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Home Automation Using Internet of Things and Machine Learning

Laila Amin, Nasru Minallah

Department of Computer Systems Engineering University of Engineering and Technology Peshawar, Pakistan

***Correspondence**: lailaamin.cse@uetpeshawar.edu.pk

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This paper proposes an energy-efficient home automation system leveraging the Internet of Things (IoT) and machine learning. The system, implemented in Python on a Raspberry Pi, enables remote control of appliances (lights, televisions, air conditioners) via a web interface accessible from any local network device. Machine learning is introduced in the second phase, utilizing linear regression to automate appliance management based on historical data stored in a database. This work demonstrates the feasibility of IoT and machine learning for cost-effective and efficient home automation, laying the groundwork for the future development of database-driven smart homes with advanced machine learning algorithms.

Keywords: Home Automation, Internet of Things, Machine Learning.

Introduction:

Home automation systems have gained significant traction in recent years, offering various functionalities and specifications [2][3][4][5][6][7][8][9]. Existing literature explores a range of approaches, including ZigBee-Arduino control for small appliances [2], low-cost Arduino UNO-based systems with web server functionality and environmental sensors [3], X10 controller and IEEE 1394 AV framework integration forremote access [4], Java-based structures for PC server control [5], PIC microcontroller-driven systems with web interfaces for slave control points [6], Bluetooth-over-internet appliance control [7], and RF module-Arduino UNO-WiFi-cloud- mobile application systems with environmental sensing for fan and light control [8]. Additionally, research has been conducted on minimizing energy usage through multiband antennas, energy-efficient sensors, and thermal management [9]. However, limitations exist in many proposed systems. Some prioritize simplicity, focusing on basic controls for fans and lights, while others target complex devices like intelligent doors. Issues arise with user-friendliness, basic functionality, cost, and energy consumption, leading to a gapbetween user requirements and system capabilities.

This paper addresses these limitations by proposing a cost-effective, user-friendly Internet of Things (IoT) home automation system. The system offers internet, PC, and mobile application control for home appliances, promoting energy efficiency. We leverage a Raspberry Pi as a bridge device, translating user interaction through a web page into signals for end-device control. The system utilizes Wi-Fi technology for local network communication and, with an internet-connected server, allows remote access via a web browser. This paper details the software and hardware implementation, focusing on the initial control of three key appliances: fan, air conditioner, and light. The proposed system promises to be cost-effective, reliable, and easy to implement, aiming to bridge the gap between user needs andexisting home automation solutions.

Figure 1: Possibilities with Smart Security [1]

Electronics and their Application in Automation:

Raspberry Pi:

This work utilizes a Raspberry Pi 3B+ as the central hub for communication and processing. The Raspberry Pi offers connectivity through one RJ45 connector, four USB ports, and an integrated Wi-Fi adapter. This allowsfor interaction with various communicating terminals within the smart home environment. The Raspberry Pi serves two primary functions, it facilitates communication between all connected appliances and sensors. It stores historical data in its memory for machine-learning purposes. A Flask server running on the Raspberry Pi manages the database andfacilitates model training.

Passive Infrared Sensor:

A Passive Infrared (PIR) sensor is employed to detect infrared radiation, enabling the system to turn appliances on or off based on user presence. Ideally, upon entering a room, lights should illuminate basedon a pre-set schedule retrieved from the database. Conversely, if a user leaves the room unexpectedly, the PIR sensor detects the absence of human movement and triggers the Raspberry Pi to turn off appliances, promoting energy efficiency. The sensor transmits a binary value ("1" for presence, "0" for absence) to a designated pin on the Raspberry Pi, which is also displayed on the web interface foruser convenience. This eliminates the need for intrusive camera installations for presence detection.

Relays:

Relays are crucial for switching connected devices on and off. The control signal received by the relay determines whether a specific pin on the IoT device is ICTIS 2024 activated or deactivated. This enables remote control of appliances within the smart home system. This project utilizes 5-volt, 10-ampere relay modules for the aforementioned functionality.

Flask Server:

Flask, a web framework, provides the necessary libraries for building web applications. In thisproject, a Flask server is implemented to host all connected devices. It facilitates sending "ON" and "OFF" signals to these devices. The server is hosted on the Raspberry Pi with a local IP address, restricting access to devices within the same local subnet for security purposes. This necessitates the smartphone controlling the system to be connected to the same subnet. Alternatively, a VPN connection could be established for remote control from outside the local network

Implementation of Home Automation System:

Prototype Development:

