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Digital Twin-Enabled Smart Energy Management System for Forecasting and Virtualized Monitoring: Sustainable Power Consumption in Smart Cities

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Abstract: By giving us smart transport and energy services, smart cities can help us lead better lives. Many people depend on electricity for their energy needs. Currently, workers who act as field personnel for electricity distribution companies read the meters and run the risk of being hurt by climate or trouble from social conditions. The owners of a residential building see their electric energy bill, yet it does not show how each household appliance uses electricity. If people could tell which devices use the most power from their historical or typical data, they might be able to take steps to decrease their energy usage. The electricity details of every equipment make it easier to balance electrical system supply and demand for both suppliers and users. The main goal is to design a system for projecting future electricity consumption and to develop a simulation of a smart meter and energy appliance management system. The software is designed around a single center; it offers interaction with users only through a web interface. Users can usually generate their individual data visualization dashboard from the UI of a Cloud platform. My idea is to automate energy used measurement and to create charts to see which indicators we can use to reduce electricity expenses. Using digital twin technology improves both modeling and the making of decisions. It enables the control of smart meters, supplies authority to gather and store their data, oversees device management, maintains software and provides alerts and extra functions. Using this module, you can observe and respond to trends, make alerts based on rules and generate reports for comparison.

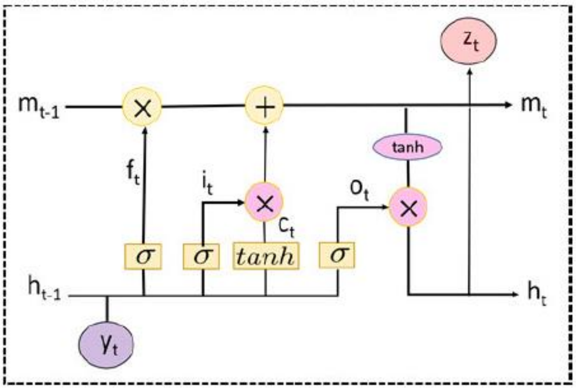
Keywords: Digital Twin, Smart Energy Management, Smart Cities, Sustainable Power Consumption, Energy Forecasting

INTRODUCTION

Human life relies on having electricity. You can use gas in your home to heat, cook, iron and handle other daily tasks. Films are used to supply electricity for industries. Heating, cooling, electronics and other power uses in offices are all powered by electricity. Thermal, coal, nuclear and hydro are just some of the sources that make it up. A plentiful supply of electricity supports the development and security of a nation's economy. As a result, there are many economic activities and a higher Gross Domestic Product. In the last few years, increasing energy use has caused major issues due to its effect on the national economy and finances. Many things in Saudi Arabia drive up energy consumption in non-residential areas. A variety of problems in the CoC can result in more consumption. Because of extreme weather, people have to keep their air conditioning on for longer which leads to higher energy consumption in the summer. During winter, the regular use of your heater means the energy bill goes up, depending on its type, size and the amount of electricity it consumes per hour. Because devices require so much energy, the rise in their numbers will also cause a bigger use of energy. Many devices and servers make up the CoC. With the rising population, we are using more energy.

. The daily schedule of lectures results in greater energy use than we see on weekends. Along with testing in practical exams, there are many other uses for these devices. Because there are so many cafeterias at college, having refundable cups means students can use the many devices in each cafe which is another reason food waste has gone up. Many devices in our environment help, but only high-quality ones will allow us to achieve the best performance. Both traditionally and weather-sensitive tools in electric power must be reliable since their defects will reduce their overall consumption. When the quality of devices decreases, there is more energy consumption.

PROPOSED WORK



The model (HSBUFC) in this project combines stacked bi-directional and uni-directional LSTMs and fully connected dense layers, producing accurate forecasts with a small error rate when compared with the tested models.

The structure of the uni-directional and bidirectional LSTMs is examined. Recognizing common patterns in energy consumption data is possible using the forward and backward passes in bi-directional LSTMs and both past and future data.

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METHODS

1. Our Forecaster Web App

The Forecaster Web App makes use of the overall sets of systems used for measuring, collecting and analysing electricity use. Unlike AMR Technology, the FWA system supports back and forth communication between the utility and the meter. By doing this, requirements like demand response, remote service barring or disconnects are possible.

2. Featuring Annotation with a Smart Metered Dataset

2.1. Training Dataset

For this analysis, we have electrical consumption data for a single household over the period from 11 January 2016 to 27 May 2016. All analyses were based on data sampled every hour. In every case, the three years of training data came from the first three years and the last year was used for testing. Electricity use for 60 hours was estimated for all of the architectures tested.

2.2. Testing Data

A dataset of real-world appliance energy information is used to build and assess the proposed hybrid model. Smart meter readings from every home electric appliance

3. Pre-processing

We are required to replace any missing data in this module by using the Mean or Median of the entire column. The soil nutrients are selected as feature variables and all NULL and repeated data are discarded from the original dataset.

4.K-means Clustering

People use K-means clustering a lot since it is simple and generally effective. Since K-means is used in several software tools across both commercial and open-source areas, it is simple to use for fast clustering. Since the K-means algorithm depends on luck at the beginning, an awkward start can lead to suboptimum results and local optima. This issue can be reduced by running the algorithm several times.

