Design of Domestic Appliance Load Modeling from Aggregated Smart Meter Data using LabVIEW

Ashwini Ankush Patil[1], Pravin B. Desai[2]

[1,2]*Electronics and Telecommunication Engineering, Ashokrao Mane Group of Institutions, Vathar Tarf Vadgaon Kolhapur, India*

---***---

Abstract - *This paper gives an overview of recent research on new application of Domestic appliances load modeling from Aggregated Smart Meter Data with differential observations (EDHMM-diff), along with a specialized forward-backward algorithm which is able to model various parameters of appliances. The main aim of appliances load modeling is to model load of individual appliances based on the aggregated power signal with state durations. The major objective of EDHMM-diff model is to handle the "aggregating effect", because the conventional HMM cannot handle this effect which generates different observations even for the same state of the same device.*

Key Words: Laboratory Virtual Instrument Engineering Workbench (LabVIEW), Explicit-Duration Hidden Markov Model with differential observations (EDHMM-diff), Hidden Markov models (HMM), Non-Intrusive Load Monitoring (NILM).

1. INTRODUCTION

As part of the smart grid deployment, smart meters can provide more energy consumption information than we could imagine before in a near real-time way. With increasing installations of smart meters in more countries, such as Australia, Canada, Italy, Japan, United States, etc., massive amount of residential electric energy consumption data has been collected and stored. Although current advanced infrastructures of smart grid could provide full potentials for advanced services, insightful analysis and modeling based on such big data is still in its early stage. Exploration of such valuable data emerges as a popular research direction both in academia and industry, and conventional services, such as load disaggregation (LD), load forecasting (LF) and demand response (DR) support, are brought back to attention. Modeling the home appliance loads plays an important role for these applications, since it is the first step for understanding the electric consumption data. In this paper, we focus on modeling home appliance loads under a general assumption, where only aggregated real-time power data is observed by ordinary smart meters already deployed, with a low data sampling rate.
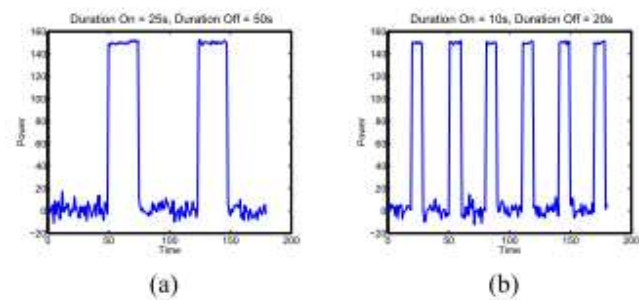

Fig - 1: Signals shown in (a) and (b) are two signals with the same emission probabilities but different state duration distributions. X axis is abstract index without unit for illustration purpose. A conventional HMM model cannot capture the difference between them since the state durations are not considered.

Power consumption signatures are used to describe the behaviors of home appliances, which include information such as time of use, on-and-off durations and patterns, power demands, etc. Some signatures also encode the transient properties of the current and voltage signals of appliances when they are turned on or off, while some signatures mainly focus on stable properties of the power signals. Most smart meters installed in the field measure and transmit the real power signals of residential users at a relatively low frequency Therefor the low sampling rate makes stable signature a more suitable choice for home appliance load modeling. Most home appliances work at one or several fixed power demands, which can be characterized by finite discrete states. In addition, one power reading at present is independent from early readings in the past. Therefore, Hidden Markov Model (HMM) [4] seems a good choice and is widely used to model home appliances to extract stable information.

However, the conventional HMM cannot model the du-ration of each state, which is important for estimating the electric energy consumption of a home appliance. The states' durations and switching patterns are also crucial for describing appliances, and could help increase the accuracy of detection and estimation. In Fig. 1 we illustrate a confusion caused by the lack of duration modeling of conventional HMM on power signals.
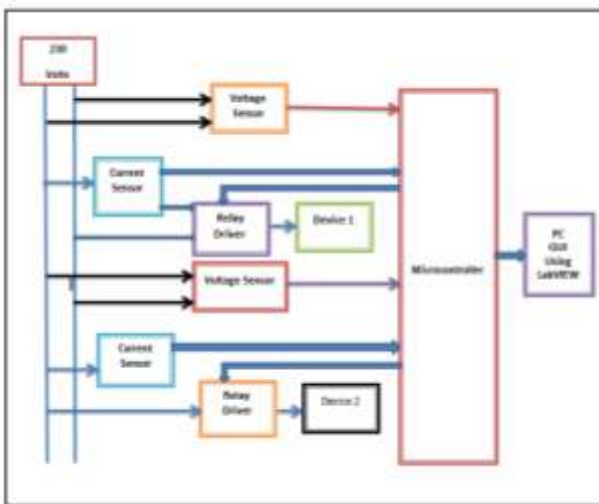