The prototype for the machine learning-based home automation system using a Raspberry Pi is connected to three electrical devices (fan, television, and light source) the connections to the Raspberry Pi are through a breadboard andjumper cables. A Flask server running on the Pi provides a web interface for remote control (on/off) of these devices. Inparallel, a Python script maintains a database logging deviceactivation times and associated GPIO pins. This data serves as the foundation for a routine learning algorithm, enabling the system to predict and automate device behavior after a seven-day training period. The web interface remains accessible from laptops or smartphones within the same localnetwork for manual control or system monitoring. The Implementation is completed in two phases

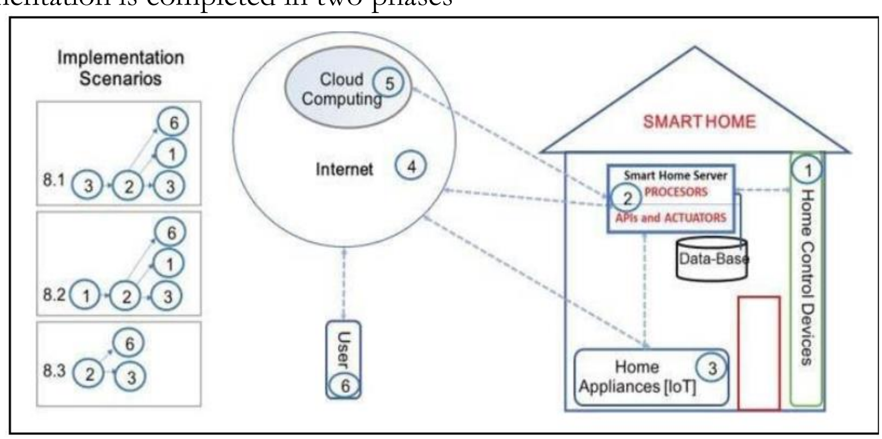

Figure 2: Smart home implementation chart

Phase 1:

Controlling all the appliances in a smart homeenvironment through any internet-enabled device like a Smartphone or Laptop etc. The connectivity is done by having a Raspberry Pi as a bridge device to translate signals generated by human interaction through web pages to the end terminal devices.

Phase 2:

Phase 1 is enhanced in phase 2 by automatinghuman interaction in the introduction of databases that aremaintained through a machine learning algorithm

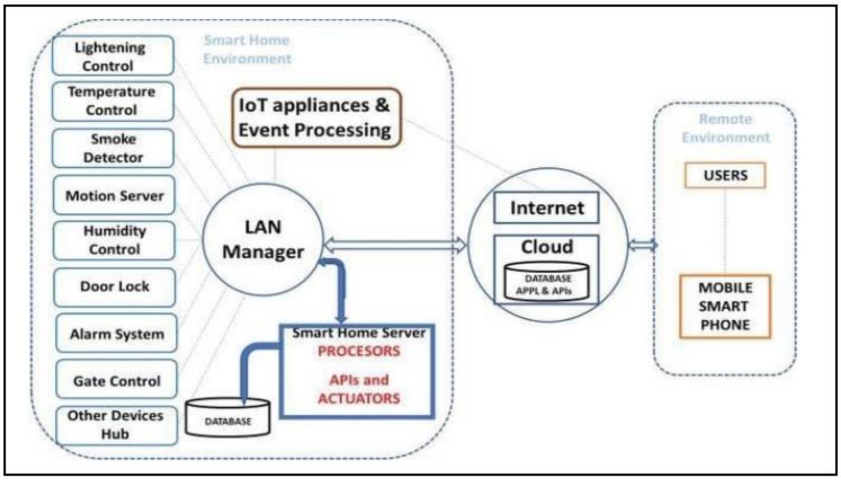

Figure 3: Detailed implementation with the introduction ofmachine learning

Setup for Smart Home Project Implementation:

