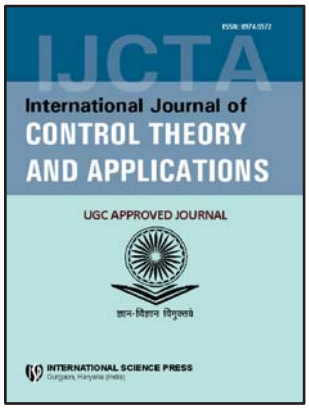

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Energy Analytics for Smart Meter Data using Consumer Centric Approach

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Abstract: A short-range residential consumer's demand forecasting at the distinct and cumulative level, by an analysis of data using consumer based centric approach. Energy intake behavior might fluctuate among various seasonal factors; the consumed current will change from one season to other. So hereby this paper is about building a model which helps to calculate future electricity consumption data from the obtainability of past smart meter data. Currently utility companies accumulate the data, use it, share for further practice, and abandon usage data at their discretion, with no input from customers. In many cases, consumers do not even have entree to their own data. But in this paper consumer can have fast admittance and control over their individual data, and also helps to choose the familiar algorithms for the data analyze rather than including third party applications. By end of analyze technique, the analyzed output will be driven to some user interactive application by creating a Graphical User Interface.

Keywords: *Cluster based forecast, Data analyze, Feedforward, Graphical user interface, Smart meter.*

1. INTRODUCTION

A smart meter help utility companies for monitoring and billing [1], it takes a new kind of gas and electricity meter readings that can digitally send to energy supplier that records consumed electricity energy that sends information in intervals of an hour or less and communicates at least back on daily basis.

So this can be used to estimate energy bills on the dailyor monthly basis.Unlike home energy monitors, smart meters can gather data for far away reporting. The Smart Meter is electronic device measuring natural gas or water consumption often refers to an energy meter. You can easily identify how much energy consumed by the smart meters which comes with displays. Some other smart meters, ordinarily referred to time-of-use meters or as interval [2], "Smart Meters" usually involve nearby real-time sensors or real-time, power quality monitoring and power outage notification. Such an advanced metering infrastructure [3] differs from traditional meter reading in that it assists two-way communications with the meter.

This paper is about to take a consumer centric approach [1]. Which will make consumer in ease of followings such as to?

1. Give a data access through the consumer's choice analytic algorithms and also helps to keep data privacy [1].
2. Provide a storage and perseverance for the consumer's data and gives control to the data [1].
3. Give a single view for the collected data so analyticscan be performed [1].

There are many techniques for energy consumption prediction on statistical and machine learning, from Linear Regression, ARMA [2, 4] and Generalized Additive Models, to Neural Networks and Support Vector Regression.

However, for very large space scales these techniques have been typically used, such as to predict the electrical load, to make data segment serving thousands of customers or even an entire country. In this paper, the focus is upon forecasting electricity consumption of residential [3, 5] customers, leveraging smart meter data.

