IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

DEVELOPMENT OF IoT BASED HOME ASSISTANT ROBOT FOR ELDERLY PEOPLE

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Abstract: As the global population ages and more people choose to live on their own, there's a pressing need for smart home monitoring systems. Many elderly individuals live independently, but for those dealing with cognitive decline, it can be quite challenging and even risky. This project introduces a moving robotic vehicle equipped with person-detection capabilities that navigates towards individuals, delivering medications at specified intervals. The proposed robotic vehicle model will feature a video camera setup along with a microphone for comprehensive monitoring. The project aims to provide not only medication delivery but also companionship and assistance to individuals in need. Control of the vehicle will be facilitated through hand gestures and voice commands, making it accessible and user-friendly. Key to its functionality will be face recognition technology, enabled by machine learning algorithms driven by computer vision and image processing techniques. The entire system will be designed to operate on a Raspberry Pi 3B platform, ensuring efficiency and flexibility. To ensure continuous operation, the vehicle will be powered by a rechargeable battery providing uninterrupted service to users.

Keywords – Internet of things (IOT), Face Recognition, Machine learning, Image processing, Application control, Gesture control, Voice control.

I. Introduction

The realm of the Internet of Things (IoT) expands exponentially, encompassing a myriad of physical devices worldwide that are seamlessly connected to the internet, actively collecting and sharing data. This transformation is propelled by the proliferation of remarkably affordable computer chips and the widespread availability of wireless networks. As a consequence, virtually any object or entity can be integrated into the IoT framework. By equipping these diverse objects with sensors and establishing connectivity, a layer of digital intelligence is imbued upon what would otherwise be inert entities, enabling them to engage in real-time data communication without necessitating human intervention. One fascinating application within this expansive IoT landscape is the development of a sophisticated moving robot, designed to be responsive to voice commands, gestures, and even capable of employing facial recognition technology, particularly geared towards assisting elderly individuals. This robotic innovation epitomizes the convergence of the digital and physical realms, illustrating how IoT technologies can enhance the efficiency and efficacy of everyday tasks. At its core, this IoT-enabled robotic system comprises a web of interconnected smart devices, each equipped with embedded systems such as processors, sensors, and communication hardware. These devices function collaboratively to gather, transmit, and interpret data gleaned from their surroundings. Integral to the operation of this robotic marvel is its ability to interface with users through various modalities, including voice commands and gestures, facilitated by advanced machine learning algorithms. Moreover, the incorporation of facial recognition technology adds a layer of personalized interaction, particularly beneficial for elderly individuals who may require specialized assistance and care. Through facial recognition, the robot can discern the identity of the individual it is assisting, tailor its responses and actions accordingly, and provide a seamless and intuitive user experience.

Central to the operation of this IoT-driven robotic system is the establishment of a robust communication infrastructure, facilitating seamless data exchange between the robot, IoT gateways, edge devices, and cloud-based analytics platforms. This interconnected network enables the robot to access a wealth of information, analyze complex datasets, and execute informed decisions.

