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SMART BUILDING ENERGY MANAGEMENT SYSTEM USING MACHINE LEARNING AND IOT

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Abstract - *Energy is the lifeblood of modern societies. In the past decades, the world's energy consumption and associated CO_2 emissions increased rapidly due to the increases in population and comfort demands of people. Building energy consumption prediction is essential for energy planning, management, and conservation. Buildings are currently responsible for more than 40% of global energy and one third of global greenhouse gas emissions. This project work aims to develop a machine learning model, method, architecture or appliance to reduce building energy use and emissions using a smart sensor for residential or commercial buildings. An experienced operator can do a good job of adjusting set points and schedule. But no matter how good they are, a human's ability is limited by the amount of data he or she can process. Significant opportunities exist to take advantage of external data sources including real-time occupancy sensor networks, changing space schedules, weather forecasts, grid carbon intensity, and other environmental conditions that could help us better predict space set-points and schedules 24x7. The sensor senses CO2 reading, sound level, ambient light, door state sensing etc. These can be used to accurately estimate the number of occupants in each room using machine learning techniques and this technique can be used to predict future occupancy. In this project we take a look at some questions regarding the construction and the exploitation of knowledge related to different types of buildings in order to optimize the use of different resources while still assuring the occupants' comfort. The Heating, ventilation and Air conditioning (HVAC) equipments data of the building are captured using IOT sensors and the vast data collected using these sensors are analyzed using Machine Learning based Big data analysis technique and the decision obtained is used to control HVAC devices automatically. We design an IOT based Big data analysis model that characterize a building as smart and finally, it is planned to make Electrical Department of our Institution smart with our SB model.*

Key Words: INTERNET OF THINGS (IOT), SMART BUILDING (SB), SENSORS, SUPPORT VECTOR MACHINE,

1. INTRODUCTION

Excessive domestic energy usage is an impediment towards energy efficiency. Developing countries are expected to witness an unprecedented rise in domestic electricity in the forthcoming decades. A large amount of research has been directed towards behavioural change for energy efficiency. Emission of greenhouse gases including CO_2 in higher layers of the atmosphere are known as the main cause of global warming phenomena. The attempt to decrease the amount of green- house gases needs significant alteration in human behaviour in energy consumption, manufacturing of more environmental friendly products and identifying and mitigating the causes of these undesirable gases. In traditional buildings, households are responsible for continuously monitoring and controlling the installed Heating, Ventilation, and Air Conditioning (HVAC) system. Unnecessary energy consumption might occur due to, for example, forgetting devices turned on, which overwhelms users due to the need to tune the devices manually. Nowadays, smart buildings are automating this process by automatically tuning HVAC systems according to user preferences in order to improve user satisfaction and optimize energy consumption.

1.1 Artificial Intelligence (Machine Learning)

Artificial intelligence (AI) is wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. AI is an interdisciplinary science with multiple approaches, but advancements in machine learning and deep learning are creating a paradigm shift in virtually every sector of the tech industry. Norvig and Russell go on to explore four different approaches that have historically defined the field of AI:

- Thinking Humanly
- Thinking Rationally
- Acting Humanly
- Acting Rationally

The first two ideas concern thought processes and reasoning, while the others deal with behaviour. Norvig and Russell focus particularly on rational agents that act to achieve the best outcome, noting "all the skills needed for the Turing Test also allow an agent to act rationally.

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn

and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

1.2 Smart building

Although the term "smart building" (SB) may bring a thought of a fictional smart space from science-fiction movies, but the reality is that SBs exist today, and their number is getting increased. With recent advances in machine learning (ML), big data analytics, sensor technologies and the Internet of Things (IoT), regular buildings can be cost-effectively transformed into SBs with bare minimum infrastructural modifications.

1.3 Need for smart building

At its most basic, a *smart building* is one that is using technology to share information about what goes on in the building between systems so as to optimise the building's performance. This information is then used to automate various processes, from heating and ventilation to air conditioning and security. There are smart office, smart library, smart home, smart health care facilities, smart hospital and many other types of SBs that can provide automated services that can provide many value-added services (such as reduction of wasted energy) and also help to ensure the comfort, health and safety of the occupants.