1.2. Basic Architecture

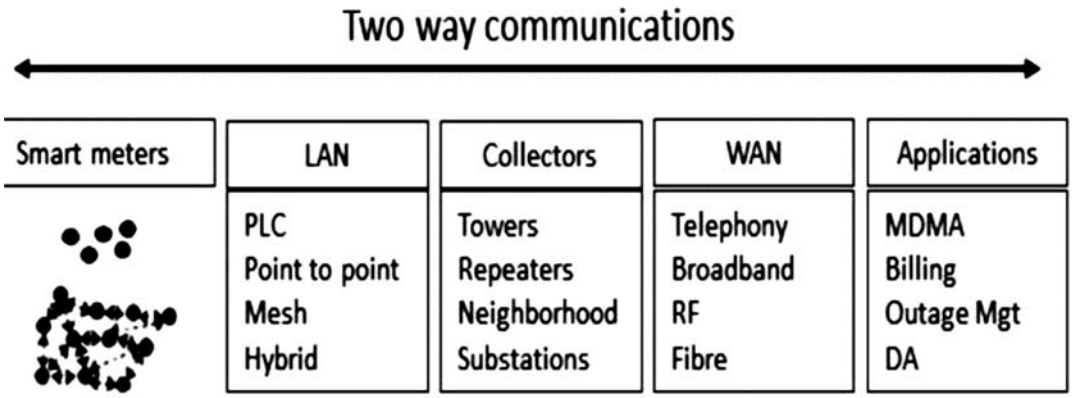


Figure 1: Smart meter model

To reach a data crew point, smart meter collects data and transfers by a local area network [6]. Energy consumption or data gives you the electricity usage which measures in kilowatt hours. The data collection happens in a frequent, which may vary from 1h to each 15 minutes, depending on the particular deployment and region [1, 6]. In terms of processing data, in best cases the energy data are transferred to the utilities companies centre by a wide area network (Fig. 1) and in some other cases data processing could be carried out at the local collection points.

The collected data help for the business purposes such as billing [6], prediction, watching, summarizing and scheduling.when you are using different electrical devices or even what channel or telecasting program is being viewed on a television can be identified through electrical consumption and the electrical noises releases, the sampling power of smart meter is reliably identify by two-second intervals, this been demonstrated by the researchers.

1.2.1. What data is collected and stored by my smart meter

Just alike analog meters, smart meters gather how much electricity you use and consumer names and addresses these get stored in the meters or transmitted across the network.. Smart meter collects a data over a day and contains more information ,Some utility companies receives snapshot of customer's energy consumption usage through smart meters for every 15 minutes[1], while others may collect hourly basis energy information. It is important to have strong privacy protections in place because smart meters gather and wirelessly transfer much more data about electricity consumption.

2. RELATED WORK

The utilities are looking to match the consumption of generated data for market-driven and deregulation purpose. An outdated meter only measure gas and electrical consumption, and does not provide any information of when [4] was the energy consumed at every metered location. Data procurement, transmission, processing, and interpretation done by smart meter and data analytics can be done, which bring aids to all stakeholders. To attain the stakeholder wants smart-meter to be designed and established in a way to relay smart meter data helps to stakeholders and the analytics tool which is developed by their own applications [6].According to some metric the groups of time series are discovered through kernel spectral clustering (KSC). For each cluster periodic autoregressive models aretrained and then projections per cluster [7] are computed.On other hand OpenTSDB, Hbase andHadoop theseOpen source tools helps to perform analytics on the time series data and store these data to get power consumption insights. As per the existing system consumers do not have access to their data in many conditions. So to provide fast control and access over their custom data ,this paper is helps about addressing by designing and implementing a consumer-based centric approachwhich will helps the consumer to analyze their data[8] based on their own choosing of applications that analyze data will be kept in a secrecy way where no one can access it.

The meter reader achieves different rates to be priced for energy which eliminates the cost of a monthly visitand time of day.Real time informs to users on usage and rates the most advanced design can provide load management. For prediction of power consumption, statistical and machine learning algorithms [6] are used. In other case in this paper building aGUI based integration which will direct to analyze techniques and presents the outcome of analyzed data.

3. LEARNING ALGORITHMS

Various learning algorithms such as supervised learning, unsupervised learning and reinforcement learning have been used to forecast large-scale electricity demand. Through these learning paradigms, the literature suggests some supervised learning. Those are Support vector regression (SVR) as one of the most effective models to forecast future energy consumption, Linear Regression and Multilayer perception.

In this paperthe system is about to use machine learning algorithm artificial neural network for analyzing smart meter data.Meanwhile training a neural network model by feeding data into it. Which will helps to minimize the cost by the predicting future consumed electricity data.

Learning algorithm: There are many algorithms which will train the network based upon the some parameters values to the available fixed data set. To train the network the data should have gone through the significant amount of practices.

Model selection: Model selection helps to represent data and applications in a significant way and also to know some challenges, when user choosing some other different model.

Sturdiness (robust): The final outcome of artificial neural network will be robust based on the algorithm and cost functions based upon the consumers are choosing.

4. IMPLEMENTATION ANALYSIS

4.1. The Dred (Dutch Residential Energy Dataset)

The DRED smart meter data collected from a household in the Netherland through the R&D department. The dataset [9] contains an appliance level devices energy consumption databased, for this paper an appliance level data is taken for the examination. The collected data helps to check the concert of energy, inventand analyze demand retort algorithms and behavior of appliance usages.