1.1 PROPOSED WORK

Fig – 2: Block Diagram of "Domestic Appliance Load Modeling From Aggregated Smart Meter Data Using LabView"

A.   LabVIEW:

LabVIEW is a program development application, much like various commercial C or BASIC development systems, or National Instruments LabWindows. However, LabVIEW is different from those applications in one important respect. Other programming systems use text-based languages to create lines of code, while LabVIEW uses a graphical programming language, G, to create programs in block diagram form. You can use LabVIEW with little programming experience. LabVIEW uses terminology, icons, and ideas familiar to scientists and engineers and relies on graphical symbols rather than textual language to describe programming actions. LabVIEW has extensive libraries of functions and subroutines for most programming tasks. For Windows, Macintosh, and Sun, LabVIEW contains application specific libraries for data acquisition. LabVIEW also contains application-specific libraries serial instrument control, data analysis, data presentation, and data storage. LabVIEW includes conventional program development tools, so you can set breakpoints, animate program execution to see how data passes through the program and single-step through the program to make debugging and program development easier.

B.   Relay:

Relay circuits are interfaced with the energy meter and microcontroller. Relays allow one circuit to switch a second circuit which can be completely separate from the first. Relay circuit are used for switching the consumer's main consumption line between cut-off and power supply mode. It is proved to be very helpful feature for energy Provider Company, who can remotely switch into cut off mode from power on mode of any consumer due to nonpayment of electricity bills / has large outstanding dues. It can reconnect the power supply after payment of dues.

A relay is an electrically controllable switch widely used in industrial controls, automobiles and appliances. The relay allows the isolation of two separate sections of a system with two different voltage sources i.e., a small amount of voltage/current on one side can handle a large amount of voltage/current on the other side but there is no chance that these two voltages mix up.
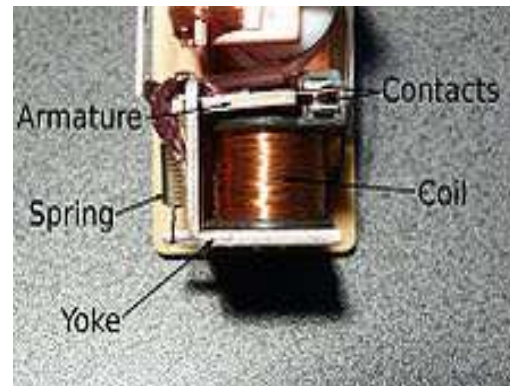

Fig – 3:   Diagram of Relay.

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

C.   Sensor:

A sensor is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. Voltage sensor a device that converts voltage measured between two points of an electrical circuit into a physical signal proportional to the voltage. A current sensor is a device that detects electric current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output.

D.   Microcontroller:

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. It collects the data from sensors and gives the output to the PC. Here we have used LPC2138 ARM 7 controller IC which is low-power 32-bit RISC microprocessor cores optimized for cost and power-sensitive consumer applications.