1.4 Technology Involved

The hyperconnectivity that will be brought about by the emergence of IoT will increase the promise of SB since now all the basic building amenities and commodities ranging from your house electronics to your plant vases will be interconnected. But this hyperconnectivity will at the same time complicate the process of managing SBs. In particular, SBs and their inhabitants are expected to create large volumes of streaming data. ML, sampling, compression, learning, and filtering technologies are becoming more significant to manage the stream of big data of individuals. In order to maximize comfort, minimize cost, and adapt to the needs of their inhabitants, SBs must rely on sophisticated tools to learn, predict, and make intelligent decisions.
SB algorithms cover a range of technologies, including prediction, decision-making, robotics, smart materials, wireless sensor networks, multimedia, mobile computing, and cloud computing. With these technologies, buildings can cognitively manage many SB services such as security, privacy, energy efficiency, lighting, maintenance, elderly care, and multimedia entertainment. The massive volume of sensory data collected from sensors and appliances must be analyzed by algorithms, transformed into information, and minted to extract knowledge so that machines can have a better understanding of humans than their environment. Furthermore, and most importantly, such knowledge can lead to new products and services that can dramatically transform our lives. For example, readings from smart meters can be used to better predict and balancing the usage of power. Monitoring and processing sensory data from wearable sensors attached to patients can produce new remote healthcare services. The main philosophy behind ML is to create the analytical models automatically in order to permit the algorithms to learn continuously from available data.

1.5 Machine Learning

Machine learning at its most basic is the practice of using algorithms to parse data, learn from it, and then make a determination or prediction about something in the world. Machine learning is the science of getting computers to act without being explicitly programmed. It is based on algorithms that can learn from data without relying on rules-based programming. In machine learning, support-vector machines are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Support Vector Machine is to be used in this proposed project as ML. SVM is used to separate the required feature data from collected datum. SVMs are highly robust models for solving non-linear problems and used in research and industry for regression and classification purposes. In the SVM algorithm, we plot each data item as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate. Then, we perform classification by finding the hyper-plane that differentiates the two classes very well.

1.6 Objective

- To design a Smart building energy management system to reduce energy consumption.
- To monitor occupancy of building using IOT sensors.
- To analyze the sensor data using Big data Analysis techniques designed in Raspberry Pi processor
- To initiate control action on electrical equipments based on knowledge obtained from Machine Learning.

2. METHODOLOGY

2.1 Framework

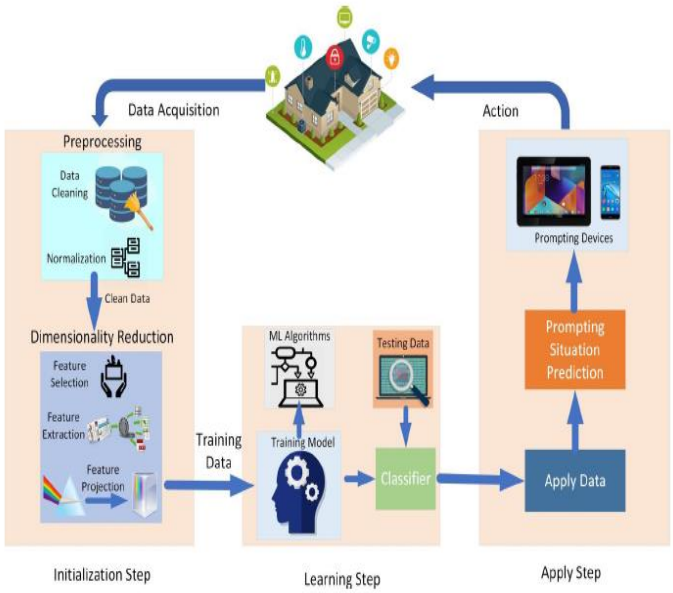

Fig – 1: Framework of Proposed SB Model

Fig - 1 represents the basic framework of the project model. It is a general depiction of ML tasks in SBs and tells about the steps taken to implement ML in an SB environment.

