IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Artificial Intelligence-Driven Smart Home Towards Energy Efficiency

1.Yash Sameer Naik
Department of Computer Engineering,
Shalaka Foundations Keystone School of Engineering, Pune, Maharashtra, India

2.Prof. Vrushali Wankhede
Department of Computer Engineering,
Shalaka Foundations Keystone School of Engineering, Pune, Maharashtra, India

Abstract:
The use of artificial intelligence technology (AI) for enhancing the efficiency of intelligent houses in energy consumption is a milestone. Smart homes can be one of the main tools in their energy use nowadays. Thanks to AI, smart homes are being used more efficiently and more cost-effectively. Over time, as the availability of AI-driven energy-efficient technologies comes to dominate the home energy market, traditional energy management technologies (such as Home Energy Management Systems (EMS) and Load Forecasting) will become a thing of the past.
Moreover, the paper also focuses on the techniques such as load disaggregation, EMS, and forecasting that are alternatives helping of smart homes to reduce energy consumption. A model for AI-empowered smart living spaces that fuse energy efficiency and user comfort is also proposed.

Keywords : Artificial Intelligence (AI), Smart Homes, Energy Efficiency, Load Disaggregation, Energy Management Systems (EMS), Demand Forecasting, IoT-Based Solutions, Renewable Energy, Smart Lighting, Home Automation, Sustainable Energy, AI-Powered Systems, User Comfort, Dynamic Energy Optimization

1. Introduction

In the past few years Energy efficiency has become a key issue around the world. This is due to increasing environmental concerns and rising energy prices. This is because the house uses a lot of energy. It is very important to make your home as energy efficient as possible. This is where artificial intelligence (AI) can help. IA can turn your home smarter. or can significantly reduce energy use And at the same time, it provides the convenience that people want. Today's smart homes do more than control devices. By being able to learn how people use it. Forecasting energy needs and create smart schools based on available data They adapt to

changes in their environment. Use renewable energy sources and work to reduce environmental impacts Essentially, IA helps homes use energy more intelligently.

Contributions of this work are following :

1.1 Why is AI important for energy efficiency?

With the rise of the Internet of Things (IoT) and advancements in AI, smart homes have advanced. Devices such as smart thermostats and smart lights can communicate with AI systems to work more efficiently. Not only does this make life more comfortable, but it also makes life more convenient. But it also significantly reduces power consumption. AI can process large amounts of data quickly. Helps homes to continuously adapt and increase energy efficiency.

1.2 What this document covers

This article provides an overview of the role AI plays in making homes more energy efficient. We will expand into AI technologies such as load splitting, energy management system and forecasting. Below, we present a model showing how these AI technologies can work together to make homes more energy efficient. And at the same time, how to make residents more comfortable?

Background Related Word :

The integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies has transformed energy management in smart homes, enabling dynamic optimization and enhanced efficiency. AI-driven techniques, such as load disaggregation and predictive analytics, have shown significant potential in reducing energy consumption by identifying high-energy appliances and optimizing their usage. Energy Management Systems (EMS) act as the backbone of smart homes, leveraging real-time data to automate appliance usage based on user behavior, environmental factors, and energy costs. IoT-enabled devices, including smart meters and lighting systems, further contribute to energy savings, with studies demonstrating reductions of up to 57% in consumption. Renewable energy integration, as seen in solutions like Tesla's Power Wall, combines AI-driven forecasting with storage systems to reduce grid dependency and promote sustainability. However, existing systems face challenges such as data privacy concerns, infrastructure limitations, and high implementation costs. This work addresses these gaps by proposing a comprehensive AI-powered model for energy-efficient smart homes, combining advanced AI techniques, IoT solutions, and renewable energy integration to optimize energy use while ensuring user comfort.

