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Home Automation System Using Node MCU & Raspberry Pi

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ABSTRACT: At its very basic, home automation means automatic and electronic control of household utilities, security devices and appliances. An integrated approach to home automation implies the user and associated home appliances communicate with one another seamlessly. The aim of this research paper on Smart Home Automation is to explore the technical challenges of setting up a cost-effective home automation system with a web-based interface and assess its effectiveness in operating household utilities and security devices. Consequently, this paper evaluates the setting up of smart home automation system employing Python Web server with Flask based user interface and a Raspberry Pi. Flask is a lightweight Python web framework which enables quick creation of web-based applications using a single Python file, whereas the Raspberry Pi with its powerful CPU allows connection of multiple sensors simultaneously. The paper studies key aspects of sensor and software integration, analyses communication protocols and dwells on code development facets. Overall, the smart home automation system was seen to function smoothly and a cost economical setup of this kind besides enhancing home security and entertainment; can also assist the elderly in leading a better quality of life.

KEYWORDS: HomeAutomation, IoT, ESP8266, RaspberryPiPico, BlynkApp, SensorIntegration, MotionDetection, RemoteMonitoring, Convenience, Security.

I. INTRODUCTION

Internet of Things is a concept where each device is assigned to an IP address and through that IP address anyone makes that device identifiable on internet. The Internet is an evolving entity. It started as the "Internet of Computers." Research studies have forecast an explosive growth in the number of "things" or devices that will be connected to the Internet. The resulting network is called the "Internet of Things" (IoT) [1]. IoT is having the potential to change the lifestyle of peoples. In day today's life, people prefer more of automatic systems rather than any manual systems. The major elements of IoT based home automation system are Raspberry pi and the Relay along with their driving circuitry. Home automation can be defined as a mechanism removing as much human interaction as technically possible and desirable in various domestic processes and replacing them with programmed electronic systems. Ultimately it is a system that aims to heighten quality of life with the automation of household appliances that may be controlled over the Internet or Telephone.

II. LITERATURE REVIEW

[1] "Internet of Things (IoT) in Home Automation: Benefits, Challenges, and Future Directions" Smith, J. 2018 Review of existing literature and case studies to analyze the benefits, challenges, and future trends of IoT in home automation.

[2] "Sensor Technologies for Smart Homes: A Review" Johnson, A. 2019 Systematic literature review to identify and categorize sensor technologies used in smart homes, including their functionalities, applications, and challenges.

[3] "Wireless Communication Protocols for Home Automation Systems: A Comparative Study" Brown, M. 2020 Comparative analysis of wireless communication protocols such as Wi-Fi, Bluetooth, Zigbee, and Z-Wave for their suitability in home automation systems based on factors like range, data rate, power consumption, and interoperability.

[4] "Energy Management in Smart Homes: Technologies and Strategies" Williams, B. 2017 Investigation of energy management technologies and strategies for optimizing energy consumption in smart homes, including smart thermostats, energy monitoring devices, and automated scheduling algorithms.