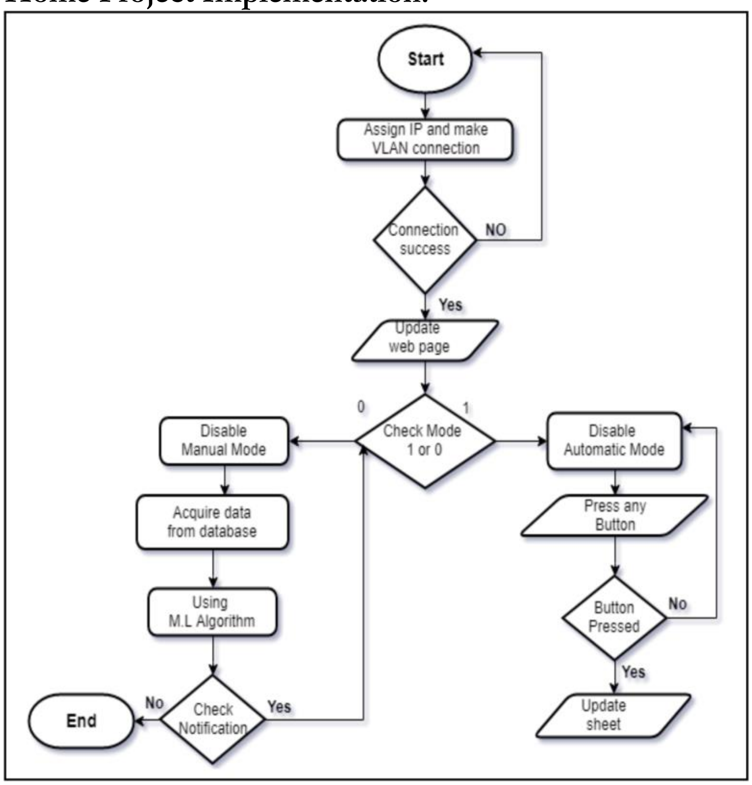

Figure 4: Flow Chart for Implementation of the Smart Home

When the device (Raspberry PI) is switched on. The most important element is its connection to the Local Area Network. In this way, it can communicate with the existing communicating devices. After the device is allocated an IP either through DHCP or assigning a static IP. The web GUI of the project can be accessed. This GUI enables the user to control the connected appliances. In the web GUI, the user canselect the mode of operation to be Manual or Automatic. The first mode enables the project to use data from the databases for the corresponding behavior of the project while the second mode needs the interaction from the user to turn on /off the connected devices. Once the interaction is complete the existing database is updated and the flow ends.

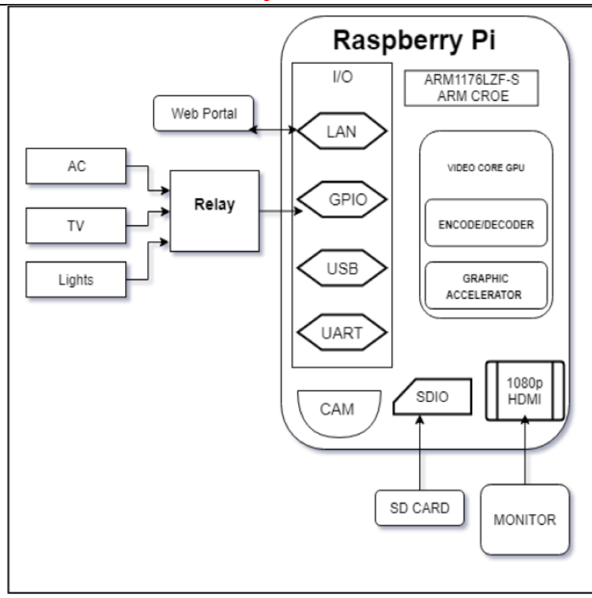

Figure 5: Procedure of Setup

The development of a machine learning-based home automation system using a Raspberry Pi 3B+ leverages Ubuntu 16.04 for visualization and Python 3.5 for core functionality. Code development is facilitated by Spyder 3.3.0. A user-friendly web interface is implemented using HTML to enable remote control and facilitate future application integration. Python scripts interact with the Raspberry Pi's GPIO pins to control connected appliances (fan, television, light source) via IoT protocols. A basic data logging system is established, utilizing a Python script to record device activation times and associated timestamps into a text file (.txt). This data serves as the foundation for a futuremachine learning algorithm, enabling the system to learn userbehavior and automate device operation.

Results:

The data of the sensor are sent to the web browser for monitoring of the system after the successful connection to the server. Thewebpage will appear when we enter the IP address in the web browser. The web server provides important information aboutthe status of the home appliances that are connected to the internet remotely. Home automation makes it possible to automate tasks relatedto security, well-being, and comfort through a smart system installed in a home or building. In other words, it integrates technology into the design of a space. One of the main advantages of home automation systems is energy efficiency.

Conclusion:

This paper contributes to the growing field of smart homeautomation by leveraging the Internet of Things (IoT) andmachine learning. We present a Raspberry Pi-based system that interfaces with various electrical appliances, enablingtheir remote control and automated operation. In the initial phase, the system provides a user-friendly interface for manual control. Subsequently, a machine learning component is introduced to analyze historical usage patterns and automate appliance switching based on learned schedules. This approach not only promotes energy efficiency but also enhances user convenience by reducing manual intervention and offering increased flexibility in managing time and resources.

Future Work:

This work's inherent scalability allows for the integration of "smarter" appliances, controllable either through smartphones or autonomously based on historical data. This opens doors to numerous domestic applications, including smart cameras, self-activating cleaning robots, and intelligentwashing machines. By leveraging machine learning algorithms, household chores can be automated through theseappliances, enhancing user convenience and promoting significant cost savings via efficient resource management.

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