Modelling Application Of Deep Learning for Energy Mix

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Problem definition/Objective

- **T**o understand what deep learning is and how it can be used to enhance a country's Energy Mix sector.

- We aim to build a deep learning model that predicts optimum energy production of a given area taking into consideration the energy production, availability of renewable and non-renewable energy resources, weather conditions and feasibility for that particular area.

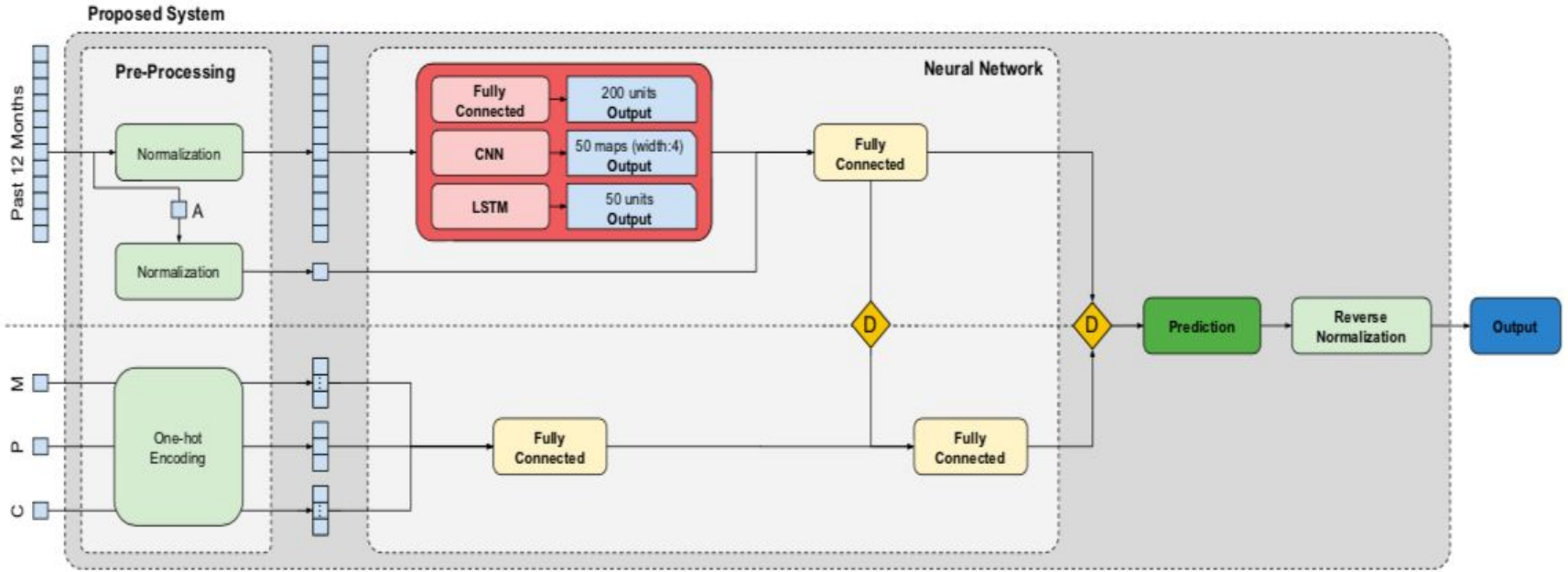
Literature Review

Existing Solutions

1. **Monthly energy consumption forecast using Deep Learning:** Energy consumption forecasting problem is a time series regression task. It consists of predicting the energy consumption for the next month given a finite history of a customer. Three deep learning models were studied: Deep Fully Connected, Convolutional and Long Short-Term Memory Neural Networks. The proposed system was validated with real data of almost a million customers (resulting in over 9 million samples). Results showed that our system can predict monthly energy consumption with an absolute error of 31.83 kWh and a relative error of 17.29%.