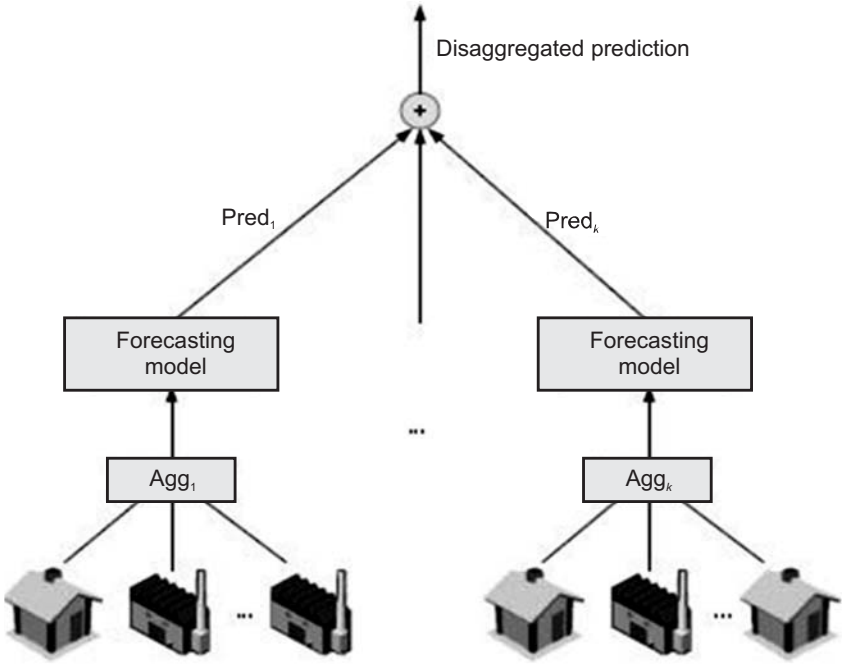


Figure 2: Data Collection and Fragmentation

4.1.2. Appliance level

Smart plug-ins is used to collect appliance level energy consumption data. There are 12 smart plugs were installed to monitor the appliances across the household. The plug-ins installed in the household communicates via Zigbee protocol by forming a mesh network and finally the data will be getting stored for the billing purpose.

In the household appliance level some machines have multiple states where others have only two states of operation. Smart meter capture the data at regularintervals andhelps stream data and transfer the same data in a high speed transfer rates. Since the smart meter is enabled with new technological abilities there is a competition among the utilities, the collected data are dissimilar in the series which will be used forecast (Fig. 4) [10] and for some variability issues.

And this paperis about to develop an MATLAB based GUI (also known as graphical user interfaces) which helps to provide single click point in control of an applications, removes the need of learning language or to type commands in edict to run the application.

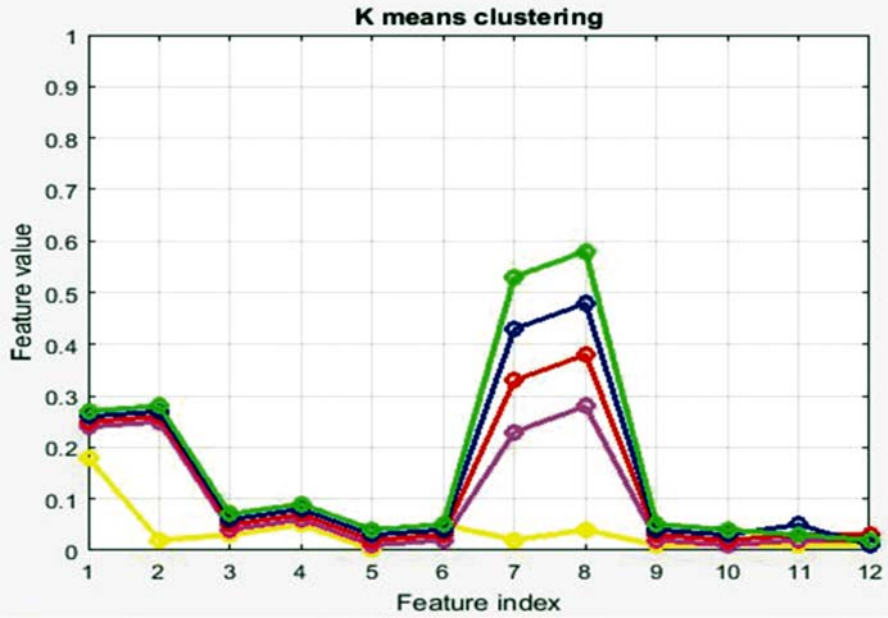
The GUI typically has gearshifts such as menu, toolbar, button, and slider. App Designer is environs for building apps. The applications [11] are independent programs with GUI in the front ends that automate a task and design. GUI integrates some primary tasks of application building programming app behavior, laying out the visual components and allows you to quickly move between graphic design in the canvas and code development.

