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Smart Energy Conservation Using Real-Time Human Detection

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ABSTRACT: In today's rapidly evolving world, the escalating demand for energy stands as a critical challenge. Energy consumption has surged exponentially over the past decade, fueled by technological advancements and population growth. This surge is evident across various sectors, spanning residential, commercial, industrial, and transportation, amplifying the strain on finite energy resources. This aims to underscore the significance of employing smart energy conservation methods as a viable solution to address this escalating demand. Smart energy conservation stands as a crucial approach in mitigating the environmental impact of burgeoning energy usage. By leveraging innovative technologies and sustainable practices, smart methods offer a promising avenue to curtail energy consumption. This paper delves into the role of smart energy conservation methods in optimizing energy usage, reducing carbon footprints, and enhancing resource preservation.

KEYWORDS: AdaBoost, Microcontroller, PIR sensors, Counters, Image processing, IoT Technology, Artificial Intelligence(AI), Machine Learning(ML)

I. INTRODUCTION

Energy usage today is skyrocketing due to technological advancements and population growth, straining finite resources and escalating environmental concerns. Significantly, energy conservation stands as a crucial solution, mitigating climate change by reducing carbon emissions. It's pivotal in sustaining resources, cutting costs, and bolstering energy security. Embracing conservation practices fosters innovation and shapes a sustainable mindset, essential for a resilient future amidst escalating energy demands and environmental challenges.

Smart energy conservation methods play a pivotal role in addressing pressing environmental concerns. Using smart energy conservation offers a multitude of benefits. Primarily, it leads to substantial cost savings by reducing utility bills for both households and businesses. Additionally, it mitigates environmental impact by curbing carbon emissions and preserving valuable resources, contributing significantly to combating climate change. Smart conservation practices also enhance energy security by diversifying sources and promoting innovative, sustainable technologies. Moreover, adopting these methods fosters a culture of sustainability, inspiring collective action towards a more resilient and environmentally conscious future. By curbing energy consumption, these methods significantly reduce carbon footprints, aiding in the fight against climate change. Simultaneously, they offer substantial cost savings for businesses and households by cutting down on utility bills. This dual impact not only fosters a healthier planet but also eases financial burdens, promoting sustainability on both environmental and economic fronts.

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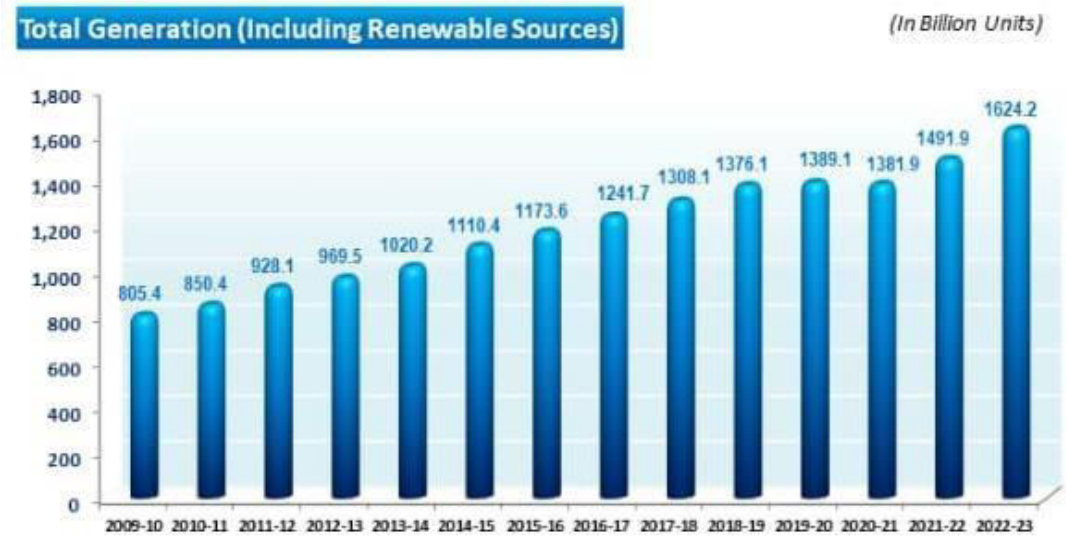

Energy usage has experienced an unprecedented surge over the last decade, fueled by technological advancements and population expansion. graphical representations vividly illustrate the surge, demonstrating an exponential increase in energy consumption across various sectors. residential, commercial, industrial, and transportation domains contribute significantly to this heightened demand, underscoring the strain on finite energy resources. concurrently, the sources supplying this escalating demand encompass a variety of energy forms, with fossil fuels remaining predominant. however, their dominance raises concerns due to environmental implications, finite availability, and the pressing need for sustainable alternatives.