2. **Modernising 'Smart Grids' using Deep Learning:** In this work, we have applied two deep reinforcement learning (DRL) algorithms designed for both discrete and continuous action space. The results showed that the agent successfully captured the energy demand and supply feature in the training data and learnt to choose behavior leading to maximize its profit.
3. **Energy Load Forecasting Using Deep Learning:** The large automation of appliances and adoption of high energy consuming utilities in homes has the potential to exert a huge constrain on the current energy infrastructure. Majority of the energy supply chain infrastructure across the world are incapable to handle large and concentrated energy demands. In this work, we evaluate smart meter energy consumption data from homes and use autocorrelation to establish decisive parameters for GRU (Gated Recurrent Unit) based recursive Deep Learning. We demonstrate better short-term forecasting results for in home energy consumption using our model.

Architecture / system design



The input data is from he past 12 months, the month that is being predicted (M), the number of phases of the customer (P) and the class of the customer (C). The average of the customer consumption (A) is derived from the original input. The proposed system can be used with or without metadata (M, P and C), represented by the decision (D).

Methodology /technique used

- The input to the system will be the total energy need of a country in (kW) along with the resources that are available in the country to generate electricity.
- These resources are further broken down to conventional and non-conventional energy resources.
- Our model will process the data for predicting the optimised usage of the provided energy mix.
- The output will have a percentage-wise breakdown of all the resources entered as input to the system to suffice the need of the total energy requirement.

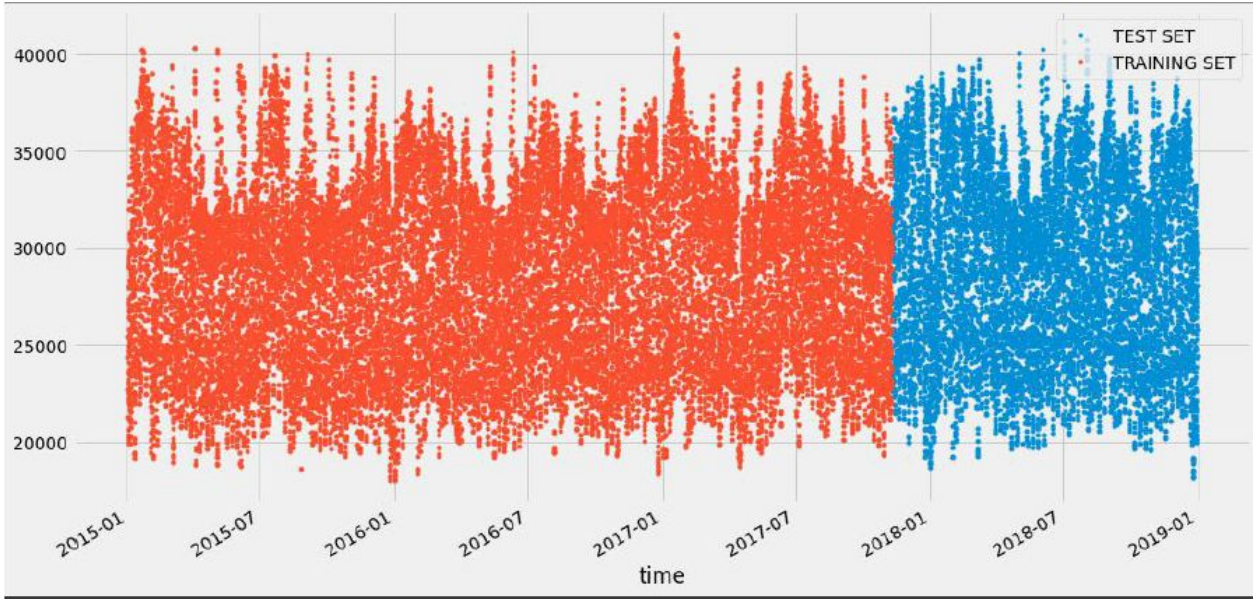
Methodology /technique used

The percentage that is associated with each resource is the optimum usage percentage of that particular resource to generate the respective amount of energy of the total energy needed. This optimum mix of energies will help to effectively make use of the non-conventional energy resource along with the conventional energy resource to meet the total energy requirement of the country.