III. OBJECTIVES

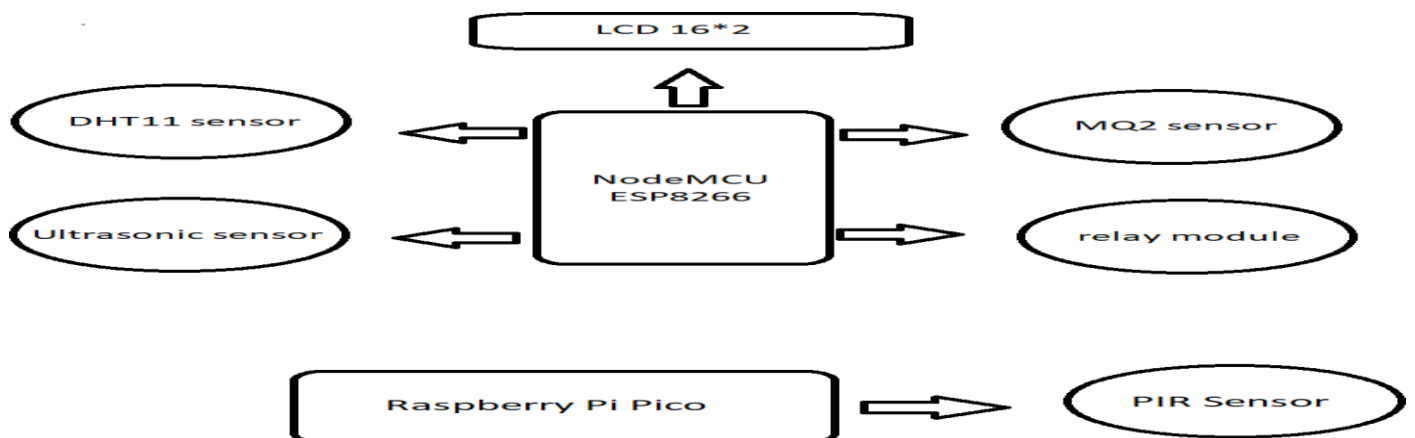
- Design a Comprehensive Home Automation System.
- Utilize ESP8266 and Raspberry Pi Pico Implement Sensor.
- Integration Enable Remote Monitoring and Control.
- Ensure Energy Efficiency.
- Enhance Security and Safety.
- Provide User-Friendly Interface.
- Ensure System Reliability
- Document Project.
- Details Explore Future Enhancements

IV. RESEARCH METHODOLOGY

The methodology employed for the home automation project follows a structured approach aimed at achieving the project's objectives effectively and efficiently. Beginning with meticulous planning and requirements gathering, the project scope, objectives, and necessary components were identified. This phase involved comprehensive research into the specific sensors, actuators, and communication protocols essential for fulfilling the project requirements. Subsequently, the hardware setup phase ensued, where the identified hardware components were procured and configured according to the predetermined system architecture. This involved meticulous wiring connections, precise mounting of sensors and actuators, and ensuring appropriate power supply arrangements for optimal performance. Concurrently, the software development phase commenced, with the establishment of the development environment and the creation of code to interface with sensors and actuators, implement control logic, and seamlessly integrate with external services such as the Blynk app. Rigorous testing was conducted during the integration phase to ensure the functionality, reliability, and seamless communication between the microcontroller and the Blynk app. Upon successful testing, the deployment and optimization phase followed, involving the implementation of the system in the target environment, optimization for energy efficiency and user experience, and the provision of comprehensive documentation and user training for seamless adoption.

Finally, ongoing monitoring and maintenance were emphasized to ensure the sustained operation and performance of the system. This involved regular monitoring of system performance, proactive maintenance activities, and timely updates to address evolving needs and requirements. By adhering to this structured methodology, the home automation project was executed systematically, resulting in a robust, functional, and user-friendly system tailored to meet the specific needs and preferences of the users.

V. BLOCK DIAGRAM & WORKING



This block diagram illustrates the modular architecture of the home automation system. Each module performs specific

functionality. The Sensor Interface Module collects data from various sensors deployed throughout the home environment. The ESP8266 Control Module serves as the central control unit, managing sensor within the home, enhancing security. The Blynk App Interface Module provides a user-friendly interface for remote monitoring and control. The Energy Management Module optimizes energy consumption within the home. The Security and Safety Module ensures the safety and security of the home environment. Finally, the Testing and Validation Module verifies the reliability and performance of the system under various conditions. Together, these modules form a cohesive and intelligent home automation system.

