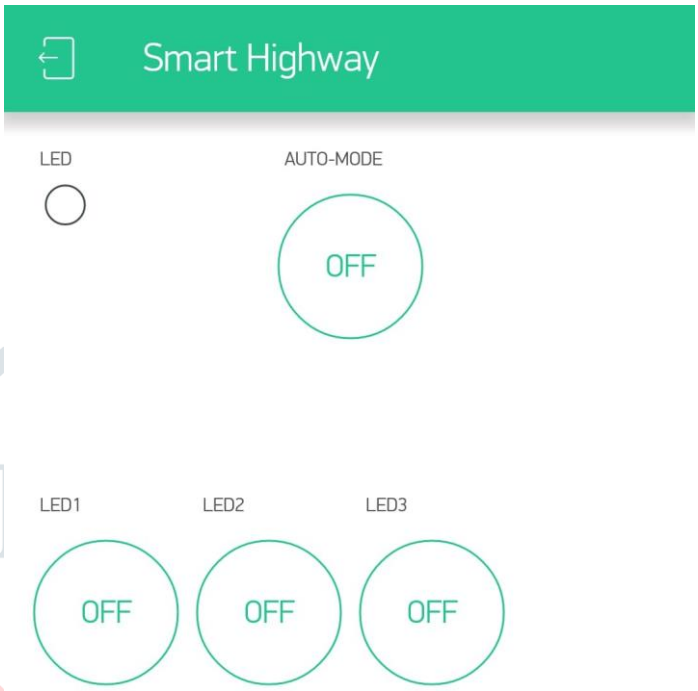

Figure-2 : Blynk App Interface of Smart Street Light

As from the figure 2, Blynk App is used to also manually handle the system. In the above Blynk App Interface, there are four buttons. If you turn ON Auto-Mode, all the LEDs get turned on automatically without any constant survey on the interface. three buttons to turn on all the LEDs manually. This manual operation is provided in-case if there turns out to be an auto-mode failure, i.e if the street lights do not turn on automatically.

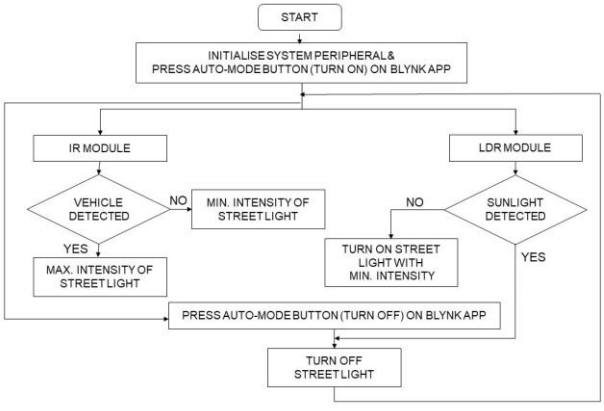

Figure-3 : Flowchart of Smart Street Light

As above mentioned if Auto-Mode is turned ON, the IR

module will work on its own and if a vehicle is right under the smart street light it will signal the microcontroller unit to turn smart street light at maximum intensity else if novehicle is on the highway it will signal the microcontroller unitto work on minimum intensity. LDR module will signal the microcontroller unit which will automatically turn ON when the night falls and turn OFF when the sun rises on smart street lights.

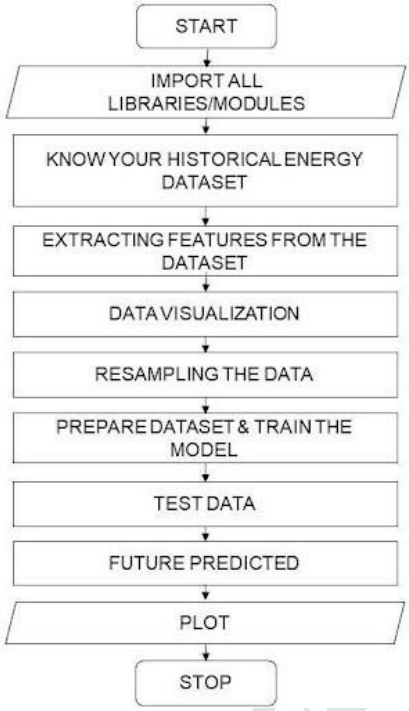

Figure-4 : Flowchart of Energy Prediction LSTM-RNN

Model Implementation of the above flowchart has been done using Jupyter Notebook. The first step was to import all the libraries to be used. Later, we got familiar with our dataset and extracted its features. By using Pandas built-in module conversion of 24 values for a day by taking a mean of it and resampling it into a single value for a day. Then, the process of training the model was started. Once trained, predicted and resulting values were plotted in graph format.

IV. RESULT AND DISCUSSION

Figure-5 : Solar Energy Based Smart Highway Model

When the vehicle is below the street lights, the lights turn on with maximum intensity and when there is no vehicle nearby the intensity of the light is reduced to conserve energy.

Figure-6 : Charging Station on Smart Highway

As from the above figure 6, the charging stations are also added to quickly charge vehicles on the go. Considering the deployment of charging stations for electric vehicles we have deployed mobile charging stations.

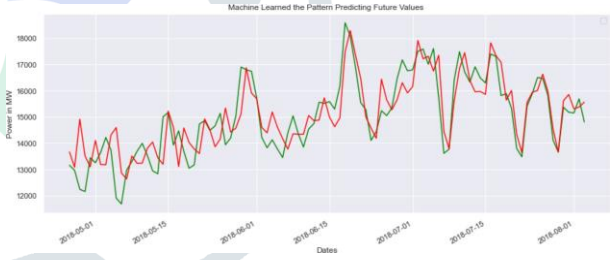

Figure-7 : Prediction Graph for Consumption of Energy

Here, you can see the red line indicates machine learning predicted values and the green line indicates actual/real values.It's pretty accurate and it is trying to learn each and every point, curve accurately. Thus, we can say the machine predicted accurately using the LSTM-RNN model.

V. CONCLUSION

To conclude, we have implemented a smart solar street light system with an A.I touch. Where it knows when to turn on/off the street lights according to the time of the day by using an LDR module. And also be able to control it's intensity by calculating the distance from the vehicle using an IR sensor. Further the highways have charging stations to charge your

cars which will be very helpful for long trips. As this smart-highway based project is fully automatic it ensures no manual labor is needed which can then save a lot of time and money after it's implementation.This system is not only smart in itself but is also a lot better than the traditional system where it consumes non-renewable resources thus endangering the risk of them getting completely depleted.

VI. FORESIGHTS

Figure-8 : Windmill

Future scope of smart highways includes the use of wind energy to generate power through a windmill. Here a DCmotor of 12V is connected to the battery which will generate and store electricity in the battery depending on the propeller'sspeed of rotation and will be used to provide power to the street lights. A Gearbox will be added to increase the speedat which the propeller rotates so that more power can beextracted. Moving further it calculates the direction of thewind using velocity sensor, which sends a deviation to the controller.The controller sends error to the Yaw motors which includes a gear tilting mechanism to properly align the blades into the direction of the wind. This will make sure that the windmill is always facing at the direction of the wind. So the goal of our project is to not only use 1 renewable energy but2 renewable energies which includes solar and wind energyto generate power for the highways thus making it extremely eco-friendly.

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