Results and conclusion

Results: Snapshots of Implemented Model

Dataset Split into Testing and Training data



Prediction of the optimum total load by the model

time	total load actual	Prediction
2017-11-09 10:00:00+00:00	30509.0	31144.351562
2017-11-09 11:00:00+00:00	31193.0	31144.351562
2017-11-09 12:00:00+00:00	31725.0	30962.738281
2017-11-09 13:00:00+00:00	31233.0	30222.998047
2017-11-09 14:00:00+00:00	30484.0	29839.412109
...	...	...
2018-12-31 18:00:00+00:00	30653.0	31332.064453
2018-12-31 19:00:00+00:00	29735.0	31698.484375
2018-12-31 20:00:00+00:00	28071.0	30738.162109
2018-12-31 21:00:00+00:00	25801.0	28696.345703
2018-12-31 22:00:00+00:00	24455.0	26239.007812

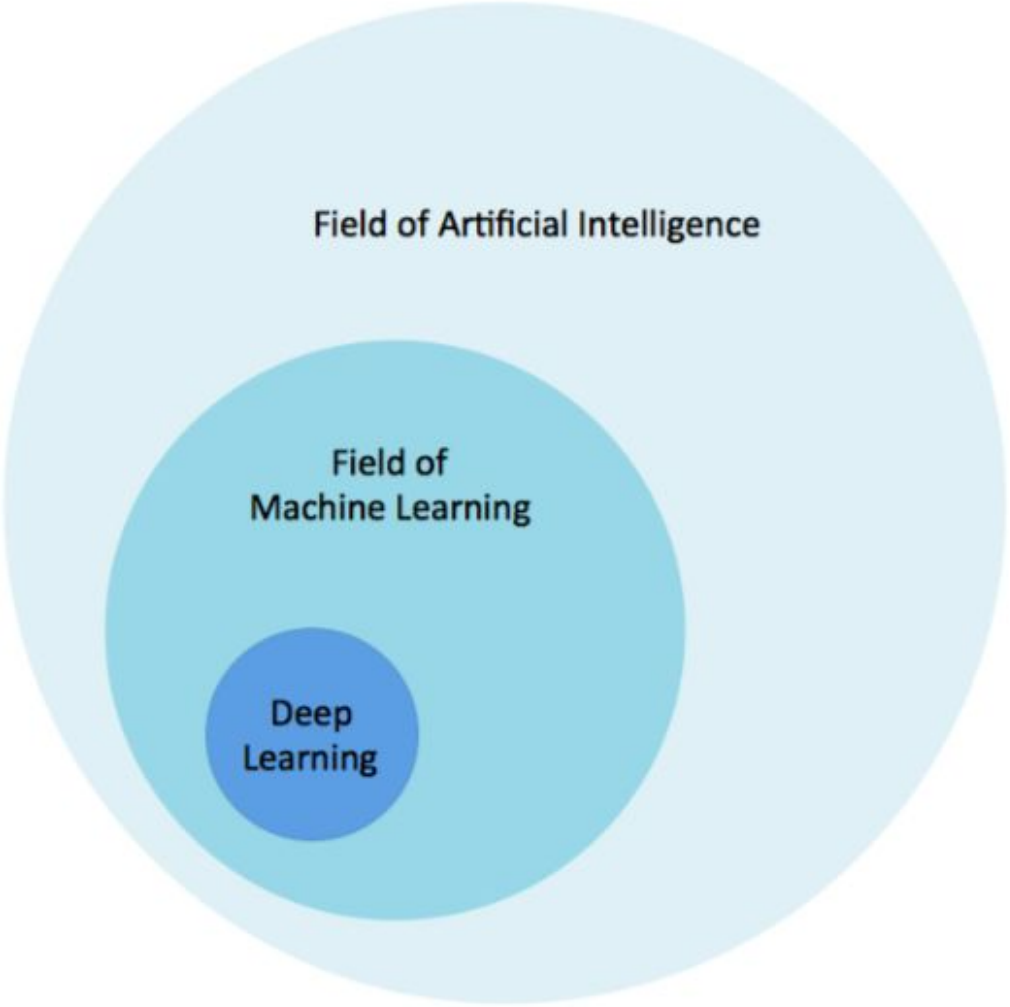
10017 rows × 2 columns

Results and conclusion

Conclusion