2.2 Block Diagram

Fig - 2 shows the block diagram of the proposed SB Model. It represents that,

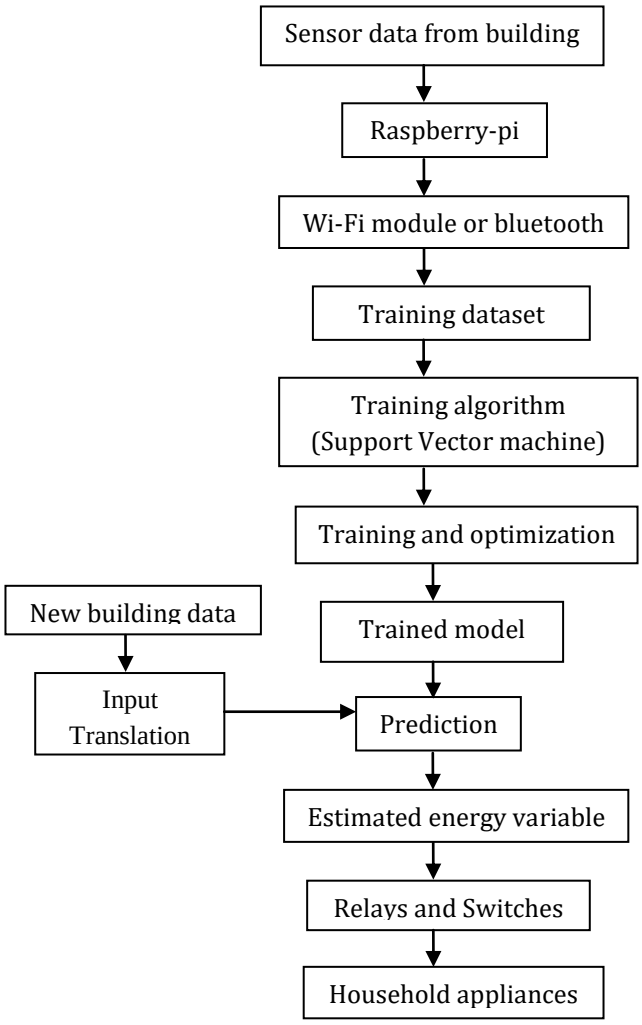

Fig – 2: Block Diagram of Proposed SB Model

- The various building data are collected from sensors like co2, infrared, sound, optical, contact, current, thermal, pressure, DHT11, RFID, motion sensors.
- The data collected by the IOT sensors are given to the Raspberry pi processor.
- Data cleaning and Data integration is done.
- Input features and important features are identified to form training feature set.
- The training set is stored in cloud if needed using Wi-Fi module.
- The Support Vector Machine Learning algorithm was trained based on the training data.
- The trained model is used to obtain output for new building data.
- The output from the estimated energy variable is processed through the relay and switches and given to all household appliances.

2.3 WORKING

The sensors are placed in appropriate places of buildings to collect required features. The output of the sensors should be given to the raspberry pi processor. The processor is accessed through Internet of Things from anywhere. This data is saved to cloud through Bluetooth or Wi-Fi module. These data are collected for one month and it is to be trained by machine learning (ML) technique using Support Vector Machine (SVM).The trained model is obtained from the input features with tuned SVM parameters. Based on this data analysis, the daily routine and occupancy pattern of a building is known. This is helpful for automatic on, off and control of electrical appliances in building using relay, switches in future. Thus our smart building saves energy automatically without human intervention.