VI. HARDWARE COMPONENTS DESCRIPTION

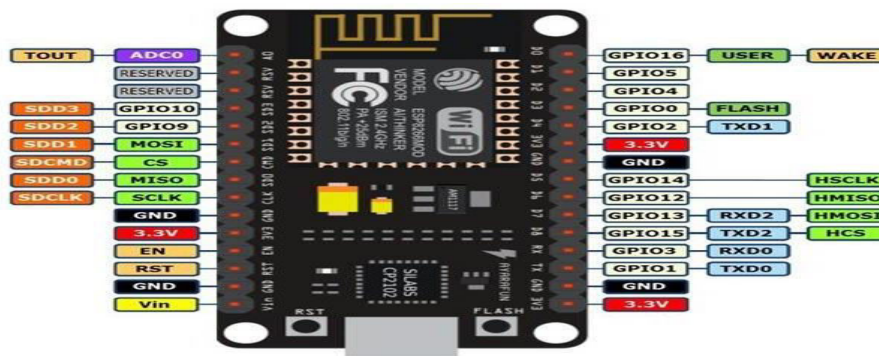


Fig 2 :ESP8266NodeMCUboard

The Node MCU (Node Micro Controller Unit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP 8266, designed and manufactured by Express if Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds .However, as a chip, the ESP8266 is also hard it in their own IoT projects But, what about Arduino. The Arduino project created an open-source hardware design and software SDK for the irversatile IoT controller.Similar toNodeMCU, theArduino hardware is a microcontroller board with a USB connector, LED lights, and standard data pins. It also defines standard interfaces to interact with sensors or other boards. But unlike Node MCU, the Arduino board can have different types of CPU chips (typically an ARM or Intel x86chip) with memory chips, and a variety of programming environments. There is an Arduino reference design forth ESP8266 chip as well. However, the flexibility of Arduino also means significant variations across different vendors. For example, most Arduino boards do not have WiFi capabilities, and some even have a serial data port instead of a USB port.

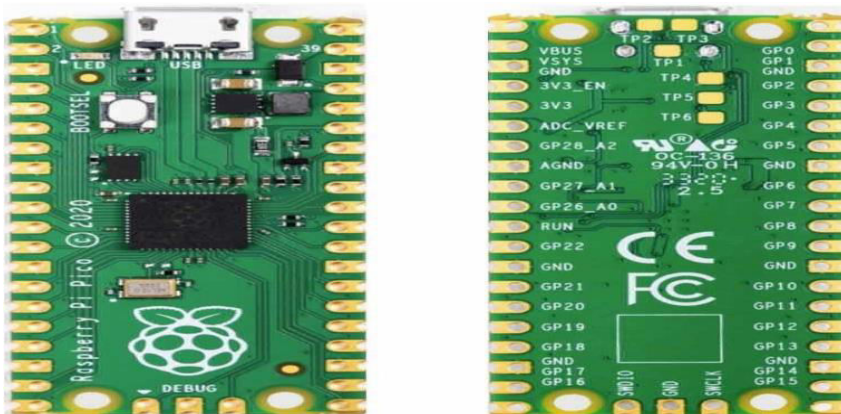


Fig 3.:Rasberry Pi Pico

Raspberry Pi refers to a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The boards have been made keeping in mind the promotion of teaching basic computer science to kids. The latest offering by Raspberry Pi is the Raspberry Pi Pico, a new flexible IoT board. Essentially, it is a microcontroller board built on silicon and designed at the Raspberry Pi Foundation.



Fig 4:DHT11 Sensor

The humidity sensing capacitor has two electrodes with a moisture holding substrate as a dielectric between them. Change in the capacitance value occurs with the change in humidity levels. The IC measure, process form. Form measuring temperature this sensor uses a Negative Temperature coefficient thermostat, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest change in temperature, this sensor is usually made up of semiconductor ceramics or polymers. The temperature range of DHT11 is from 0 to 50 degree Celsius with a 2-degree accuracy. Humidity range of this sensor is from 20 to 80% with 5% accuracy. The sampling rate of this sensor is 1Hz .i.e. it gives one reading for every second. DHT11 is small in size with operating voltage from 3 to 5 volts. The maximum current used while measuring is 2.5Ma