- Majority of the Deep Learning technologies today are limited to private organizations or sectors. This leads to a lot of redundancies and problems because of the volume, variety and velocity of the data. Thus, a more generalized solution needs to be put up which eliminates the problems of the existing solutions. Deep Learning can be applied to a broader scale, which can help us improve Energy Mix.
- Although Deep Learning for Energy Mix has a number of existing solutions, there is none yet that enables us to make optimum use of energy resources. Our attempt was to build such a model and we've successfully implemented this model on a small scale basis.

Future work


Field of Artificial Intelligence
Field of
Machine Learning
Deep
Learning

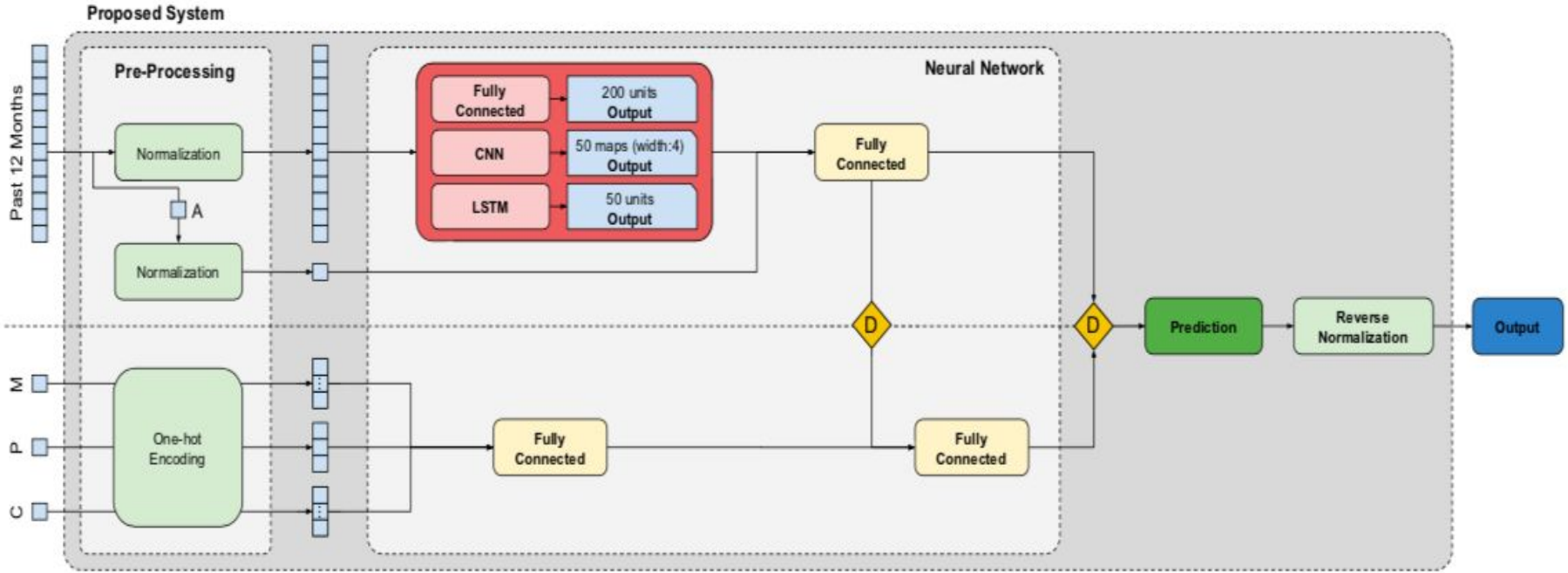
What is Deep Learning?

