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AI – Driven Smart Home System for Dynamic Appliances Control using Environmental and Occupancy Data

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KEYWORDS

Home automation, IoT, AIML, CNN, OpenCV, occupancy detection, environmental sensing, predictive control, energy efficiency.

ABSTRACT

Raspberry Pi–based smart home automation system is developed to intelligently control household appliances using machine learning and computer vision. The system collects environmental data such as temperature, humidity, air quality, and light intensity, along with time features (hour of day and day/night). Occupancy is detected using a camera-based CNN model implemented with OpenCV, replacing traditional IR sensors. Using sensor fusion, the Raspberry Pi processes real-time inputs locally and predicts optimal appliance operation (lights, fan, air conditioner) based on historical patterns of occupancy, environmental conditions, and time. The system also enables real-time fire monitoring and human identification in the monitored space. This approach provides adaptive, energy-efficient, and predictive automation with dynamic decision-making, improving comfort, safety, and power savings.

INTRODUCTION

The notion of smart homes has been developing at a rapid pace with the development of wireless communication, AI, and IoT technologies. To meet with the requirements of lighting control, HVAC, security and electrical equipment, today's smart homes include sensors, connected devices and intelligent control systems for monitoring and automation in real-time via smartphones or web portals. Unlike traditional rigid automation, AI-based systems observe user patterns, sense environmental parameters including temperature, humidity, illumination, and occupancy, and take predictive and context-aware actions. As a result, is able to enable energy-efficiency, increase comfort, improve security and promote sustainable lifestyles. For instance, smart thermostats fine tune the temperature based on occupancy trends while smart lighting brighten up or shut down according to room occupants.

In the beginning, more smart home systems were built around rule-based control or short-range communication technologies like Bluetooth that were rigid and non-accessible from afar. Subsequently, approaches based on GSM and Internet of Things (IoT) allowed real-time notifications along with remote monitoring and control over more scalable system architecture. Low-cost platforms such as Raspberry Pi have been an essential player as the central controller in many applications due to their relevance in embedded AI solutions. Reviews have also been pointed out on the significance of user-friendly interfaces with graphical and virtual environments for better usability and user experience. Recent studies on the development of machine learning and deep learning for predictive.

Homes automation and energy management. AI models can predict appliance usage, power consumption, activity detection, and decision-making efficiency. Occupancy detection and smart surveillance are also achieved by computer vision technology, especially real-time object detection models such as YOLO, which can be applied in further automation and security. These methods show substantial enhancements in terms of responsiveness, energy meticulously, and tailored control over traditional manual or rule-based schemes.

Nevertheless, bottlenecks still exist, such as the issues of privacy, interoperability, hardware limitation and computational expense. Secure communication protocols, unified architectures, and prescient data management strategies would facilitate large scale deployment. In summary, AI and IoT in smart home standoff zones hold a promise to change rudimentary remote control to intelligent and autonomous spaces that learn from users, minimize energy waste, and increase the overall quality of living.

II. PROPOSED SYSTEM

The system proposed is an AI-enabled smart home automation system incorporating the Raspberry Pi for data-driven context-aware control of home appliances rather than the fixed rules-based operation. The sensors used for this work are the environmental sensors (DHT11/DHT22 for temperature and humidity, LDR for light intensity) and Pi camera for CNN/YOLO-based occupancy recognition with temporal features (time of day and day–night cycles). The system architecture includes four layers, i.e., data acquisition, data processing, decision making and execution. The data are acquired by a Rasp- berry Pi, which also preprocesses the sensor and image data, runs a pre-trained machine learning model to predict the optimal state of the appliances and operates the lights, fans, air conditioners, and motorized curtains through relay modules and motor controllers connected to the general-purpose input/output pins. The system has sensing → processing → prediction → actuation flow, provides web dashboard and HDMI interface for real time monitoring and manual override, and is powered by 5 V/5 A for stable operation. The system achieves improved energy efficiency, user comfort, scalability and sustainability by contextually real-time adaptivity to the surrounding environmental conditions and presence of the user, with which an intelligent edge-computing platform for future smart homes is anticipated.