3. DISCUSSION

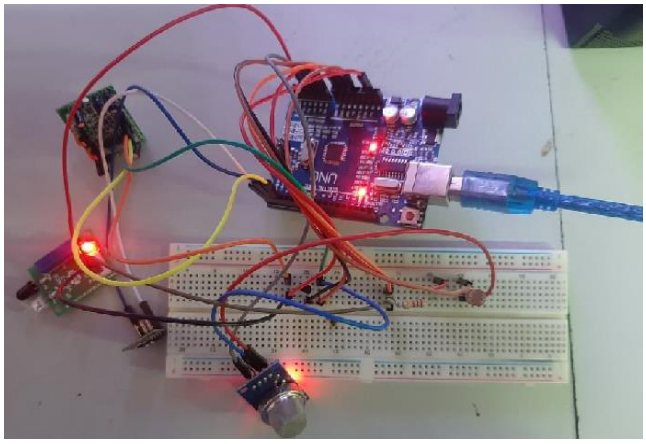

FIG – 3: Interfacing Temperature, CO2, LDR sensors with Wi-Fi module

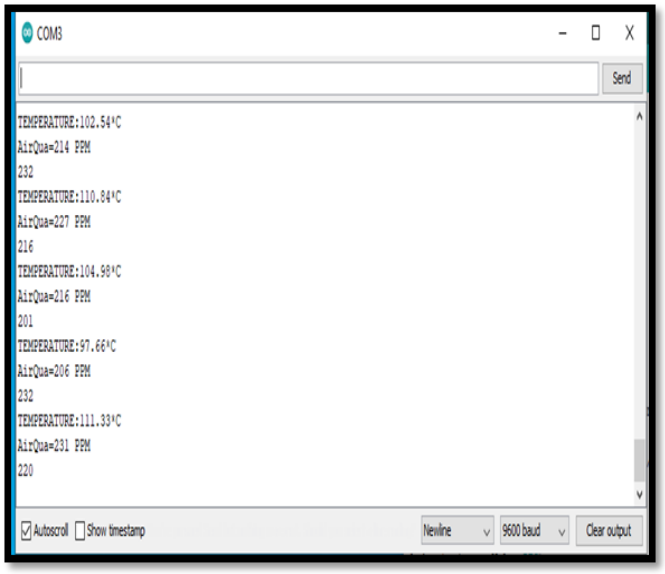

FIG - 4: Output for interfacing sensors with Wi-Fi module

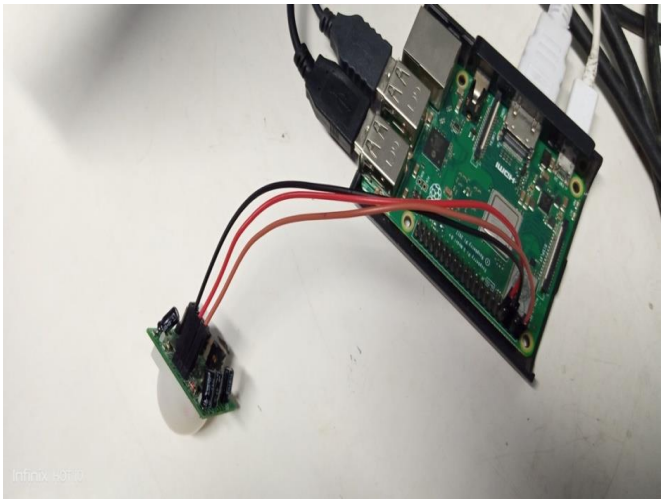

FIG – 5: Interfacing Raspberry-pi with IR sensor

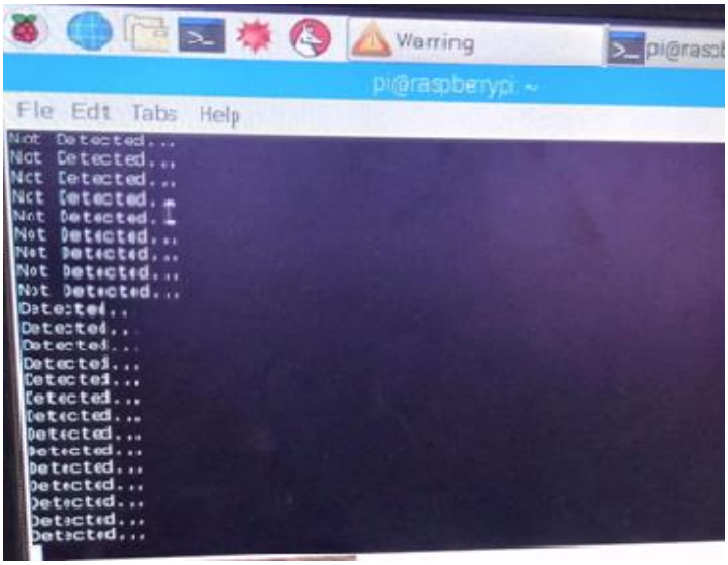

FIG - 6: Output for interfacing Raspberry-pi with IR sensor

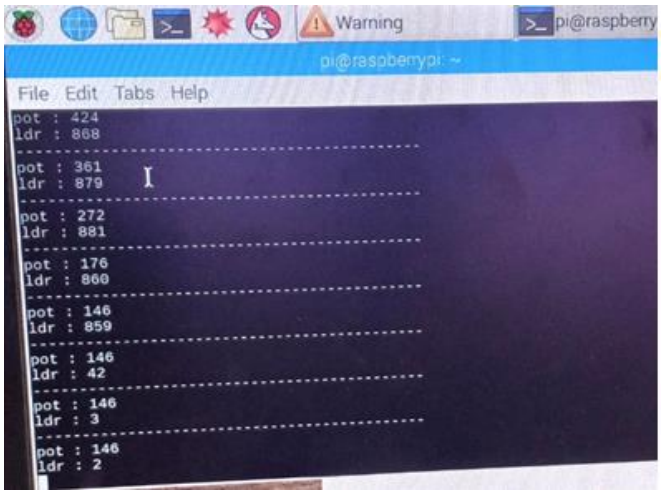

FIG - 7: Output for interfacing Raspberry-pi with LDR sensor

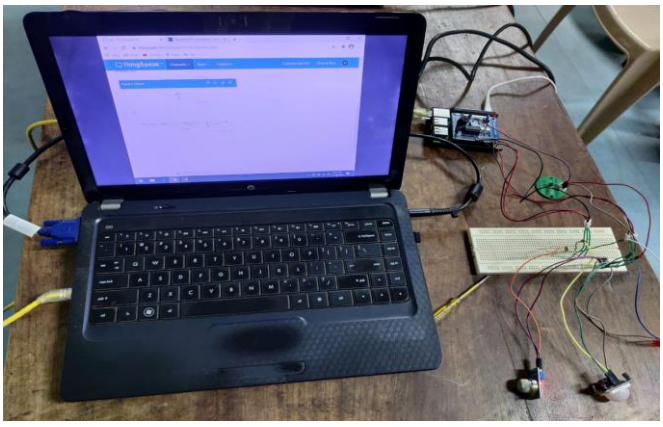

FIG – 8: Sending sensor data to Thingspeak IOT Platform using Raspberry-pi

```
>> SBsample

totcorrect =

        2608


accuracy =

   97.8612

>> length(data)

ans =

        8143

>> length(testdata)

ans =

        2665
```

FIG - 9: Output of Machine Learning

4. CONCLUSIONS

The global warming issue raised by greenhouse gasses emission is getting more attention every year. Our project mainly focused on reducing the usage of energy and automating the building. The significant part of making a building smart is that we can reduce the overheads and rectify an issue so that it doesn't occur again. It becomes tedious to solve the problems that are repetitive and this can save human labour and also guesswork can be avoided. Sensors are essential to monitor each system and collect data. This data help us to decide the allocation of resources and energy