II. METHODOLOGY

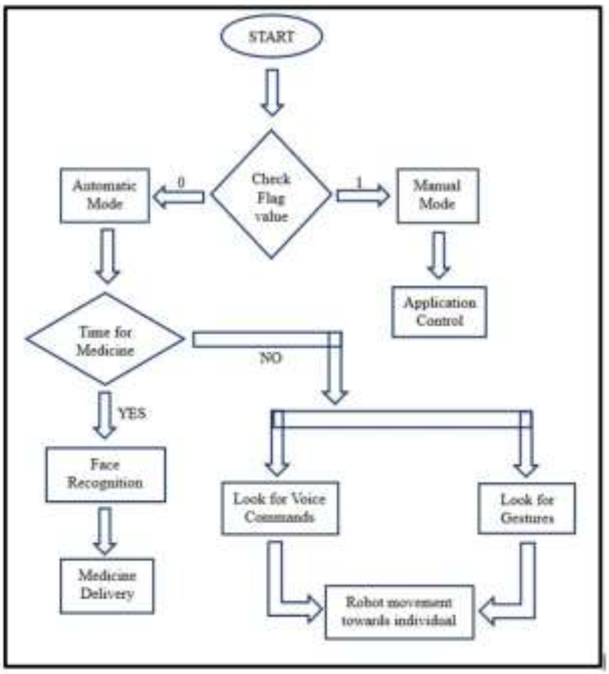

Fig.1) Flowchart of the project

The initial phase, Automatic Mode, entails a system or device operating autonomously, devoid of human intervention. The methodology for this phase varies depending on its intended context and objectives, potentially incorporating sensors, algorithms, or other mechanisms to detect and execute actions automatically. Following Automatic Mode is the designated period for medication administration, aptly titled "Time for Medicine." The methodology here hinges on the medical scenario's intricacies and the particular necessities surrounding medication delivery. It may encompass scheduling mechanisms, reminder systems, or automated dispensing setups to ensure timely medication administration. Subsequently, the process involves Robot Movement, indicating the involvement of a robotic system. The methodology for controlling robot movement relies on the specific functionalities and programming of the robot in question. It could entail the utilization of sensors, algorithms, or programmed instructions to orchestrate precise movements or task execution. The presence of the Flag Value element denotes a signaling mechanism used to indicate specific conditions or prompt actions within the system. The methodology for handling flag values depends on how they are set or manipulated within the system framework. In summary, the methodology for this process is contingent upon its distinct context and objectives, potentially incorporating automated systems, designated medication administration schedules, and robot movements.

III. HARDWARE USED

(1) RASPBERRY PI MODEL 3B

The Raspberry Pi 3 Model B is a popular single-board computer developed by the Raspberry Pi Foundation. It offers a low-cost, compact solution for various computing projects, including DIY electronics, programming, IoT (Internet of Things) projects, and more. It features a 1.2GHz 64-bit quad-core ARM Cortex-A53 CPU, offering improved performance compared to previous models. The Raspberry Pi 3 Model B typically comes with 1GB of RAM, providing sufficient memory for many tasks and projects. It includes built-in Wi-Fi (802.11n) and Bluetooth 4.1, allowing for wireless communication and connectivity to peripherals such as keyboards, mice, and other devices.

- Processor: Broadcom BCM2837 64-bit ARMv8 quad-core Cortex-A53 CPU.
- Clock Speed: 1.2GHz
- RAM: 1GB LPDDR2 SDRAM
- Connectivity: 10/100 Ethernet, 2.4GHz 802.11n wireless, Bluetooth 4.1, BLE
- Ports: 4 USB 2.0 ports, 40 GPIO pins, Full-size HDMI, 3.5mm audio jack, CSI camera port, DSIdisplay port, MicroSD card slot for data storage
- Power: 5V/2.5A DC via micro-USB connector
- Dimensions: 85mm x 56mm x 17mm
- Weight: 45g

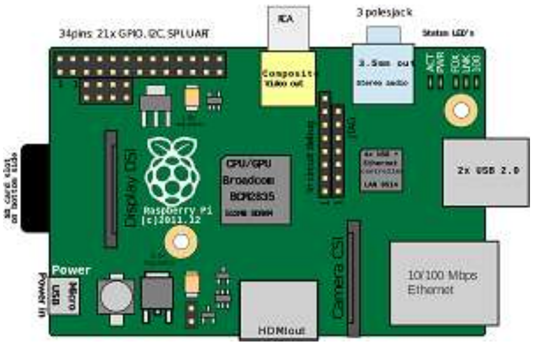

Fig.2) Raspberry pi model 3B SOC-block diagram

(2) MOTOR DRIVER

The L298N motor driver, featuring dual H-bridges, enables precise control of DC motors in both forward and reverse directions, facilitating accurate speed and direction adjustments. It supports a voltage range of 5V to 35V and can manage up to 2A per channel, with heat sinking necessary for high-current loads. Compatible with logic-level signals, it easily interfaces with microcontrollers like Arduino and Raspberry Pi. Built-in flyback diodes safeguard against voltage spikes, while the enable pins offer control over motor channel activation, useful for power-saving or safety measures. However, significant heat generation requires proper dissipation techniques. External connections for motor power, ground, outputs, and control signals are essential for operation, highlighting the L298N's capability for robust motor management in various projects.

Fig.3) L298N Motor Driver

(3) MICROPHONE

USB microphones are an ideal choice for Raspberry Pi users, offering a plug-and-play experience without the need for additional hardware or drivers, thanks to their compatibility with USB ports. These microphones provide a digital audio interface, ensuring high-quality, interference-free audio capture by transmitting signals digitally. Features to look for in USB microphones include wide frequency response, low noise levels, and good sensitivity for clear and accurate recordings. They also often support higher sampling rates, such as 48 kHz or 96 kHz, enhancing audio quality for various applications. Moreover, many USB microphones come with built-in drivers, facilitating seamless integration with operating systems, including Linux-based Raspberry Pi, allowing immediate use upon connection.

Fig.4) Microphone with USB port

(4) CAMERA

This camera comes equipped with an inbuilt sensitive microphone, enabling the capture of clear audio alongside video. It boasts an interpolated image resolution of 25 megapixels, from a hardware resolution of 500K pixels, and supports a 16 MP image resolution, though interpolation may not always yield true high-resolution images. Enhanced by six light sensors, the camera promises improved image quality in low light. Its USB interface ensures compatibility with a multitude of devices, while night vision capabilities extend its utility to low-light conditions. With a focus range from 4 cm to infinity and adjustable image controls for color saturation, brightness, sharpness, and contrast, it offers versatility and quality in capturing images and videos.