- Deep learning is a subset of machine learning in artificial intelligence (AI). But a very specific subset, inside of Representation Learning.
- It has networks capable of unsupervised learning from data that is unstructured or unlabeled.
- It is also known as deep neural learning or deep neural network.
- DL teaches a computer to filter inputs through layers to learn how to predict and classify information.
- Deep Neural networks have shown promising results over different research areas including but not limited to: Speech Recognition, image classification, video analysis and regression.

How deep learning works?

- The neurons are grouped into three different types of layers, as shown in the following diagram:
  - Input Layer
  - Hidden Layer(s)
  - Output Layer
- One of the challenges in creating neural networks is deciding the number of hidden layers, as well as the number of neurons for each layer.
- The “**Deep**” in Deep Learning refers to having **more than one** hidden layer.

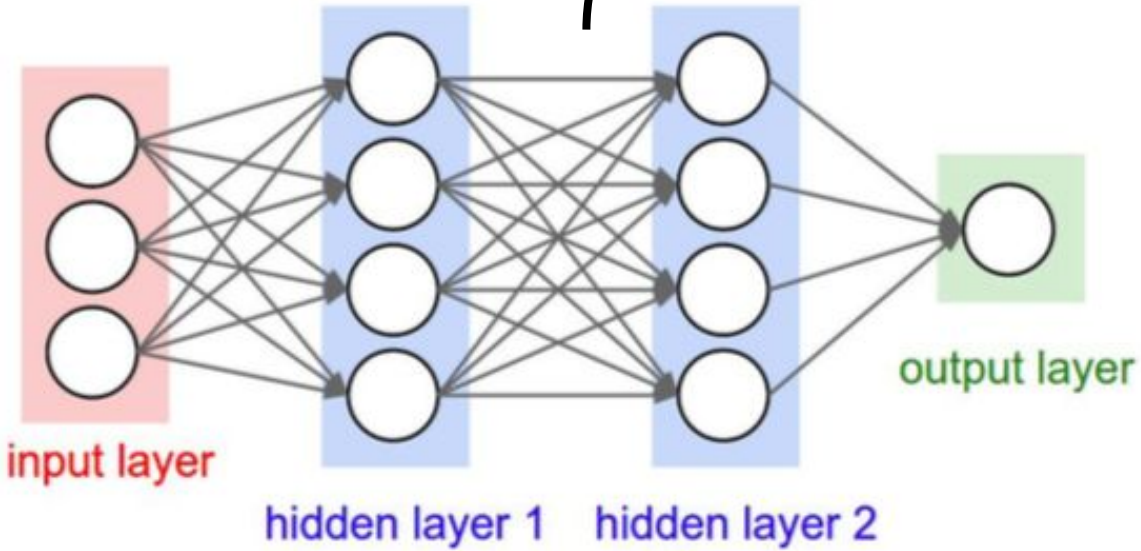
System Architecture



The input data is from he past 12 months, the month that is being predicted (M), the number of phases of the customer (P) and the class of the customer (C). The average of the customer consumption (A) is derived from the original input. The proposed system can be used with or without metadata (M, P and C), represented by the decision (D).

The **input layer** receives input data.

The **hidden layers** perform mathematical computations on our inputs.



The **output layer** returns the output data.

What is energy mix ?

- The **energy mix** is a group of different primary energy sources from which secondary energy for direct use - usually electricity - is produced.
- Energy plays a crucial factor in technological and economic development of present society.
- Renewable energy technologies have enormous potential.
- Renewable energy resources like photo-voltaic, solar thermal, geothermal, tidal waves, wind power, and biomass which has been growing rapidly in energy sector.