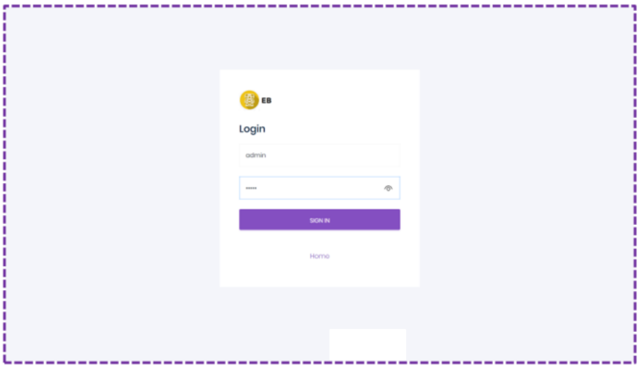
RESULTS

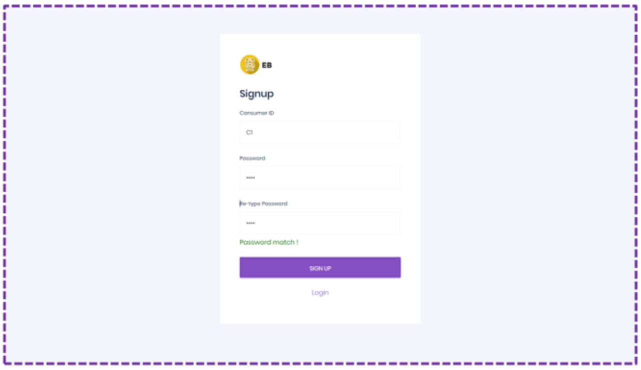
Smart cities have shown great advantages in both sustainability and efficiency of power consumption after implementing a Digital Twin-enabled SEMS. The system uses live data collection, prediction tools and virtual monitoring to make precise energy predictions and allow for flexible load management.

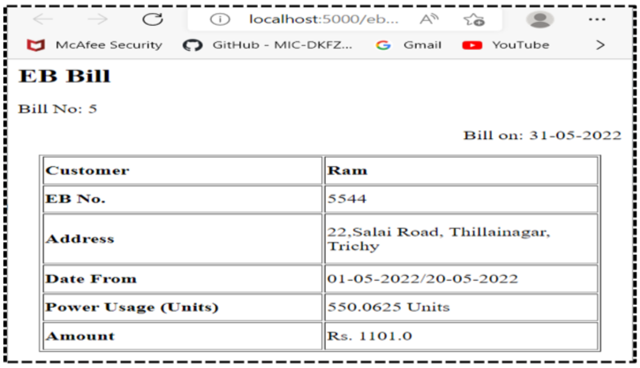
The digital twin model can be tested in both virtual and real ways to reflect energy infrastructures and people’s behavior, allowing stakeholders to make the best decisions about energy planning. Thanks to the system’s forecasting features, energy wastage is reduced, loads are better balanced and renewable sources are more easily added to the grid.

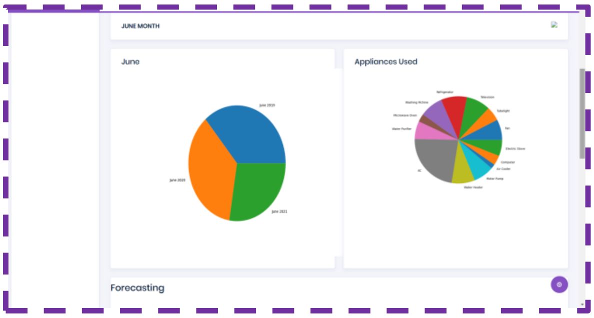
Experimentation reveals that peak demand loads are reduced and the system now responds better to changes in energy demand. Additionally, since equipment can be accessed remotely, remote diagnosis and ongoing upkeep reduce expenses and strengthen the grid.

The results reveal that digital twins are helpful for managing energy and lead to better urban infrastructure with a focus on sustainability.









CONCLUSION

The “smart meter firmware” project with LSTM for forecasting, monitoring and controlling household appliance energy use and online reading is both significant and possible. It is intended to help customers view their energy use, set up limits, review their invoices and make payments using the internet. Among the things included in the project are web administration for smart meter data, access to appliance use data by consumers, setting personal limits and bill report generation. For forecasting and observing household electrical appliance consumption, the LSTM algorithm is applied, while Python Flask and MySQL are used for implementation. The project's feasibility study revealed that it is possible and the process of implementing it is manageable too. The project is valued because it can assist in conserving energy, raise consumer awareness about using energy and help people cut their electricity bills. Both black box and white box testing were used for this project, mainly focusing on unit testing. According to the test results, the project functioned as intended and what it produced met the project’s requirements. Consequently, this work could improve energy conservation, give consumers more awareness of their energy use and lower their energy costs. Testing and applying the project proved that its goals can be met and it has the functionality it needs. Enhancing the system with LSTM for forecasting energy use makes the system both more intelligent and effective. The project, called “smart meter firmware,” could bring important changes to the energy industry and provide consumers with more control over their energy usage.

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