Fig.5) Camera with USB port

(5) BATTERIES

These 3.7V lithium-ion batteries are known for their stable voltage output, rechargeability, and widespread use in various electronic devices due to their lightweight, compact design, which enhances portability. Their high energy density enables extended usage, making them ideal for powering smartphones, laptops, drones, and wearable technology. As rechargeable batteries, they offer cost savings and environmental benefits over disposable alternatives, capable of being recharged multiple times.

Fig.6) Lithium-Ion batteries

(6) POWER CONVERTER

This power converter features four USB ports, enabling the simultaneous charging of multiple devices, ideal for environments like homes, offices, or vehicles where numerous devices require power. It supports a broad input voltage range (DC36V, 24V, 12V, 9V), accommodating a variety of power sources, including car batteries and solar panels. Designed to deliver a stable 5V output, it ensures compatibility and safe charging for USB devices such as smartphones and tablets. Furthermore, each USB port offers a high 3A current output, facilitating fast charging and reducing wait times for device users. This converter embodies versatility, efficiency, and convenience for charging USB devices across different settings and applications

Fig.7) Power converter

(7) DC MOTORS & WHEELS

To optimize robot performance, choosing DC motors with higher RPM ratings is essential, as it increases wheel rotation speed, providing agility and swift movement critical for applications like racing or autonomous navigation. Incorporating PWM (Pulse Width Modulation) capabilities in motor controllers or drivers is crucial for effective speed control, allowing for the fine-tuning of motor speed through adjustments in the PWM signal's duty cycle, which enhances smooth acceleration and deceleration. For versatile mobility, integrating bidirectional control using H-bridge motor drivers enables the robot to move both forward and backward by reversing motor terminal polarity. To ensure reliability, it's important to implement safeguards against motor overheating or stalling by monitoring motor temperature and current draw, reducing motor speed or pausing operation if necessary.

Fig.8) DC Motors & Wheels

IV. SOFTWARE USED

(1) BUSTER: Users like Buster OS because it blends Debian's dependability and abundant software options with Raspberry Pi's tailored optimizations, creating an effective and flexible operating system that suits the unique needs of this single-board computer, offering good support and features.

(2) OPENCV: OpenCV is a free and open-source software library for computer vision and machine learning, offering a variety of tools and functions to help with tasks like image processing and computer vision, originally created by Intel and now supported by the OpenCV community.

(3) CMAKE: CMake is a tool that helps developers build software on different types of computers by using a simple language to describe how the software should be built, and it creates the necessary files for various operating systems like Unix and Windows.

(4) MEDIA PIPE: MediaPipe, made by Google, is a helpful toolkit for developers, giving them ready-to-use tools and parts to create things like hand tracking, face detection, and pose estimation in computer vision and machine learning projects.

(5) FACE RECOGNITION: Face recognition is like a computer skill that helps machines recognize and confirm people's faces in pictures or videos by using special computer programs and learning methods.

(6) SPEECH RECOGNITION: Speech recognition is a technology that changes spoken words into written text, using computer algorithms and machine learning to understand and transcribe what is being said.

(7) IOT MQTT PANEL APPLICATION: The "IoT MQTT Panel App" is a mobile application designed for managing and monitoring IoT (Internet of Things) devices through the MQTT (Message Queuing Telemetry Transport) protocol. It provides users with an intuitive interface to interact with their IoT devices, allowing them to send commands, receive data. The app offers remote control capabilities, empowering users to efficiently manage their IoT ecosystem from their smartphones or tablets.

V. RESULTS

As mentioned in the methodology section, the results are obtained and are described here case by case.

(1) FACE RECOGNITION:

The script continuously captures frames from a video stream, detects faces in each frame using the Haar cascade classifier, computes facial embeddings for the detected faces, and compares them with the known encodings. If a match is found, it keeps track of the recognized faces and updates the display with bounding boxes and labels. The recognition process involves counting votes for each recognized face, and the name with the highest vote count is considered the recognized face. The recognized names are displayed on the screen, and the loop continues until the user presses the 'q' key to quit. The frames per second (FPS) of the video stream are also calculated and displayed.