Deep Learning in Energy

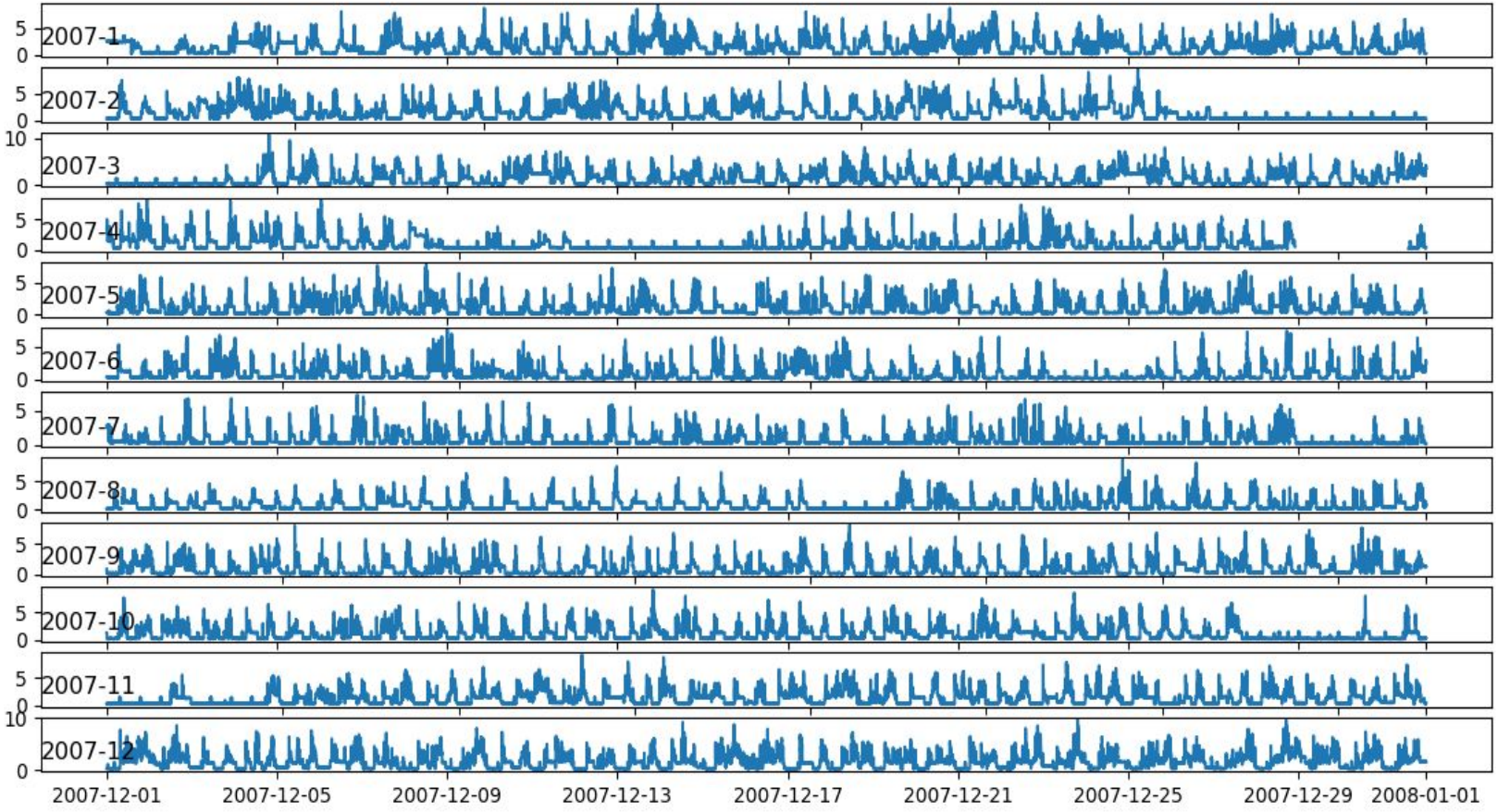
- DL is a reliable tool for monitoring and energy consumption regulation.
- The data collectors and sensors present in the industries lead to bulk data collection regarding the energy consumption.
- There are various other standard models of weather that predict the strength of incoming of the storms and the weather variations of a given region.
- Deep Learning and big data together can make power sources more grid friendly and it can operate more efficiently.