2. AI techniques in smart homes AI offers a variety of powerful tools.

For the smart home ecosystem which helps manage and increase energy efficiency the main technique we will focus on is load splitting. Energy management systems (EMS) and demand forecasting

2.1 Load separation

Have you ever wondered which of your appliances uses more energy? Load splitting, or non-intrusive load monitoring (NILM), helps break down total energy consumption into device-level data. AI algorithms are used to analyze energy data from smart meters. It indicates which device uses more power. For example, the

NILM system can differentiate between the energy consumption of a refrigerator and an air conditioner. This way, you can identify which devices are consuming power and adjust their usage accordingly. Research shows that using NILM can reduce household energy use by up to 15% (rehman2020).

2.2 Energy Management System (EMS)

An Energy Management System (EMS) acts as the energy brain of a smart home. These AI-powered platforms monitor your home's energy usage in real time. By offering a way to increase efficiency, EMS systems can adjust electrical appliances such as heaters or air conditioners can be automatically according to needs, occupation and weather conditions For example, the system can unplug the thermostat when no one is home. Or program appliances to run outside of peak use for 2 hours. This dynamic optimization not only saves energy, but also saves energy. But it also reduces your electricity bill.

2.3 Forecast One of the two superpowers of IA is its ability to predict or predict future energy use.

By analyzing past data weather pattern and user behavior, IA models can predict how much energy your home will use in the near future. This allows him to improve his energy use with available renewable energy sources such as solar power. This reduces dependence on the electrical grid. For example, AI models can predict when solar panels will produce more electricity during the day. He can then schedule energy-intensive tasks like doing laundry or swimming. You can do it during that time. This helps you save on energy costs and at the same time make the most of your clean energy sources (IEEE)

3. A Narrative on the Intelligent Housing Device Development

In this article, the author presents an approach which incorporates artificial intelligence methodologies explained before: load disconnections, electronic management system, turnover and other related apparatus.

3.1 Basic Working Principles of AI-Driven Energy Efficiency Systems in Smart Homes

1. Smart Meter: Monitors the current energy consumption in all the electrical devices present in the house.
2.Data Processing: Energy consumption by appliances is done using clever strategies to identify the specific appliance that is consuming the most energy.
3. EMS Control: It regularly moderates the rate of energy consumption through occupancy, users' preferences and the amount of renewable energies modulated.
4. Forecasting Engine: Utilization of healthy models to ascertain the energy contrived in the future and the energy resources to be available, in interrogating energy balances.
5. User Interface: Educates the user of the property on the trends of capital consumed on energy and provides ways an individual can improve the trends.

3.2 Advantages of the Model

This system not only cuts down energy consumption but goes a step further in adding an intelligent touch to your residence:
1. Decreased Utility Costs: Energy efficiency enables enhancement in the occupancy understanding which leads to better management of utility costs.
2. Reduces Pollution: The model also incorporates renewable thus reducing the pollution of the house.
3. Increased Convenience: Smart houses help in conserving energy by automatically making changes on the settings to provide comfort without the use of excess energy.

4. Case Studies

Objective

To evaluate the practical application and effectiveness of AI-driven techniques, including load disaggregation, Energy Management Systems (EMS), and demand forecasting, in reducing energy consumption while maintaining user comfort in a smart home environment.

Methodology :

The methodology for implementing the AI-driven energy efficiency model in a residential setting consists of several key components. First, IoT-enabled devices, including smart meters, thermostats, smart lighting, and solar panels, were installed and integrated into an AI-powered Energy Management System (EMS) for real-time monitoring and control of energy consumption.

AI algorithms were then used for **load disaggregation**, breaking down energy usage at the appliance level to identify high-energy-consuming devices. This allowed the system to optimize their operation and reduce waste.

The **Energy Management System (EMS)** dynamically adjusted appliance settings based on real-time inputs such as occupancy, temperature, and weather conditions, ensuring energy use was optimized without compromising user comfort.

Demand forecasting was employed to predict future energy needs using historical data and environmental factors. This allowed the system to schedule energy-intensive tasks during peak renewable energy production, reducing reliance on grid power.

Lastly, **renewable energy** from solar panels was integrated into the system, with AI optimizing the use of solar power to meet household energy needs, further enhancing sustainability.