lost in every room In this paper, we have created a SB model using machine learning. This SB model is used to reduce greenhouse gases by over usage of AC Our SB model can provide automated services that can provide many value-added services (such as reduction of wasted energy) and also help to ensure the comfort, health, and safety of the occupants .Our project can be implemented in commercial, residential buildings, educational Institutions, hospitals. Although the recent advancements in technologies that make the concept of SBs feasible, there are still a variety of challenges that limit large-scale real- world systems in SBs field. Addressing these challenges soon will be a powerful driving force for advancements in both industrial and academic fields of SB research.

REFERENCES

[1] D. Zhang, B. Guo, and Z. Yu, "The Emergence of Social and Community Intelligence," Computer, vol. 44, no. 7, pp. 21–28, Jul. 2011.

[2] N. Javaid, I. Khan, M. N. Ullah, A. Mahmood, and M. U. Farooq, "A Survey of Home Energy Management Systems in Future Smart Grid Communications," in 2013 Eighth International Conference on Broad- band and Wireless Computing, Communication and Applications, Oct. 2013, pp. 459–464.

[3] J. Al-Jaroodi and N. Mohamed, "Characteristics and Requirements of Big Data Analytics Applications," in 2016 IEEE 2nd International Con- ference on Collaboration and Internet Computing (CIC), Nov. 2016, pp. 426–432.