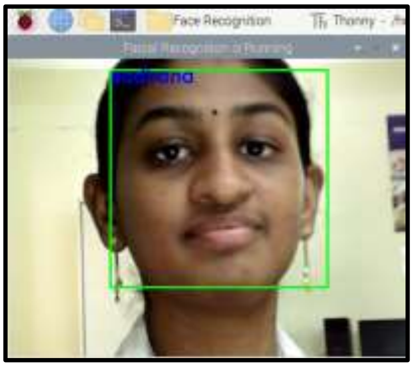

Fig.9) Face is Recognized and displayed the name of the person

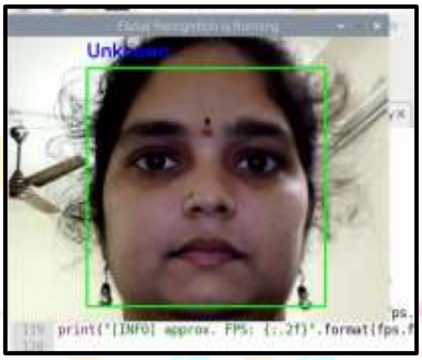

Fig.10) Face is not recognized and displayed as Unknown

(2) GESTURE BASED CONTROLLING:

The finger count obtained from hand tracking is used to control the movement of a robotic vehicle. The code sets up GPIO pins on a Raspberry Pi to control the motors of the vehicle. Depending on the finger count, different motor configurations are activated to make the vehicle move forward, backward, turn left, turn right, or stop. This allows the user to control the robotic vehicle by making specific gestures with their hand, detected through the hand tracking process.

Fig.11) Forward

Fig.12) Backward

Fig.13) Left

Fig.14) Right

Fig.15) Stop

Out of 32 finger combinations we have selected these 5 hand combinations for gesture controlling.

(3) VOICE BASED CONTROLLING:

The code uses the Raspberry Pi GPIO (General Purpose Input/Output) library to control the motor connected to specific GPIO pins on the Raspberry Pi. Motor movements such as forward, backward, left, right, and stopping are implemented by setting the corresponding GPIO pins to high or low states. Speech recognition is integrated using the `speech_recognition` library. The program continuously listens for voice commands, recognizes them using Google's Speech Recognition service, and performs motor movements based on the recognized commands. The speech recognition loop continues until the user interrupts it with a voice interrupt "OUT", at which point the motors are stopped, GPIO is cleaned up, and the program exits.

7

```
Say a command...
result2:
{'alternative': [{'transcript': 'forward'}], 'final': True}
FORWARD
```

Fig.16) Forward

```
Say a command...
result2:
{'alternative': [{'transcript': 'backward'}], 'final': True}
BACKWARD
```

Fig.17) Backward

```
Say a command...
result2:
{'alternative': [{'transcript': 'left'}], 'final': True}
LEFT
```

Fig.18) Left

```
Say a command...
result2:
{   'alternative': [{'transcript': 'right'}, {'transcript': 'write'}],
    'final': True}
RIGHT
```

Fig.19) Right

```
Say a command...
result2:
{   'alternative': [{'transcript': 'stop'}, {'transcript': 'stop stop'}],
    'final': True}
stop
```

Fig.20) Stop

(4) APPLICATION BASED CONTROLLING:

This configures a Raspberry Pi to control connected motors via MQTT protocol. It initializes GPIO pins to manage motor direction and movement. MQTT settings such as broker address and topic are specified, along with a unique client ID. Upon receiving MQTT messages, the script triggers corresponding motor control functions like moving forward, backward, turning left or right, and stopping. The MQTT client subscribes to the specified topic and continuously listens for incoming messages within a loop. Exception handling ensures graceful termination, disconnecting from the MQTT broker and cleaning up GPIO resources upon interruption. This setup enables remote control of the Raspberry Pi's motors via MQTT commands.

Fig.21) Forward, Backward, Left, Right, Stop

VI. CONCLUSION

In conclusion, the developed moving robot represents a pioneering solution designed with the well-being of elderly individuals living alone in mind. In its primary Automatic Mode, the robot seamlessly operates autonomously, ensuring the timely and accurate delivery of medication to the elderly user. This system incorporates sophisticated sensor technologies, algorithms, and automated dispensing setups to streamline the medication administration process. The project's innovation extends further with the incorporation of a Manual Mode, where users can effortlessly control the robot through intuitive gesture and voice commands, fostering a user-friendly interface that caters to the unique needs of the elderly population. This dual-mode functionality not only provides a reliable and efficient medication delivery system but also offers a personalized and interactive experience for users. With a keen focus on user safety, convenience, and independence, this robot serves as a valuable companion, addressing the healthcare needs of elderly individuals by blending cutting-edge technology with thoughtful design. Ultimately, this project represents a significant step towards enhancing the quality of life for elderly individuals, promoting autonomy, and ensuring the timely and accurate management of their medication regimen.

VII. REFERENCES

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