HOME ELECTRICITY USAGE PREDICTION AND ANOMALY DETECTION

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Introduction

With the development of technology, many fields have been changed and upgraded. Due to industrialization and a higher population growth rate, world energy demand has increased significantly in the last few years. Therefore it is expected that the energy demands will further increase in the next two decades. Urban development heavily relies on electric energy systems, which require real-time energy consumption and energy generation. Energy production below actual needs will result in overload problems in the electricity grid, leading to blackouts, while production above actual needs will render the electric energy system financially unsustainable. Thus, short-time prediction of the energy needs is crucial for electric energy systems and given that 27% of the global energy consumption corresponds to the residential sector. Therefore prediction of residential energy consumption is essential. The problem of predicting residential energy use is a time series prediction problem. The household energy consumption data can be collected from smart meters, one per customer, which in most cases is equivalent to per household data.

The energy consumption data, which are usually collected with a sampling period from 1 second to 1 hour, in most cases consist of active power samples and less often reactive power, load angle, and current harmonics. For the residential sector, the interest is mainly in short-term prediction (sub-hourly, hourly) for the prevention of blackouts, but also in long-term prediction (monthly, yearly) for national planning and investment.The Energy consumption prediction is a difficult task because except the periodic patterns (e.g. daily and weekly routine) irregular components appear in the energy consumption signal as well.Several deep research Articles have been proposed that residential energy consumption prediction, most of which are based on machine learning algorithms for regression, e.g. Linear Regression (LR) , Support Vector Regression (SVR), Decision Trees (DT s), and deep learning methods like Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs) and Long Short Term Memory (LSTM). In most proposed approaches, the short or long-term history of energy consumption predicts, future energy load demands. Except for energy demand forecasting approaches based on energy data, the use of non-energy data that can affect load demand has been evaluated. Such data are the weather conditions, calendar information, and socioeconomic factors.In this project weather data and calender information will be used.But socioeconomic factors like age consumer details ,No of consumers amount in one house will not be used. The use of non-energy consumption data improved the electricity demand forecast generally.

In this project, I will use a Gated Recurrent Neural Network method for short-term prediction of residential electricity load demand .

Background

As a developing country, Srilanka has faced many difficulties in the power management field. The main reason is still Srilanka is using the old traditional power grid system. As a result of these old mechanisms, nobody is aware of the future energy consumption rates, whether the current power generation points are enough to fulfill those needs. When compared to the USA, they are converting their power grid system to smart grid systems because of as a country, they experience that the traditional one-way communication grid is not enough to prevent blackouts. Even though Sri Lanka has experienced a few blackouts in recent history, somehow, Sri Lanka managed the conditions by monitoring the grid using a load dispatch center to balance the supply-demand. Though this method helps to survive for tiny lands, this doesn't help full for largest countries.

But Sri Lanka also will not survive lengthy blackouts in the future. Because Still major thermal power plants repeatedly get inactive due to mechanical issues in the turbine and equipment part. On the other hand, most significant power plants work using Coal and diesel fuel to power up plants. But these natural resources are decreasing day by day from the earth very quickly. On the other hand, these power plants will definitely be banned due to environmental issues like global warming in the near future. The most optimal solution to overcome this problem is to predict our future energy demand and give AI power to machines to control themselves according to the Current grid statistics and add various backup capabilities (Solar panels, wind turbines) to the system.

As the first step, I am going to predict the household energy consumption of the house. For that, I will use the Individual household dataset as support data in this project. This data set location is France, and it contains nine attributes .they are date-time, global active power, global reactive power, voltage, global intensity, submeter 1, submeter 2, and sub-meter 3 values. But this data set didn't contain the local weather data stats for each consumption. Therefore, I will use my previous computer engineering project smart meter system database value. It is stored in a cloud database. Both data sets attributes are the same, and my data set will be more suitable because the voltages and other factors are different from one country to another.

Aims and Objectives

Aim - Implement a Deep learning model to predict the energy consumption in the next period.

Objectives

- The main objective of this project is to build a deep learning model to predict the future energy consumption for a single house.
- Detect anomalies in electricity usage.
- Reduce energy wastage, cost and manage demand.

Plan of Implementation

Planning and preprocessing

Initially, cleaning should be done to the dataset for remove noisy data and outliers. Then some preprocessing steps will be done before the next step. Some of preprocessing steps have being done to the dataset already. But there need some more organization in it before process. After that, some visualization of the dataset will be done, and it will help to identify patterns in the dataset. Then with that knowledge of the dataset, I can move to the model implementation stage.

Model Implementation

I hope to use RNN architecture to build deep learning models in this project.

- **Time Series Forecasting**

Even though Machine learning algorithms can be used for predictions, their accuracy is too low. For that reason, energy consumption prediction is a critical task; the accuracy and prediction speed should be high . Therefore I am going to use LSTM (Long Short Term Memory) Model for this system.Because these algorithms used historical data as feedbacks to the system.

- **Anomaly detection**

Here I am using a dataset that data observed from a sensor(pzem 004T). Therefore some times, there might be abnormal behavior of the data set. For example, due to some sensor issues, the reading value would be extremely high, or there might be only one day that energy consumption is too high. Those days might happen only a few times in a decade. Therefore those abnormal data points should not be included in our prediction. To remove those abnormal points, I will

use LSTM Autoencoder mechanism. On the other hand, this technique identifies when some electric device uses abnormal usage in real-time due to various reasons.

Technologies

- TensorFlow software will be used for implementation mainly.
- Main Language will be python. Keras, Matplotlib, NumPy, and many more libraries will be used in the implementation.
- Flask web app technologies will be used for front-end web dashboard development, and Heroku cloud services will be used to deploy the model in the cloud.

Milestones

- **Data Preprocessing and Data cleaning**
  Cleaning of the dataset and some other preprocessing will be done in this stage. It may need more deep understanding of the Individual household electric power consumption to make the dataset more useable.
- **Preparing the data set**
  Identification of Special patterns in the electricity consumption dataset will be done. The study of features in the dataset will lead to better identification.
- **Model Implementation**
  Using deep learning techniques, making a model that fits the purpose will be done. LSTM models as a RNN achitecture will be implemented in this stage.
- **Training And Testing**
  Models will be trained to make predictions.On the other hand, these models will be deployed in the Heroku cloud environment.
- **Evaluation Finetune**
  Testing the model and optimization will be done in this stage.Here I will use the web application dashboard to show realtime graphs that predicting future energy consumption.On the other hand some usefull graphs such as humidity Vs consumption and temperater Vs consumption graphs also would be generate to show in the web application.

Timeline

Activity	Week													
	1 - 2	2 - 4	4 - 6	6 - 10	10 - 14	14 - 18	18 - 23	23 - 25	25 - 27	27 - 28	28 - 31	32 - 34	35 - 37	38 - 40
SELECT THE DATA SET														
DATA CLEANING AND PREPROCESSING														
PREPARING DATASETS														
LSTM TIME SERIES PREDICTION MODEL														
LSTM AUTO ENCODER MODEL														
FINAL COMBINATION MODEL														
TESTING AND EVALUATION														
DATA VISUALIZATION														

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