[4] A. Ali, J. Qadir, R. u. Rasool, A. Sathiaseelan, A. Zwitter, and I. Crowcroft, "Big data for development: applications and techniques," Big Data Analytics, vol. 1, no. 1, p. 2, Jul. 2016.

[5] D. Geesen, H. J. Appelrath, M. Grawunder, and D. Nicklas, "Challenges for Personal Data Stream Management in Smart Buildings," Creating Personal, Social, and Urban Awareness through Pervasive Computing, pp. 201–219, 2014.

[6] S. Talari, M. Shafie-khah, P. Siano, V. Loia, A. Tommasetti, and J. P. S. CatalÃčo, "A Review of Smart Cities Based on the Internet of Things Concept," Energies, vol. 10, no. 4, pp. 1–23, 2017.

[7] E. Al Nuaimi, H. Al Neyadi, N. Mohamed, and J. Al-Jaroodi, "Applications of big data to smart cities," Journal of Internet Services and Applications, vol. 6, no. 1, p. 25, Dec. 2015.

[8] D. Bandyopadhyay and J. Sen, "Internet of Things: Applications and Challenges in Technology and Standardization," Wireless Personal Communications, vol. 58, no. 1, pp. 49–69, May 2011.

[9] J. Bangali and A. Shaligram, "Design and Implementation of Security Systems for Smart Home based on GSM technology," International Journal of Smart Home, vol. 7, no. 6, pp. 201–208, Nov. 2013.

[10] J. A. Stankovic, "Research Directions for the Internet of Things," IEEE Internet of Things Journal, vol. 1, no. 1, pp. 3–9, Feb. 2014.

[11] M. S. Hossain, M. A. Rahman, and G. Muhammad, "CyberâĂ Ş physical cloud-oriented multi-sensory smart home framework for elderly people: An energy efficiency perspective," Journal of Parallel and Distributed Computing, vol. 103, pp. 11–21, May 2017.

[12] N. K. Suryadevara, A. Gaddam, R. K. Rayudu, and S. C. Mukhopadhyay, "Wireless sensors network based safe home to care elderly people: Behaviour detection," Sensors and Actuators A: Physical, vol. 186, pp. 277–283, Oct. 2012.

[13] J. King and C. Perry, "Smart Buildings: Using Smart Technology to Save Energy in Existing Buildings," American Council for an Energy-Efficient Economy,

Washington, DC, USA, Technical Report A1701, Feb. 2017.

[14] M. Jahn, M. Jentsch, C. R. Prause, F. Pramudianto, A. Al-Akkad, and R. Reiners, "The Energy Aware Smart Home," in 2010 5th International Conference on Future Information Technology, May 2010, pp. 1–8.

[15] Alzubi, J., Nayyar, A., Kumar, A.: Machine learning from theory to algorithms: an overview. In: 2018 2nd National Conference on Computational Intelligence (NCCI): Journal of Physics, vol. 1142, p. 012012. IOP Publishing (2018)

[16] H. Fang, R. Srinivasan, and D. J. Cook, "Feature selections for human activity recognition in smart home environments," International Journal of Innovative Computing, Information and Control, vol. 8,, pp. 3525– 3535, May 2012.

[17] J. P. Cunningham and Z. Ghahramani, "Linear Dimensionality Reduction: Survey, Insights, and Generalizations," Journal of Machine Learning Research, vol. 16, pp. 2859–2900, 2015.

[18] Y. Saeys, I. Inza, and P. LarraÃs´aga, "A review of feature selection techniques in bioinformatics," Bioinformatics, vol. 23, no. 19, pp. 2507–2517, Oct. 2007.

[19] Y.-L. Chen, X. Wu, T. Li, J. Cheng, Y. Ou, and M. Xu, "Dimensionality reduction of data sequences for human activity recognition," Neuro-computing, vol. 210, pp. 294–302, Oct. 2016.

[20] O. D. Lara and M. A. Labrador, "A Survey on Human Activity Recognition using Wearable Sensors," IEEE Communications Surveys Tutorials, vol. 15, no. 3, pp. 1192–1209, 2013.