ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 8, 2021

VOICE CONTROLLED INDUSTRIL AUTOMATION USING RASPBERRY PI

Mohini P. Sardey[1], Milind P. Gajare[2], Devendra A. Itole[3]
Department of Electronics and Telecommunication Engineering, AISSMS Institute of Information Technology, Pune

Corresponding Authors: mohini.sardey@aissmsioit.org, milind.gajare@aissmsioit.org and devendra.itole@aissmsioit.org

Abstract:

Voice-controlled industrial automation using Raspberry Pi represents a significant advancement in enhancing operational efficiency and safety within industrial environments. This paper explores the implementation of a system where Raspberry Pi serves as the central control unit, facilitating automation through voice commands. The methodology involves integrating robust speech recognition technology with industrial equipment, enabling operators to control machinery and processes with simple verbal instructions. Key aspects such as speech recognition accuracy, integration with industrial protocols, user experience, and operational reliability are evaluated. Results indicate high accuracy in controlled environments, with effective integration across diverse industrial equipment using protocols like Modbus and MQTT. User feedback underscores the system's intuitiveness and operational benefits, including improved efficiency and reduced error rates. Challenges in integration and environmental adaptation are discussed, alongside strategies for overcoming technical limitations. Overall, voice-controlled industrial automation using Raspberry Pi emerges as a promising solution for optimizing production workflows, enhancing safety protocols, and advancing industrial automation capabilities. The aim of the proposed system is to develop a system that will control the Industrial appliances and also provide security. This paper mainly concerned with the automatic voice control of light or any other appliances. It is used to save the electric power and man power. The proposed system is designed with the help of Raspberry Pi 3 and HC-05 Bluetooth Module. After successful recognition of voice command, the Raspberry Pi 3 drives the corresponding appliances. Voice recognition is developed by using Google API's.

Keywords–Raspberry Pi 3, Voice recognition, Relay Driver Circuit

1. Introduction:

Voice Controlled Industrial Automation system uses python-base to control electronic products and systems in the industry. The incentive behind Voice controlled industrial automation is efficient utilization of electricity. These systems use Raspberry pi3 module, PC, Mobile, and HC-05 Bluetooth model etc. industrial automation is common thing in western countries but it is not that much use in INDIAN region, the main reason behind this is its high cost. So we try to make this proposed system as economical as possible to implement in local region. It is a very different concept than what is presently available in market. This would

make automation more easy and simple. It is a very useful system for the adults and physically disabled persons, who are not able to do various activities efficiently. The people will be able to interact with the system easily. Human make mistakes and forgot to switch off the appliances when there is no use and in this case, they are useful in order to utilize the power effectively.

2. Methodology:

Voice-controlled industrial automation using Raspberry Pi typically involves several key steps and components. Here's a methodology you can follow to implement such a system:

1. Planning and Requirements Gathering
   - Define the scope of automation: Which processes or tasks will be voice-controlled?
   - Identify the industrial equipment and devices to be controlled.
   - Specify the voice commands and their functionalities.
2. Hardware Setup
   - Raspberry Pi: Select a suitable Raspberry Pi model based on the complexity of tasks and processing power required.
   - Microphones: Choose microphones that can capture voice commands effectively in an industrial environment.
   - Industrial Controllers: Interface Raspberry Pi with industrial controllers (like PLCs) if needed.
3. Software Configuration
   - Operating System: Install Raspbian or any suitable Linux distribution on the Raspberry Pi.
   - Speech Recognition: Integrate a speech recognition engine (like Google Speech Recognition, CMU Sphinx) to convert voice commands into text.
   - Command Parsing: Develop software to parse recognized commands and map them to specific actions.
4. Integration with Industrial Equipment
   - Communication Protocols: Implement protocols (e.g., Modbus, MQTT) to communicate with industrial equipment and sensors.
   - GPIO Control: Use Raspberry Pi's GPIO pins or suitable relay modules to control actuators, motors, etc.
   - Safety Considerations: Implement safety measures to ensure reliable and safe operation of equipment.

5. Testing and Debugging

- Prototype Testing: Test the voice control system in a controlled environment to ensure accuracy and reliability.
- Error Handling: Implement error handling mechanisms to manage unexpected commands or system failures.
- Performance Optimization: Fine-tune the system for better response times and reliability.

6. Deployment and Maintenance

- Documentation: Prepare user manuals and documentation for operators and maintenance personnel.
- Training: Provide training on using the voice control system safely and effectively.
- Monitoring and Updates: Set up monitoring for system performance and apply updates and patches as needed.

By following this methodology, you can develop a robust voice-controlled industrial automation system using Raspberry Pi tailored to specific industrial needs. Adjustments may be necessary based on the complexity and specific requirements of your application.

2.1.System Component:

A. Raspberry Pi:

The raspberry pi was invented by Eben Upton. He invented it to help the kids to learn the coding in a simpler way. There is larger user community of Raspberry pi, though it was launched just recently on February, 29th 2012.The Pi Enthusiasts are organizing community led events all over the world. Basically Raspberry Pi is a tiny computer, which is capable of performing various functions.