With a comparisonmade for my paper with existing, which used to analyze and store the data. Google power meter Hohm these commercial software solutions- are being used for analytics provide a fixed set of data. This paper also helps to can check on data, privacy provide data in a different way with a sight change in values but it burdens them with data maintenance through tools, which helps for run integrity check.In this paper smart meter dataset are taken to perform examine, that dataset is fragments (Fig. 2) into different parts depends upon the aspects present into it & done a analyze [12].So the consumers can choose their familiar algorithm for the data to perform analyze. An overview of autoregressive moving average (ARMA) model is

ARIMA model which is an autoregressive integrated moving average which helps to evaluate time series data. Both models are fixed to time series data either to forecast future points in the series or to better know the data. ARIMA [13-14] models are useful in some circumstances where data show sign of non-stationary.The analyzed data are shown below in agraphical representation one by one as follows;

4.2. K-means c1ustering

K-means is an unsupervised learning algorithm helps to overcome the cluster problems. This simple algorithm partitions data to form a group of cluster by taking a centroid point among the each group, The Fig. 3 shows the formation of cluster with and without adjustments.



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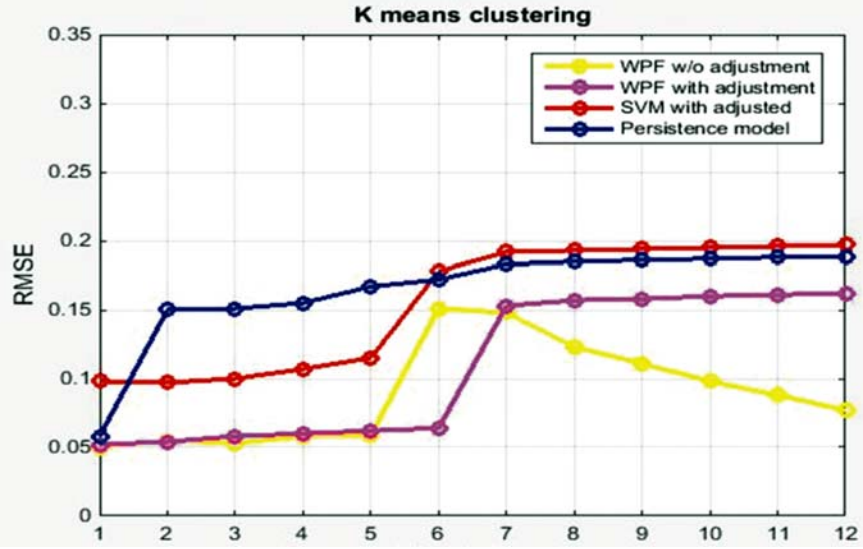

(*b*)

Figure 3: K-Means: (*a*) K-Means clustering (*b*) With and without adjustments

4.3. Feed forward method

Feedforward is a network contains N series number of layers. The network input has been given to the first layer for the connection. Every other following layer is connecting with the previous layer as shown in the Fig.4. The output is derived from the final or last layer in the network. This method is mainly used for the input output mapping [15]. Any input output mapping problems in a network can be solved by one hidden layer which contains enough neurons in present in feed forward network.

Feedforward is an artificial neural network, it has connections but it does not form a cycle, it is not a regular way of forming a network connection. This network moves an information in one way direction (*i.e.*) from the input node to output node through the hidden node inbetweeen.so this will resolves the problems such as loop or cycle formation.