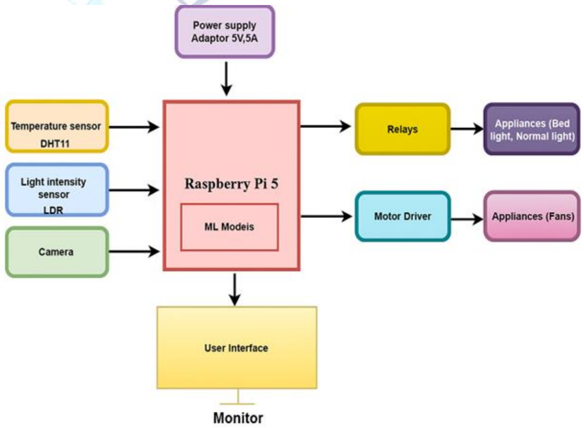

Figure 1: Block Diagram

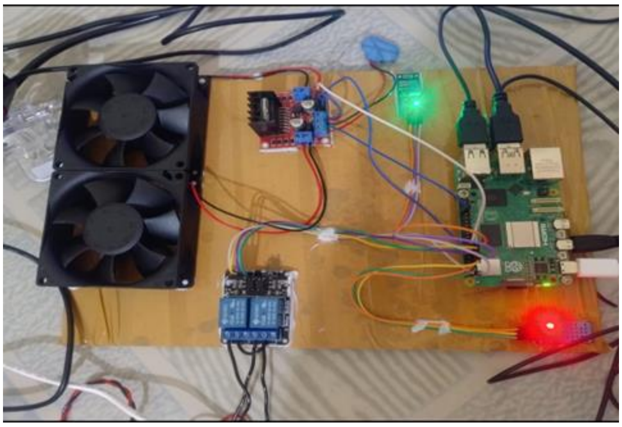

Figure: 2 Circuit Diagram

Methodology:

The systemin the proposed work is a Raspberry Pi 5-based intelligent smart home hub that combines environmental monitoring, camera-based occupancy detection, and machine learning to provide real-time appliance automation. Temperature and humidity (via a DHT11), light intensity (via an LDR) and presence of human (via a YOLO/CNN vision model)are detected. These inputs (along with the temporal features hour of day and day/night) are concatenated into a single feature vector. Sensor readings are normalized and transformed to create structured input for a supervised learning model that is learned from past environmental and occupancy data. Among the tested algorithms (Decision Tree, Logistic Regression, Random Forest), Random Forest was superior in treating nonlinear and high dimensional data. The trained model was serialized using joblib and executed on the Raspberry Pi for low-latency inference.

The lights and fans (through GPIO-controlled relay module and PWM motor driver module) are automatically controlled by this system based on the model prediction. The appliance operation is overridden to OFF when no motion is detected for fail-safe energy saving. This facilitates context-aware, adaptive and energy-aware automation with minimum human interference and real-time reacting.