E.   PC:

A Personal computer is a machine that can be programmed to manipulate symbols. In this proposed system Graphical User Interface by using Labview is used to display the various parameters like voltage and current waveforms.
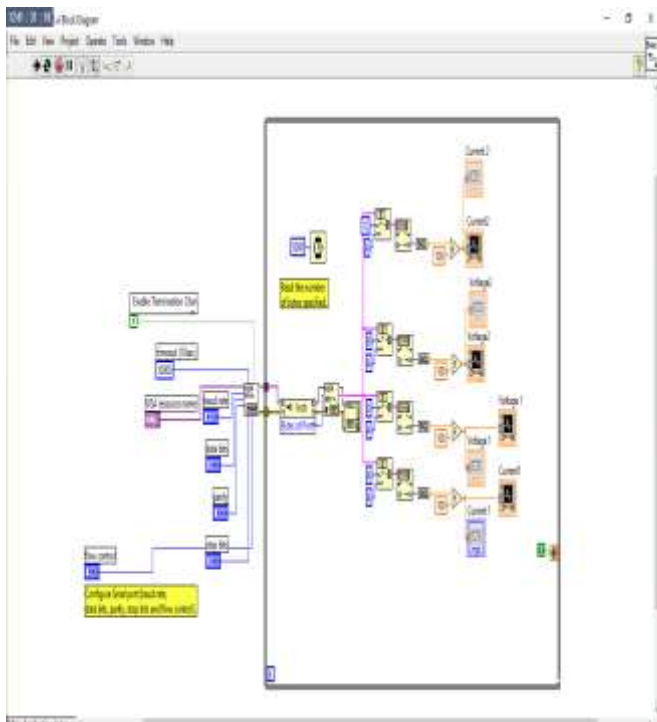
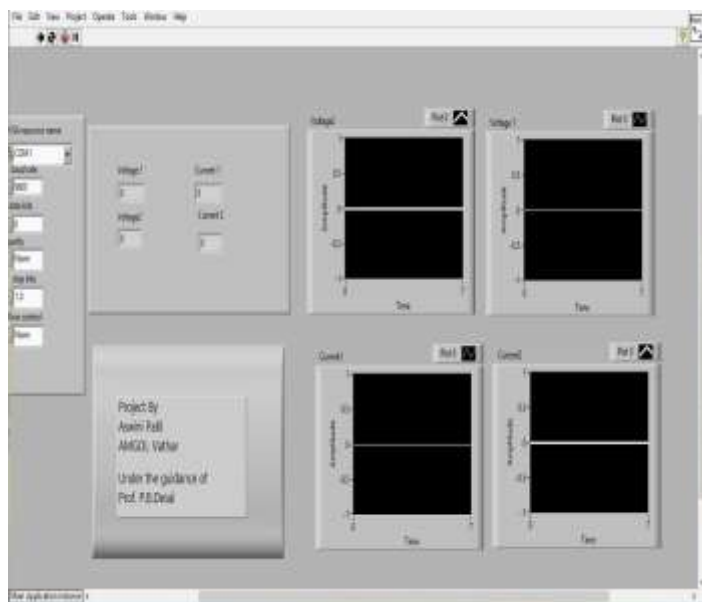**Fig – 4:** Block diagram in Labview software

2. RESULT

Fig - 5. Results in GUI of Labview

Here appliances voltage and current waveform is displayed in graphical representation. The X-axis shows time and the Y-axis shows the amplitude of the voltage and current.

3. CONCLUSION

LabVIEW is the effective tool for the load modeling with some additional hardware. It is of very low cost and user friendly system that anyone can handle it. This system models load of home appliances very effectively. The future scope of this system is we can save connected appliances load history in this software so at any instant we will have all appliances history of a home.

REFERENCES

[1] Zhenyu Guo, Z. Jane Wang, Senior Member, IEEE, and Ali Kashani, "Home Appliance Load Modeling From Aggregated Smart Meter Data" IEEE transactions on power systems, vol. 30, no. 1, [2015].

[2] Oliver Parson, Siddhartha Ghosh, Mark Weal, Alex Rogers, "An Unsupervised Training Method for Non-intrusive Appliance Load Monitoring", Electronics and Computer Science University of Southampton, Hampshire, SO17 1BJ, UK [2014].

[3] Ahmed Zoha, Alexander Gluhak, Muhammad Ali Imran and Sutharshan Rajasegarar, "Non-Intrusive Load Monitoring Approaches for Disaggregated Energy Sensing: A Survey", Center for Communication Systems Research, University of Surrey, Guildford, GU2 7XH,UK [2012].

[4] Sean Barker, "Model-Driven Analytics of Energy Meter Data in Smart Homes", University of Massachusetts Amherst [2014].

[5] S. Raj Rajagopalan, Lalitha Sankar, Soheil Mohajer, H. Vincent Poor, "Smart Meter Privacy: A Utility-Privacy Framework", Dept. of Electrical Engineering, Princeton University, Princeton, NJ 08544[2011].

[6] Sean Barker, Student Member, IEEE, Sandeep Kalra Student Member, IEEE, David Irwin, Member, IEEE, and Prashant Shenoy, Fellow, IEEE, "Empirical Characterization, Modeling, and Analysisof Smart Meter Data" University of Massachusetts Amherst, [2014].