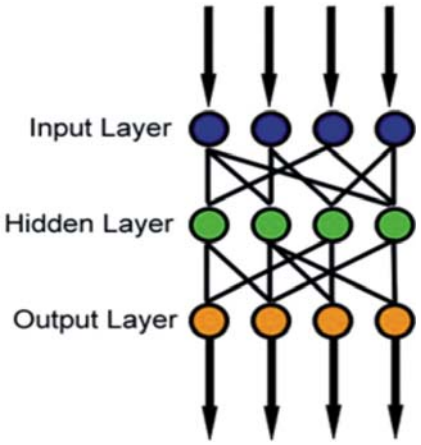

Figure 4: Feed forward neural network

In this paper, classification algorithm is used to train the nodes based upon the previous node value using the neuron like processing units, meanwhile it helps to predict the data among the set of datasets.

4.4. ARIMA Model

Autoregressive Integrated Moving Average which helps to evaluate time series data, this time series data actually classified into two types based upon the values present into it they are Stationary data and Non Stationary data.

1. Stationary data contains the value which will not change or fluctuate; this means there won't be a growth and it remains horizontally along the time series. Importantly the mean and variance does not change at any cause.

2. In opposite, non-stationary data will change and fluctuate among the mean and variance.

This work is about building a model to forecast our data. Forecasting helps to estimate the future values with the available past values for the time series data. In other hand prediction helps to estimate current or past, future value through regression for the data.

The forecast error density Fig.5 means the difference between the actual and predicted value for the time series data.in this figure the error density is calculated for each and every hour with the given smart meter data.

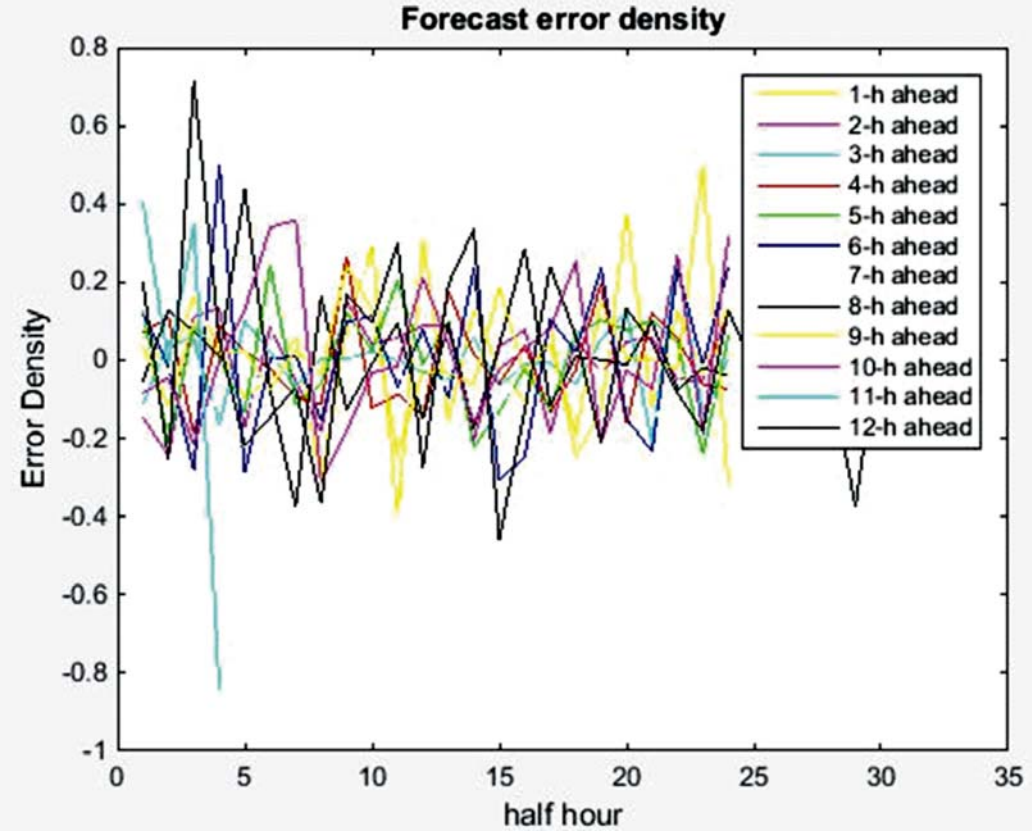

Figure 5: Forecast Error Density

In this project work the Matlab functions along the threshold values is defined below:

1. Forecast the conditional mean response of simulated data over a 30-period horizon.
2. Simulate 299 observations from a multiplicative seasonal MA model with known parameter values.

```
Mdl = arima('MA',{0.5,0.3},'SMA',0.4,'SMALags',12,...'Constant',0.04,'Variance',0.2);
      rng(299);
Y =  simulate(Mdl,299);
```

3. Fit a seasonal Moving Average model to the first 100 observations, and reserve the remaining observations to evaluate forecast performance.

```
ToEstMdl = arima('MALags',1:2,'SMALags',12);
EstMdl = estimate(ToEstMdl,Y(1:100));
```

Table 1
ARIMA (0,0,2) Model with Seasonal MA(12):Conditional Probability Distribution: Gaussian

Parameter	*Value*	*Standard Error*	*t Stastic*
Constant	–0.0164561	0.0731351	0.0731351
MA{1}	0.496486	0.0896514	5.53796
MA{2}	–0.337496	0.0917487	–3.67848
SMA{12}	0.38826	0.116393	3.31484
Variance	0.218289	0.032023	6.8104

EstMdl is a new arima model with parameters estimated.

Use the fitted model to forecast a 30-period horizon, and visually compare the forecasts to the holdout data.

```
[YFYMSE] = forecast(EstMdl,30,'Y0',Y(1:100));
```