Fig 5 :RelayModule2 Channel

5V Relay Module 2 Channel provides a reliable and efficient solution for controlling two devices independently. With its low operating voltage and versatile design, this relay module is perfect for various electronics projects and automation applications controlling input. There lay scan be used to switch higher voltage and current loads than a micro controller can traditionally accomplish. ADIY 5V Dual Channel Relay Module be used to control various appliances, and other equipment with large current. It can be controlled directly with 3.3V or 5V logic signals from a microcontroller (Arduino, 8051, AVR, PIC, DSP, ARM, ARM, MSP430, TTL logic)



Fig 6:Push Button

A slide on-off switch, often referred to as sliders witch, is a simple but effective electrical component used to control the flow of electricity in a circuit. It consists of a sliding lever or actuator that, when moved, physically opens or closes a pair of electrical contacts. In the "off" position the contacts are separated, interrupting the flow of electricity and



effectively turning the connected device or circuit off. When the lever is slid to the "on" position, it brings the contacts together, completing the electrical circuit and allowing current of low, thus turning the device or circuit on. Slide on-off switches are commonly found in a wide range of electronic devices, from electronics. They are straight forward to operate, making them user-friendly for controlling power sources and functions, and their durable design ensure long-lasting performance.

VII. SOFTWARE COMPONENTS DESCRIPTION

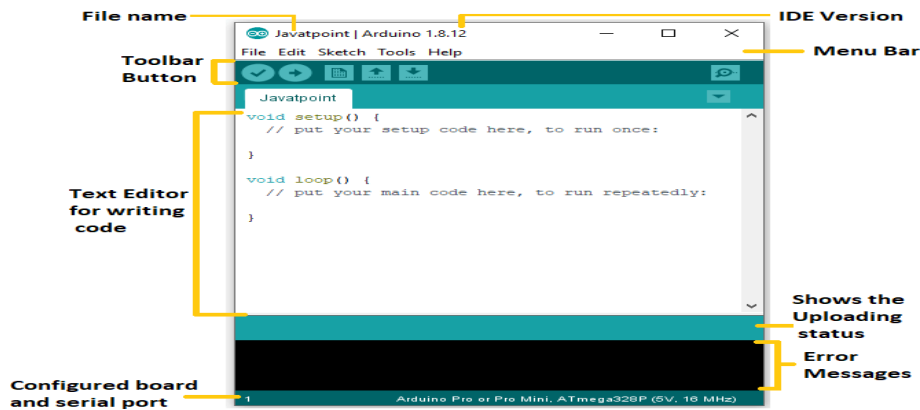


Fig7 .: Arduino IDE

Within the IDE, users find a user-friendly code editor equipped with features like syntax highlighting and auto-completion, of ArduinosketcheswrittenintheArduinoprogramminglanguage,basedonC/C++.Theplatformalso incorporates a library manager, enabling effortless installation and management of pre-written code libraries, expanding the functionality of the Arduino boards. Additionally, the IDE provides a board manager facilitating the selection and configuration of Arduino board variants, while managing the installation of pertinent board-specific files and drivers. Crucially, the IDE includes a serial monitor tool, essential for debugging and real-time interaction with Arduino sketches via the serial port. Furthermore, it streamlines the upload process, seamlessly compiling sketches and transferring the resulting binary files to connected Arduino boards, enabling swift prototyping and experimentation. Supported byan extensive array of built-in examples and tutorials, coupled with a vibrant community offering forums and support resources, the Arduino IDE empowers users of all levels to delve into electronics and programming, fostering innovation and collaboration within the Arduino ecosystem