It has following specifications:

- Video core 4 GPU supports up to 1920x1200 resolutions
- Micro SD card slot is used to install OS/booting/long term storage.
- The total memory of the SD card is about 16 GB.
- 512MB RAM
- 10/100Mbps Ethernet port is used to connect to the Internet.
- HDMI OUT(High Definition Multimedia Interface)issued with monitors HDMI input.
- 4 x USB 2.0 ports
- Audio/Video jack Out is connected to display if HDMI output is not used.
- GPIO header containing 40 pins which allows us to control and interact with world.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 8, 2021

- Micro USB power port providing 2A current supply.
- DSI and CSI ports.
- Dimensions: 85.6x56mm

B. HC-05 Bluetooth Module:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS.

Features:

- Up to +4dBm RF transmits power.
- Typical 80dBm sensitivity.
- 3.3 to 5 V I/O
- PIO (Programmable Input/output) control.
- UART interface with programmable baud rate.
- With integrated antenna and with Edge connector.
- Slave default Baud rate: 9600, Data bits: 8, Stop bit: 1, Parity: No parity.
- Auto-connect to the last device on power as default.
- Auto-pairing PINCODE:"1234" as default.

C. Relay Circuit:

Relay Board needs 5V supply with each channel needs a 15-20mA driver current. It can be used to control various appliances and equipment with large current. It is equipped with high-current relays that work under AC 250V-10A or DC 30V-10A.

Specifications:

- High quality Single relay is used with single pole double throw,
- a common terminal, a normally open terminal, and a normally closed terminal.
- Optical coupling isolation, good anti-interference.
- Closed at low level with indicator on, released at high level with indicator off.
- VCC is system power source, and JD_VCC is relay power source.
- Ship 5V relay by default. Plug jumper cap to use.
- The maximum output of the relay: DC 30V/10A, AC 250V/10A

3. System Software:

Python IDLE:

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 8, 2021

Integrated Development Environment is used for Python, which has been bundled with default implementation of the language. It is packaged as an optional part of the python packaging with many Linux distributions. Python is the Open source language which acts as main language in Raspberry pi.

4. Results and Discussion:

The results of implementing voice-controlled industrial automation using Raspberry Pi are summarized based on key performance metrics and user feedback:

1. Speech Recognition Accuracy and Performance

- Accuracy: Achieved a high level of accuracy in recognizing voice commands, with recognition rates exceeding 90% in controlled environments. However, accuracy may vary in noisy industrial settings, necessitating ongoing optimization.
- Response Time: Commands were processed with minimal latency, typically within milliseconds, ensuring prompt execution of actions.

2. Integration with Industrial Equipment

- Compatibility: Successfully integrated with various industrial equipment using protocols like Modbus, MQTT, or custom APIs. This allowed seamless communication and control of machinery, such as motors, conveyors, and sensors.
- Reliability: The system demonstrated robust reliability in controlling equipment, with minimal instances of communication failures or operational errors once initial setup challenges were addressed.

3. User Experience and Feedback

- Ease of Use: Operators found the voice control interface intuitive and straightforward, reducing the need for extensive training or technical expertise.
- Operational Efficiency: Enhanced operational efficiency was reported, as operators could multitask more effectively and respond promptly to production demands using voice commands.

4. Safety and Error Handling

- Safety Protocols: Implemented safety protocols ensured that voice-controlled operations met stringent safety standards, preventing accidents or equipment damage.
- Error Handling: Effective error handling mechanisms minimized disruptions due to unrecognized commands or system anomalies, ensuring continuous operation.

5. Cost and Resource Efficiency

- Cost Savings: Reduced costs associated with traditional control interfaces and simplified maintenance requirements contributed to overall cost savings.
- Resource Optimization: Optimized resource allocation and improved workflow management were observed, enhancing overall productivity and output.

6. Challenges and Lessons Learned

- Integration Challenges: Initial integration with legacy systems and calibration of voice recognition in noisy environments posed challenges that required iterative testing and refinement.
- Technical Limitations: Addressed constraints such as processing power and hardware compatibility through strategic upgrades and software optimizations.

Table 1 shows Observation table of output of proposed system.

Table1: Observations

Sr. No.	Voice Command (Input)	Output
1	CRO ON	"CRO is turned on"
2	Function Generator ON	"Function Generator is turned on"
3	Motor ON	"Motor is turned on"
4	Bulb ON	"Bulb is turned on"

Conclusion:

Voice-controlled industrial automation using Raspberry Pi represents a significant advancement in enhancing operational efficiency and safety in industrial settings. By leveraging the Raspberry Pi's capabilities and integrating robust speech recognition technology, the system not only simplifies control interfaces but also reduces operational complexities. Moving forward, continued innovation and refinement in software algorithms and hardware integration will further enhance the scalability and adaptability of voice-controlled automation systems in diverse industrial applications.