Existing models

- Monthly energy consumption forecast using Deep Learning
- Modernising ‘Smart Grids’ using Deep Learning
- Energy grid balancing using Deep Learning
- Energy load forecasting using Deep Learning
- Deep Learning models for Wind Energy Prediction
- Electricity Price Forecasting using Deep Learning models
- Optimization of decentralized renewable energy system by weather forecasting using Deep Learning techniques
- Prediction of renewable energy resources using Deep Learning

Monthly Energy Consumption Forecast: A Deep Learning Approach

- A practical application of deep neural networks to the problem of monthly energy consumption forecast for energy companies.
- Our dataset consists of monthly energy consumption and minimal necessary metadata of customers.
- We try to predict the next-month energy consumption based on the 12 previous months, using noisy data collected during electrical meters reading.
- Three deep learning models were studied: Deep Fully Connected, Convolutional and Long Short-Term Memory Neural Networks.
- Due to the sensitivity of these models to the input range, two normalization techniques were also used in the proposed system: Standardization and Customer-wise Normalization.


2007-1
2007-2
2007-3
2007-4
2007-5
2007-6
2007-7
2007-8
2007-9
2007-10
2007-11
2007-12
2007-12-01
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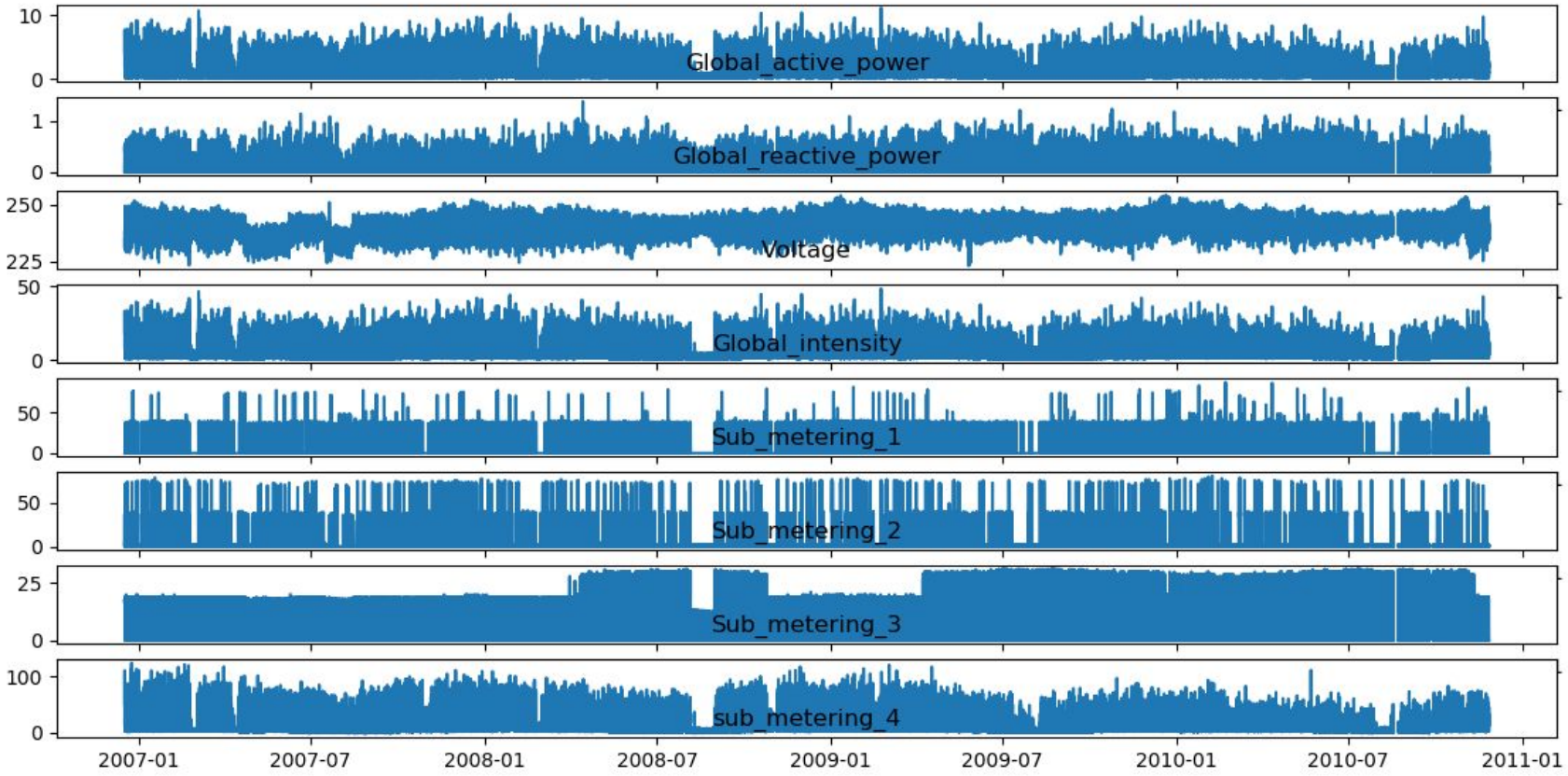
2007-12-13
2007-12-17
2007-12-21
2007-12-25
2007-12-29
2008-01-01