III. RESULTS AND DISCUSSION

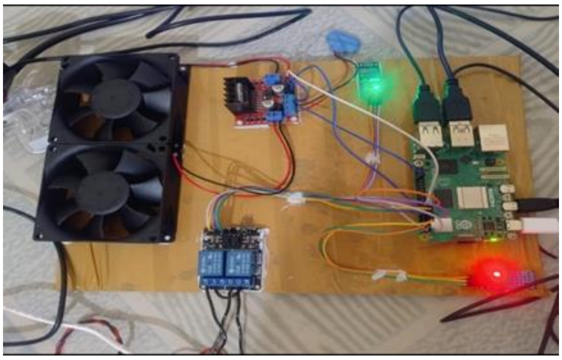

Figure: 3 Prototype setup with Raspberry Pi

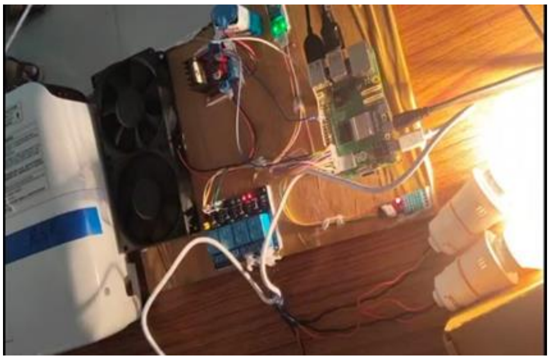

Figure: 4 System controlling real loads (lights Sensors, relay bulbs fans) in live module and dual fans

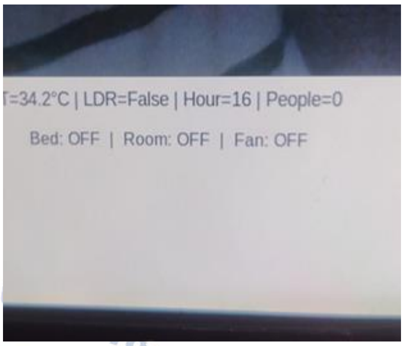

Figure: 5 UI o/p No occupancy
→ Bed OFF | Room OFF | Fan OFF.

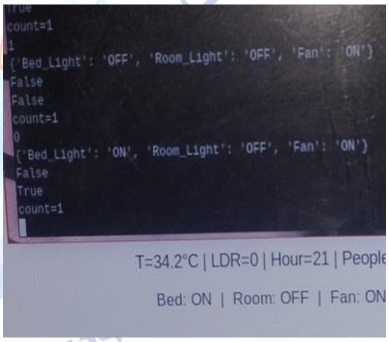

Figure: 6 Console-based prediction result displaying smart Appliance

Figure: 7 Bed lamp glowing ON during night – triggered autonomously by model.

The result analysis shows that the proposed AI-based SHSOS can realize real-time prediction and intelligent control of home appliances by collecting environmental sensor data, occupancy detection result based on camera, and environmental data, that are fused with ML algorithms. The system retrieves the temperature, humidity and light intensity values at a constant rate and combines it with the information about human presence to so context-aware detection. The fusion of data at this point gives the model a more comprehensive understanding of the surrounding environment and the activity patterns of the user, which are then used to guide a more effective and dynamic appliance control method compared to traditional fixed-threshold/schedule-based methods.

The performance was evaluated under a wide range of indoor environmental conditions to monitor the reliability and climate adaptability of the system. Several machine learning algorithms were applied and the performance comparison was done in terms of accuracy, precision, recall and F1-score. Among all classifiers,the Random Forest classifier comes as the best one for overall performance as it works well in non linear scenario and by the virtue of ensemble learning it prevent the problems of overfitting. The Results of DT are also promising but it is a bit less stable in terms of performance while the performance of Logistic Regression is relatively lowest due to the fact that it is formulating complex feature relations Among the features.

Full-scale real-time testing and deployment on the Raspberry Pi platform results show a fast system response to occupancy and environmental changes with minimal latency. Devices like lights and fans were turned ON or OFF at an appropriate time so that energy efficiency was maintained without compromising user comfort. Occupancy detection model could efficiently detect the presence or absence of a person, preventing unnecessary power consumption when the room is empty. This resulted in quantifiable energy savings compared to classical manual operation or rule-based automation systems. In addition, the system was satisfactory reliable and consistent in appliance control which minimized human intervention. Adaptive learning enables the model to make better decisions over time with the knowledge of usage. In summary, the proposed methodology offers a reliable, scalable, and cost-efficient smart home solution, and suggests that the integration of IoT, computer vision and machine learning is a viable approach for intelligent energy management and improved living comfort.