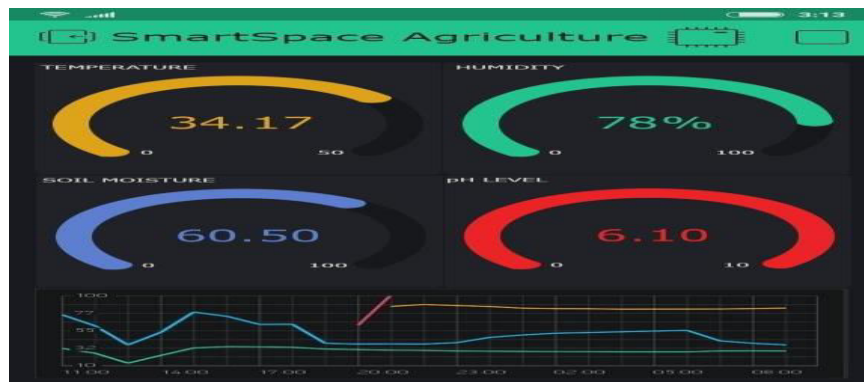
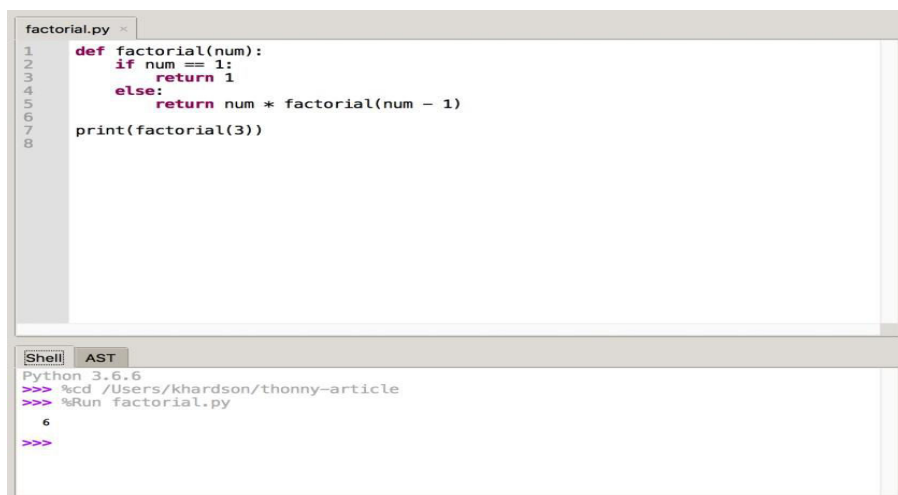


Fig 8 : Blynk app

The Blynk app is a powerful tool designed for remote monitoring and control of Internet of Things (IoT) devices, offering a and intuitive design make it a popular choice forh hobbyists, makers, and professional like .With Blynk, users can easily create custom dashboards to visualize data from sensors, control actuators, and receive notifications based on predefined conditions. The app supports a wide range of hardware platforms, including Arduino, Raspberry Pi,

ESP8266, ESP32, and more, allowing for seamless integration with various IoT projects. Key features include drag-and-drop widgets for creating interactive interfaces, support for virtual pins enabling bi-directional communication between devices and the app, and the ability to share projects with collaborator community.



```

factorial.py
1  def factorial(num):
2      if num == 1:
3          return 1
4      else:
5          return num * factorial(num - 1)
6
7  print(factorial(3))
8

Shell  AST
Python 3.6.6
>>> %cd /Users/khardson/thonny-article
>>> %Run factorial.py
6
>>>

```

Fig 9: Thonny Python

Micro Python is a light weight implementation of the Python3 programming language optimized for micro controller sand embedded systems, making tan ideal choice for programming The Raspberry Pi Pico. Installation involves hardware peripherals, and external components such as sensors and actuators. Micro Python's standard library and community- contributed modules provide extensive functionality, covering a wide range of tasks from basic I/O operations to networking and beyond. Supported by comprehensive documentation and an active community, Micro Python empowers users to harness the capabilities of the Raspberry Pi Pico and create innovative embedded projects with ease.

VIII. CONCLUSION

In this highly developing era, where directly or indirectly, everything is dependent on computation and information technology, Raspberry Pi proves to be a smart, economic and efficient platform for implementing the home automation. This provides a basic application of home automation using Raspberry Pi which can be easily implemented and used efficiently. The code provided is generic and flexible in a user friendly manner and can be extended for any future applications like power control, surveillance, etc, easily.

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