4.1 The ThinkHome Project

ThinkHome created an energy management system with AI capabilities to minimize energy consumption in a building. It observes devices and aligns their functions optimally to eliminate energy waste. As such, ThinkHome has been presented to be able to achieve 20% energy savings in household energy footprints.

4.2 Power Wall by Tesla.

Power Wall is a storage battery developed by Tesla for excess solar energy which embraces machine learning in its operations. It forecast energy consumption and demand in your house, hence allowing you to lessen the dependence on the power company. This definition save cost and it also extend to environmental concerns.

4.3 Smart Lighting systems based on IoT technology

These systems are known as smart lighting and use photo sensors, occupancy sensors, and AI techniques to turn on and off lights according to the light present and the person. Research on smart LED bulbs found that these bulbs could potentially reduce electrical energy usage by around 57 percent in contrast to regular LED bulbs controlled through remote dimming and brightness settings (IEEE).

5. Challenges and Future Directions

5.1 Confidentiality of Data

This is because energy data is referred to as sensitive data and homeowners are bound to be concerned about private issues. Smart homes must ensure that such information is kept intracellular and safeguarded against any use.

5.2 Insufficient Infrastructure

This is not the case in all the homes as not all of the homes are ready to embrace AI. The older homes, for instance, may be built in a way that smart technology integration may prove to be expensive and house renovations may be needed.

5.3 Developments in The Future

With the growth of AI, such models will evolve, which will be able to accommodate the erratic patterns of human behavior and atmospheric factors. AI system designs that combine renewables with better energy management schemes should be the next focus of development.

6. Conclusion

Automatically controlled systems in smart homes, powered by AI technologies, offer more than just convenience—they provide a significant solution to the rising energy consumption in the residential sector. By integrating advanced systems like load disaggregation, energy management systems (EMS), and demand forecasting, these smart homes can drastically reduce energy usage and costs while enhancing the comfort of the residents. Load disaggregation allows for precise identification of high-energy-consuming devices, enabling their optimal operation. EMS adapts appliance usage based on real-time data such as occupancy and weather conditions, ensuring energy is used efficiently without compromising user comfort. Demand forecasting further optimizes energy consumption by predicting future needs, allowing the system to adjust and take advantage of renewable energy sources when available.

As AI technology continues to evolve, the impact of these smart systems on energy efficiency will become even more pronounced. The integration of renewable energy, coupled with increasingly sophisticated AI algorithms, will allow homes to reduce their reliance on the grid, lowering both energy costs and environmental impact. In the future, AI-powered smart homes will offer even greater levels of energy savings, user convenience, and sustainability, contributing to a more energy-efficient society and supporting global efforts to reduce carbon emissions. These advancements will make smart homes a cornerstone of modern energy management solutions, ultimately helping to address the challenges of climate change and energy sustainability.

7. References

1. Ghahramani et al., "AI Predictive Algorithms for Energy Optimization," Jour nal of Artificial Intelligence Research, 2020.

2. Khan et al., "IoT and AI Integration for Real-Time Energy Management," *IEEE Transactions on Industrial Informatics*, 2019.

3. Jenkins et al., "Smart Home Energy Management Systems: A Review," Journal of Building Engineering, 2020.

4. Iyer, S. S. et al., "Smart Home Energy Management Using Artificial Intelli gence," IEEE Transactions on Smart Grid, 2019.

5. Chen, Y. et al., "Deep Learning for Energy Efficiency in Smart Homes," Journal of Building Engineering, 2020.

6. Liu, J. et al., "AI-Driven Energy Optimization in Smart Homes," Energy and Buildings, 2018.

7. Singh, A. K. et al., "Intelligent Energy Management System for Smart Homes," IEEE Transactions on Industrial Informatics, 2022.

8. Sharma, R. K. et al., "Energy Efficiency in Smart Homes Using Machine Learning," Journal of Intelligent Information Systems, 2017.

9. Kim, H. et al., "Smart Home Energy Management Using Deep Reinforcement Learning," IEEE Transactions on Smart Grid, 2021.

10. Wang, X. et al., "AI-Based Energy Efficiency Optimization in Smart Homes," Energy and Buildings, 2020