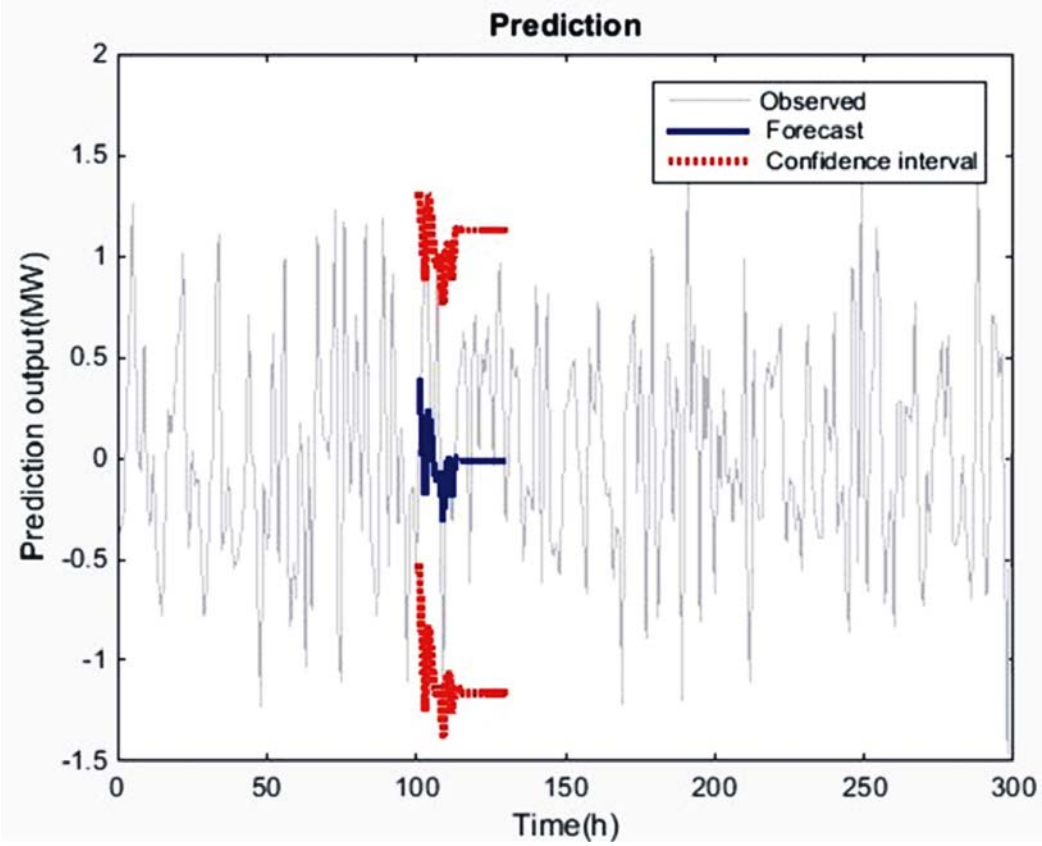

Figure: 6:30-period forecast with Confidence interval

The above Fig.6 shows the observed value along with the forecast (30-period) and the confidence interval.

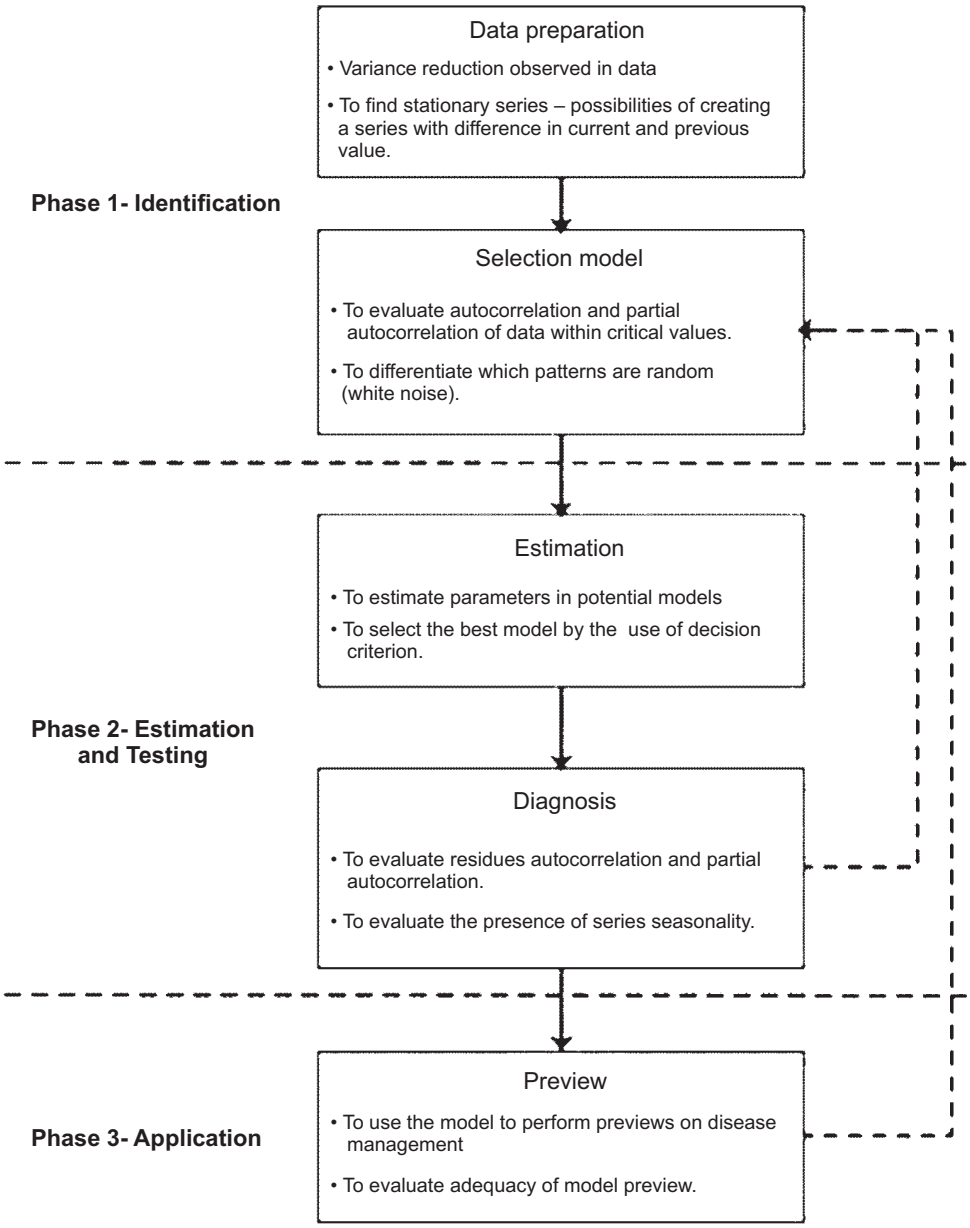

Figure 7: Scheme for the use of Box-Jenkins Methodology (ARIMA Model)