II. LITERATURE REVIEW

Viola Jones et al. [1], describes a visual object detection framework that is capable of processing images extremely rapidly while achieving high detection rates in the paper "Robust Real Time Object Detection". There are three key contributions. The introduction of a new image representation called the "Integral Image" allowing the features used by their detector to be computed very quickly and AdaBoost, a learning algorithm which selects a small number of critical visual features and yields extremely efficient classifiers. Last contribution is a method for combining classifiers in a "cascade" allowing background regions of the image to be quickly discarded. The system yields face detection performance comparable to the best previous systems. Implemented on a conventional desktop, face detection proceeds at 15 frames per second. Whereas, The Author Sukanya Reddy et al. [2] proposed in the work "Design of Smart Power controlling and Saving system in Auditorium by using MCS 51 Microcontroller", to design and employ power saving in general public places like auditoriums, shopping malls, theatres, classrooms, laboratories etc. Generally closed premises consist of so many electrical and electronic devices or equipment. To control and monitor all these equipment or appliances we need a person or controlling system.

"Automatically Controlled Energy Conservation System for Corporate Office on Microcontroller" (2019) by Koushik Ahmed et al. [3] ensures the conservation of energy by minimizing the wastage of electricity. Two microcontrollers are used for this setup. One of them is used to control the electrical appliances automatically depending on human presence in a particular room or area. When the passive infrared sensor (PIR) and proximity sensor find the motion and presence of human inside the area then it will turn on the electrical appliances and will count the number of persons. Automatic controls play an ever-increasing role in a human way of life. The distinct characteristic of automatic control is that it reduces the human operator. One such gadget is the fan. The fans are generally available with speed control, depending on the requirement the speed is set. This is done manually using human. Mustafa Saad et al. [4] suggested an automatic control solution to control the speed in his paper titled "Automatic Fan speed Control system using Microcontroller". A circuit with the LM35DZ temperature sensor, a PIC16F877A microcontroller, brush less DC motor and few of electronic components is designed and implemented to control the fan speed automatically.

The Project 'Automatic Room Light Controller Using microcontroller and visitor counter' by Kimbley et al. [5], controls a room light as well as count the number of individuals entering and leaving a room by incrementing and decrementing the counter. When the number of individuals in a room is greater than 5 then 2 lights will be switched ON. When the individuals in a room are more than 10 then 3 lights will be switched ON. Similarly on increase of every 5 individuals one more light will switched ON. Lights will turn OFF when all the individuals go out of a room. The

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total number of individuals present inside a room is also displayed on the LCD display. IR sensors sense the obstruction and microcontroller receives the signals produced by the obstruction from the sensors. Likewise, In "Visitors Counter with Gate Control and Automatic Light Control (ON/OFF)", the Author Muhammad Ahmad Baballe et al. [6], designed and presented to count visitors to an auditorium, hall, offices, malls, sports venues, and so on. The system tracks both entering and exiting visitors to the auditorium, hall, or other location where it is installed. The system identifies the visitor's entry and exit based on the interruption of the sensors. When the system is successfully implemented, it displays the number of visitors present in the auditorium or hall. Counting visitors can be time-consuming, so it helps to maximize employee efficiency among other things.

"Energy conservation in Iot-Based Smart home and its Automation" by Mamta Mittal et al. [7], discusses electrical network architecture and energy monitoring points, causes of energy losses and the scope for energy losses reduction. Further load shedding, utility demand energy management system using automation and the role of buildings in energy conservation have been discussed. The importance and need for energy conservation in consumer's house, using IoT devices are discussed. This chapter also discusses data security model, data encryption, and their practical approaches in smart home. It classifies the various important components in smart home. Whereas, In "Method of automatic people counting used in air-conditioning energy saving", Qing Ye et al. [8] proposes a method of automatic people counting used in air conditioning energy- saving. The method has counted the number of people in the indoor environments through three modules: image pre-processing module, image marking module and people counting module, in order to control air-conditioning controller to achieve the purpose of saving energy. The experimental results show that the method of automatic people counting about a large number of indoor images is effective and can maintain high statistics accuracy to those images which have little background noise.

N. Shri bhagat Varma et al. [9] intended to design a power management system which will sense if the room is vacant and accordingly turn the lights off in the paper titled "Automatic Electrical Appliances control based on Image Processing". They design a power management system which will sense if the room is vacant and accordingly turn the lights off. To avoid this sheer loss of money and resources, an automated power management system looks to detect whether the room is empty and accordingly switch off the lights and fans. The camera captures live feed of the room and gives it to the computer to process it. The face detection module then detects human presence.

"Energy Management in Smart Buildings and Homes" [10], gives a comprehensive state of the-art on various recent techniques and solutions which provide energy savings in smart homes and buildings by installing a new energy infrastructure called the ''Smart Grid''. This helps to manage the electricity generation and distribution in an efficient manner. Buildings and other structures are the biggest consumers of electricity.This includes statistical models, cloud computing based solutions, fog computing and smart metering based architectures, and several other. IoT (internet of things) inspired solutions. It also present a hypothetical model that treats energy supply and usage in buildings as a self-managing energy system (SES). This paper is concluded by highlighting several open issues.