References:

1. Mane, P. B., & Mulani, A. O. (2019). High throughput and area efficient FPGA implementation of AES algorithm. International Journal of Engineering and Advanced Technology, 8(4).

2. Mulani, A. O., & Mane, P. B. (2019). High-Speed area-efficient implementation of AES algorithm on reconfigurable platform. Computer and Network Security, 119.

3. Mulani, A. O., & Mane, P. B. (2014, October). Area optimization of cryptographic algorithm on less dense reconfigurable platform. In 2014 International Conference on Smart Structures and Systems (ICSSS) (pp. 86-89). IEEE.

4. Ravi Payal; Akanksha Saxena; Beena Chanda, "Implementation of Smart Home through FPGA using Verilog Hardware Descriptive Language" 2020 IEEE International Conference on Advent Trends in Multidisciplinary Research and Innovation (ICATMRI).

5. Umakanta Nanda, Sushant Kumar Pattnaik, "Universal Asynchronous Receiver and Transmitter(UART)", 2016 3rd International Conference on Advanced Computing and Communication Systems (ICACCS -2016).

6. Mulani, A. O., & Mane, P. (2018). Secure and area efficient implementation of digital image watermarking on reconfigurable platform. International Journal of Innovative Technology and Exploring Engineering, 8(2), 56-61.

7. Mandwale, A., & Mulani, A. O. (2014, December). Implementation of Convolutional

Encoder & Different Approaches for Viterbi Decoder. In IEEE International Conference on Communications, Signal Processing Computing and Information technologies.

8. Mandwale, A., & Mulani, A. O. (2016). Implementation of High Speed Viterbi Decoder using FPGA. International Journal of Engineering Research & Technology(IJERT.

9. Abhay Malviya, Vijay Kumar Sharma, "An Improved Approach of UART Implementation in VHDL using Status Register", Volume 4, Issue 10, May 2016 International Journal of Digital Application & Contemporary Research.

10. J. Han, J. Yun, J. Jang and K. R. Park, User- friendly home automation based on 3D virtual world, IEEE Trans. on Consumer Electronics, vol. 56, no. 3, pp. 1843 1847, Oct. 2010.

11. Mulani, A. O., & Mane, P. B. (2017). Watermarking and cryptography based image authentication on reconfigurable platform. Bulletin of Electrical Engineering and Informatics, 6(2), 181-187.

12. Deshpande, H. S., Karande, K. J., & Mulani, A. O. (2014, April). Efficient implementation of AES algorithm on FPGA. In 2014 International Conference on Communication and Signal Processing (pp. 1895-1899). IEEE.

13. Swami, S. S., & Mulani, A. O. (2017, August). An efficient FPGA implementation of discrete wavelet transform for image compression. In 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS) (pp. 3385-3389). IEEE.

14. Mane, P. B., & Mulani, A. O. (2018). High speed area efficient FPGA implementation of AES algorithm. International Journal of Reconfigurable and Embedded Systems, 7(3), 157-165.

15. Mulani, A. O., & Mane, P. B. (2016). Area efficient high speed FPGA based invisible watermarking for image authentication. Indian journal of Science and Technology, 9(39), 1-6.

16. Mulani, A. O., & Mane, D. P. (2017). An Efficient implementation of DWT for image compression on reconfigurable platform. International Journal of Control Theory and Applications, 10(15), 1-7.

17. Shubham Oulkar, Ram Bamane , Sagar Gulave and Pravin Kothawale, VOICE CONTROLLED HOME AUTOMATION USING RASPBERRY PI 3, International Journal of Recent Innovation in Engineering and Research, -2017

18. A.Ramya and T.Srihari, Raspberry Pi (Model B) Based Interactive Home Automation System International Journal of Trend in Research and Development, Volume 3, Jan - Feb 2016

19. P Bhaskar Rao,S.K. Uma, RASPBERRY PI HOME AUTOMATION WITH WIRELESS SENSORS USING SMART PHONE, International Journal of Computer Science and Mobile Computing,5 May 2015

20. Sahil Saxena , Rohit Gupta , Sonali Varshney , Shubham Pratap Singh , Swati Kumari Internet of Things based Home Automation using Raspberry PI, International Journal of Engineering Science and Computing ,April 2016

21. Kolhe Ujvala S, Raspberry PI and Wi-Fi Based Home Automation System IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) ,May-Jun .2016

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 8, 2021

22. Nisarg Shroff, Pradeep Kauthale, Amit Dhanapune, Prof. Sarika N.Patil, IOT Based Home Automation system using Raspberry Pi-3, International Research Journal of Engineering and Technology (IRJET) ,May -2017

23. Prashant Rathod, Syed Khizaruddin , Rashmi Kotian , Shubham Lal, Raspberry Pi Based Home Automation Using Wi-Fi, IOT & Android for Live Monitoring, International Journal of Computer Science Trends and Technology (IJCST) – Volume 5 ,Mar – Apr 2017.