4.5. Regression

The regression [16] helps to predict the future, current or past value for the given smart meter data. The visual representation for the regression analysis is given below, you can see the straight line which means the data is fit and trained for examining.

Linear regression is model which is used to build a relationship between dependent and explanatory variable.

1. Dependent variable is one which dependsupon any other variable, so it doesget affected easily.
2. Explanatory variable is an independent variable, so it does not get affected with the any other variable.

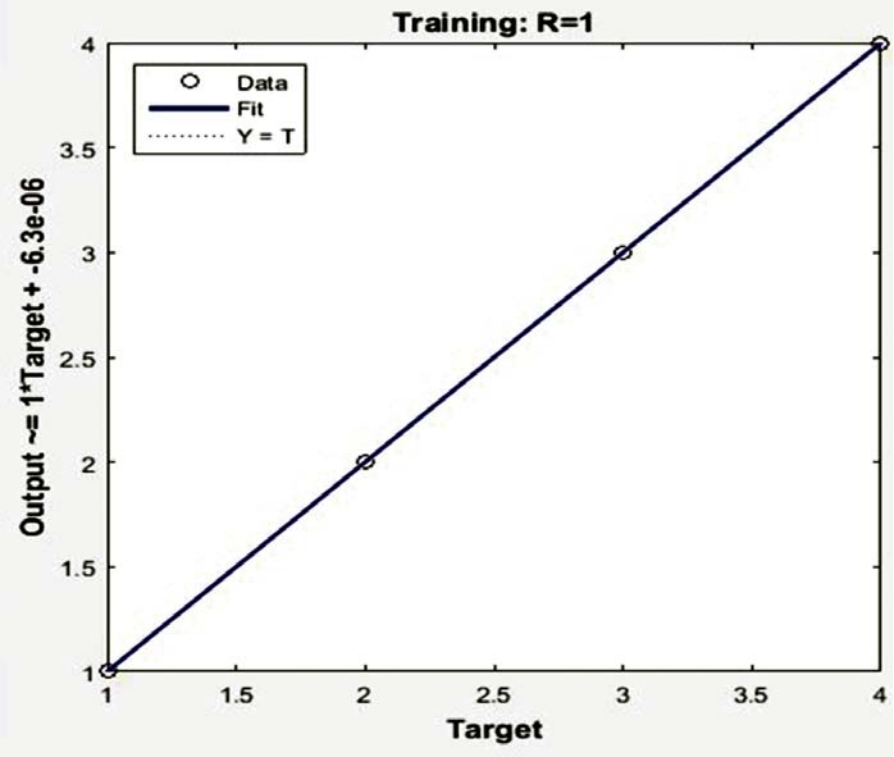

Figure 8: Regression

5. CONCLUSION

In this paper have done analyze of smart meter data for short-rangedistinct and cumulativeestimating of residential electricity consumption. Smart meter is helps to get the energy data, which will bring the key important influences to perform data analytics. This analytics will help stakeholders or consumers for obtaining, processing and clarifications about the data. Energy demand forecasting has been broadly studied in the literature by examining the various mechanisms and techniques. Consumers preserve ownership and fine-grained control over their energy consumption data while enabling third party applications to examine that data in a secrecypreservative fashion. However demandis keep on growingfor the next forecasting is for large scale, this forecasting technique will brings you Cost effective way for the future power consumption.

6. FUTURE ENHANCEMENT

The prediction is actually done with the small amount of data for the residential customers. So in effective way this paper is about to build a model in such a way to analyze the data produced by a large scale industry or organization and also in cost effective manner in both billing and estimating.

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