The Author Simon Atuah et al. [11] presents a proposed smart energy conservation system in a study room in his paper "Smart energy conservation system for study rooms", that employs an infrared remote-control mechanism to turn on or off an energy system in the absence of humans. Embedded technology was used to create an energy-saving solution. The testing was done with a range of scenarios and key performance indicators. The test results showed that the proposed system was effectively implemented, and a comparison of the system to a case study system demonstrated that it had a better design, lower cost, and higher operational efficiency. The findings of this study will be essential to a wide variety of stakeholders.

The Author Amith K Jain et al. [12], proposed to develop a Smart Energy Conservation System that will help various organizations to play an effective role in saving electrical energy in his paper " Low Power Fully Automated Smart Energy Conservation Switching Box". The major sector which consumes maximum amount of electricity is observed to be the educational institutions. In order to conserve energy, automated lighting system using Raspberry Pi that monitors the electrical lighting and the running of fans is proposed. The experimental results show that we can reduce our bill to the extent of 50% and also conserve energy, if the electrical appliances are switched OFF promptly when not in use.

One of the important ways of to improve the energy conservation is energy audit. Energy conservation without compromising the usage is a great task. Ramya Lekshmanan et al. [13] focuses on the importance of energy conservation in "Energy Conservation – A Case Study" by considering the loads of a class room of an educational institution and considering the energy consumed by the present loads and recommending energy efficient appliances and an efficient yet simple sensor based model to reduce the energy consumption and comparing the results.

The research of Da sheng Lee et al. [14] in 2022, targeted to facilitate the commercial application of AI in the field of energy saving in the paper "Universal workflow of artificial intelligence for energy saving". Through a comprehensive analysis of experimental data, the universal workflow can confirm 35% energy cost saving in the building, 25% energy saving of the heating, ventilation and air conditioning equipment, 50% artificial lighting system energy saving, up to 70% reduction of information transfer and communication power, a continuous output of 30%

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peak power from the renewable energy device to the microgrid; and 20% power demand reduction in the factory. The universal workflow developed in this study provides a workable method to assist the use of AI in various applications.

In 2023, Stavros Mischos et al. [15], studied intelligent systems for energy management in residential, commercial and educational buildings, classifying them in two major categories depending on whether they provide direct or indirect control. The article also discusses what the strengths and weaknesses are, which optimization techniques do they use and finally, provide insights about how these systems can be improved in the future.

III. BACKGROUND KNOWLEDGE

Smart energy conservation in our daily lives involves adopting practices and utilizing technologies that reduce energy consumption without compromising comfort or functionality. In the literature review, we can see several methods to conserve energy using various technologies. From sophisticated deep learning models for real-time human detection to the application of microcontrollers in automating power management, these innovations strive to enhance energy efficiency. The integration of Artificial Intelligence, sensors, counters, smart metering architectures, Image processing, alongside IoT-inspired solutions, further contributes to the multifaceted landscape of smart energy management. Additionally, studies delve into the potential of statistical models, and signal processing through IoT-based devices, showcasing a comprehensive exploration of cutting-edge technologies in the pursuit of sustainable and intelligent energy consumption.

IV. DISCUSSIONS

In the implementation of Smart methods in energy conservation, various techniques like using Microcontrollers, Microprocessors, Image processing, Sensors and counters, and Artificial Intelligence and Machine Learning were used and all of them had deficiencies. The present methodologies and their corresponding limitations, discovered through the study, are outlined below:

METHODS	DEFICIENCY
Using Microcontrollers	PIC microcontroller may exhibit constraints in terms of versatility due to potentially fewer built-in peripherals limiting their adaptability to diverse application scenarios and PIC16F877A may face limitations in its processing power and memory capacity, restricting its capability to handle complex and resource-intensive applications effectively.
Using Microprocessors	A potential deficiency in using Raspberry Pi for smart energy conservation lies in its relatively higher power consumption compared to dedicated microcontrollers, which may limit its suitability for certain low-power and resource-constrained applications.
Using Image processing	Deficiency lies in its vulnerability to environmental variations, such as changes in lighting conditions, which can impact the reliability and accuracy of human presence detection algorithms.
Using Sensors and Counters	Face challenges in scenarios with high crowd density or variable movement patterns, impacting the system's effectiveness in optimizing energy usage.
Using AI and ML	Deficiency in using machine learning algorithms like AdaBoost for smart energy conservation lies in the need for substantial training data and the risk of misclassification errors, particularly in dynamic environments, which may impact the accuracy of occupancy predictions and subsequently affect energy optimization strategies.

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V. CONCLUSION

The energy consumption is going to become a major concern for the world as the rate of energy consumption is continuously increasing. Energy is mainly generated through renewable sources and non-renewable sources. The non-renewable sources are getting depleted at a very high rate and this is going to affect the future. The government and other authorities are taking major steps to preserve the natural resources through effective energy conservation. The smart cities need to be equipped with energy conservation systems for reducing the energy usage. The study has thoroughly discussed about the systems that could be beneficial for the smart conservation. In our Future work, we aim to overcome the defects of the discussed methods and to find an upgraded solution for conserving Energy using Real-Time Human Detection.

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