IV. CONCLUSION

Experimental validations with actual loads show consistent occupancy-based accuracy, adaptability to environmental changes, automatic turn-off under unconditioned spaces, and measurable energy savings when compared to manual operation as well as to an established automatic control scheme. The hierarchical system architecture: data acquisition, preprocessing, intelligent decision making, and actuation, provides scalability, robustness, and an optimal resource AI-enabled smart home automation system based on Raspberry Pi is presented, that offers environmental sensing, camera-based occupancy detection, machine learning–based decision making for dynamic appliance control. The architecture proposed in this paper differs from traditional rule-based systems as it applies sensor fusion temperature, humidity, light intensity, temporal features, and occupancy) to achieve context aware and predictive automation. A supervised learning method is used, where several models are compared and the Random Forest classifier outperforms in terms of the accuracy, precision, recall and F1-score. The resulting model was ported to a device for performing real-time on-device inference enabling direct, low-latency control of lights and fans via relay modules and PWM motor driving.

Utilization on a cost-effective embedded system. Overall, the results show that the integration of IoT, computer vision, and machine learning can greatly improve smart home intelligence while at the same time keeping costs down as well as operating in real-time.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] J. Han, J. Yun, J. Jang, and K.-R. Park, "User-friendly home automation using 3D virtual world," IEEE Transactions on Consumer Electronics, vol. 56, no. 3, pp. 1843-1847, Aug. 2010.

[2] Vamsikrishna, P., Kumar, S.D., Hussain, S.R. and Naidu, K.R., 2015, March. Raspberry PI controlled sms-update-notification (Sun) system. In 2015 IEEE international conference on electrical, computer and communication technologies (ICECCT) (pp. 1-4). IEEE.

[3] Larhgotra, A., Grover, Y., Kour, S., Dadarwal, K., Singh, M. and Bahuguna, R., AI Driven Smart Home Automation.
[4] Severance, C., 2013. Eben upton: Raspberry pi. Computer, 46(10), 14-16.
[5] Kulshreshtha, K., Gautam, J., Alabdeli, H., Abdullaev, J., Rani, R. and Kharayat, P.S., 2024, September. AI in Home Automation Systems. In 2024 International Conference on Communication, Computing and Energy Efficient Technologies (I3CEET) (pp. 1082-1087). IEEE.
[6] Khan, I.R., Jha, A.K., Ahmad, N. and Rawat, H., 2024. Home Automation and Security Systems Using AI and IoT. In The Next Generation Innovation in IoT and Cloud Computing with Applications (pp. 157-173). CRC Press.
[7] oji, E.S., Gnanamalar, S., Arumugam, N., Priscila, S.S., Selvam, N. and Rajest, S. S., 2024. AI driven computer vision for smart home automation and surveillance systems. In Explainable AI Applications for Human Behavior Analysis (pp. 242-257). IGI Global.
[8] Elkhalik, W.A., 2023. AI-Driven Smart Homes: Challenges and Opportunities. Journal of Intelligent Systems & Internet of Things, 8(2).
[9] A, M.R., B.I.R., A, M.A.M. and B.I.R., 2012. A review of the smart home – Past, present, and future. Information Forensics and Security: IEEE Transactions on Systems, Man, and Cybernetics Part C (Applications and Reviews), 42(6), pp.1190-1203.
[10] Pavithra, D. and Balakrishnan, R., 2015, April. IoT based home automation monitoring and controlling system. In 2015 global conference on communication technologies (GCCT) (pp. 169-173). IEEE.
[11] N. Sriskanthan, F. Tan, and A. Karande, "Bluetooth based home automation system," Micr, 26(6):281–289, 2002.
[12] A. Alaa, A. A. Zaidan, B. B. Zaidan et al., "A systematic survey of IoT-based smart home applications," Journal of Network and Computer Applications, vol. 97, pp. 48–65, 2017.
[13] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You Only Look Once: Unified, real-time object detection," in Proc. IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 779–788.