Global_active_power
Global_reactive_power
Voltage
Global_intensity
Sub_metering_1
Sub_metering_2
Sub_metering_3
sub_metering_4
10
0
1
0
250
225
50
0
50
0
50
0
25
0
100
0
2007-01
2007-07
2008-01
2008-07
2009-01
2009-07
2010-01
2010-07
2011-01

In the proposed system, an artificial neural network is used to perform the prediction of the energy consumption.
The 3 core methods used are:

Fully Connected Neural Network : On the FC-based model, single hidden layer with 200 neurons. Each neuron has linear activation

Convolution Neural Network: Our core method comprises 2 one-dimensional convolutions with a max pooling in-between.The length of the input is of 12 units.

Long Short-Term Memory Network model: There is a stack of 3 LSTM layers. Each unit processes through the time dimension of the input, i.e. each LSTM unit process 12 time steps, one value at a time.

Shared Architecture

- Past consumption input data passes through the core method.
- The output is concatenated with the normalized average and given to a 1000-units fully connected layer.
- If we don't use metadata this last layer is connected to a single neuron in order to compute the final output of the model, i.e. the prediction for the next month.
- Otherwise, when using metadata, a parallel branch is added into the architecture.
- Finally, a single neuron is used to compute the forecast.

For Implementation: Tensorflow

- Tensorflow provided by Google, is arguably the best Deep learning frameworks, among others, mainly because of its flexible architecture. It provides a collection of workflows to develop and using Python, JavaScript, or Swift, and to easily deploy in the cloud, on-prem, in the browser, or on-device no matter what language you use.
- We use Tensorflow to help develop the proposed system and produce the assumed output by using the deep working of neural networks with several hidden layers.

References

- Monthly Energy Consumption Forecast:A Deep Learning Approach (IEEE Paper)
- Energy Statistics 2018 , Central statistics office, ministry of statistics and programme
- Implementation government of India, New Delhi.
- https://www.enlitic.com/
- https://www.kaggle.com/robikscube/tutorial-time-series-forecasting-withxgboost - Hourly Time Series Forecasting using XGBoost