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Care Taker Bot: A Smart Assistive Device for Elderly Care

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Abstract

The growing demand for assistive technologies in healthcare and elderly care has driven the development of intelligent robotic systems. This research work describes the design, hardware integration, and software implementation of a caretaker bot built around the Raspberry Pi 4B module. The system combines essential components such as a speaker, a buzzer, a power bank for portability, a SIM card module for cellular connectivity, and a mobile application for real-time notifications. In addition to the hardware specifications and interconnections, the study details the Raspberry Pi 4B pin diagram, provides an overview of the operating system installation and configuration, includes sample Python code for audio recording and notification functionality, and outlines the system's overall architecture using block diagrams and flow charts. The final output showcases a fully functional prototype designed to monitor events and deliver timely alerts. This system proves to be an effective solution for remote caregiving and emergency support, offering real-time updates that enhance responsiveness and safety. By integrating sensor-based monitoring and instant notifications, it ensures that critical situations are promptly addressed, thereby reducing response times. Its reliable performance and ease of deployment make it a valuable tool for elderly care, patient supervision, and other vulnerable scenarios. Overall, the prototype highlights the potential for scalable implementation in healthcare and smart home environments requiring remote oversight.

Keywords: Caretaker bot, Raspberry Pi 4B, assistive technology, emotional support, elderly care, voice interaction, IoT, AI companion

INTRODUCTION

The increasing need for elderly care in an aging society has led to the development of intelligent caretaker systems that can assist individuals in maintaining their independence while ensuring prompt help during emergencies. This project focuses on designing a compact, affordable caretaker bot that integrates a range of hardware components into a cohesive system. Central to this design is the Raspberry Pi 4B, a versatile single-board computer known for its robust performance, connectivity, and ease of interfacing with peripheral devices. The caretaker bot is intended to serve as an assistive device capable of recording audio in response to a manual trigger, processing the captured data and sending notifications via a mobile application [1].

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The Emotional Touch Caretaker Bot leverages the Raspberry Pi 4B module as its core processing unit, integrating various hardware components to create a compact and efficient system. The bot is equipped with a speaker for voice output, a button for user interaction, a power bank for portability, and a SIM card for sending notifications to caregivers. Additionally, a mobile app is developed to log daily task data and provide real-time updates

to caregivers. This study outlines the design, implementation, and testing of the bot, focusing on its hardware and software integration, as well as its emotional and functional capabilities.

HARDWARE COMPONENTS AND SPECIFICATIONS

Raspberry Pi 4B Microprocessor

The Raspberry Pi 4B is the central processing unit of the Caretaker Bot, providing computational power, connectivity, and interfacing capabilities required for smooth operation (Figure 1). It is a compact yet powerful single-board computer (SBC) that integrates multiple functionalities, making it an ideal choice for IoT-based smart assistance systems like the Caretaker Bot. The Broadcom BCM2711 processor, a quad-core Cortex-A72 (ARM v8-A) CPU clocked at 1.5 GHz, ensures efficient multitasking, allowing the bot to handle voice interactions, daily task reminders, and mobile app notifications simultaneously without performance lag. The 64-bit architecture enhances processing speed, enabling real-time emotional responses for elderly users [2].

One of the standout features of the Raspberry Pi 4B is its expanded memory options, offering 2, 4, and 8 GB LPDDR4 RAM variants. The high-speed memory improves system responsiveness, ensuring that the bot can process voice data, record logs, and send notifications efficiently. Additionally, the USB 3.0 ports allow high-speed data transfer. For connectivity, the Raspberry Pi 4B supports dual-band Wi-Fi (2.4 and 5.0 GHz), Bluetooth 5.0, and Gigabit Ethernet, which are crucial for ensuring seamless communication between the bot and the mobile application. These wireless features allow the bot to send real-time notifications, receive software updates, and integrate with cloud-based services for data backup.

The 40-pin GPIO (General Purpose Input/Output) interface is another essential aspect of the Raspberry Pi 4B, enabling direct connections to sensors, buttons, speakers, and a microphone. The bot's speaker and microphone are interfaced via I2S or USB to enable high-quality voice recognition and playback, which is fundamental to delivering emotional support. To operate efficiently, the Raspberry Pi 4B runs on the Raspberry Pi OS, a Linux-based operating system optimized for the hardware. The OS is installed on a microSD card, providing a lightweight yet robust platform for executing Python scripts, managing databases, and interfacing with external APIs for notification services [3].

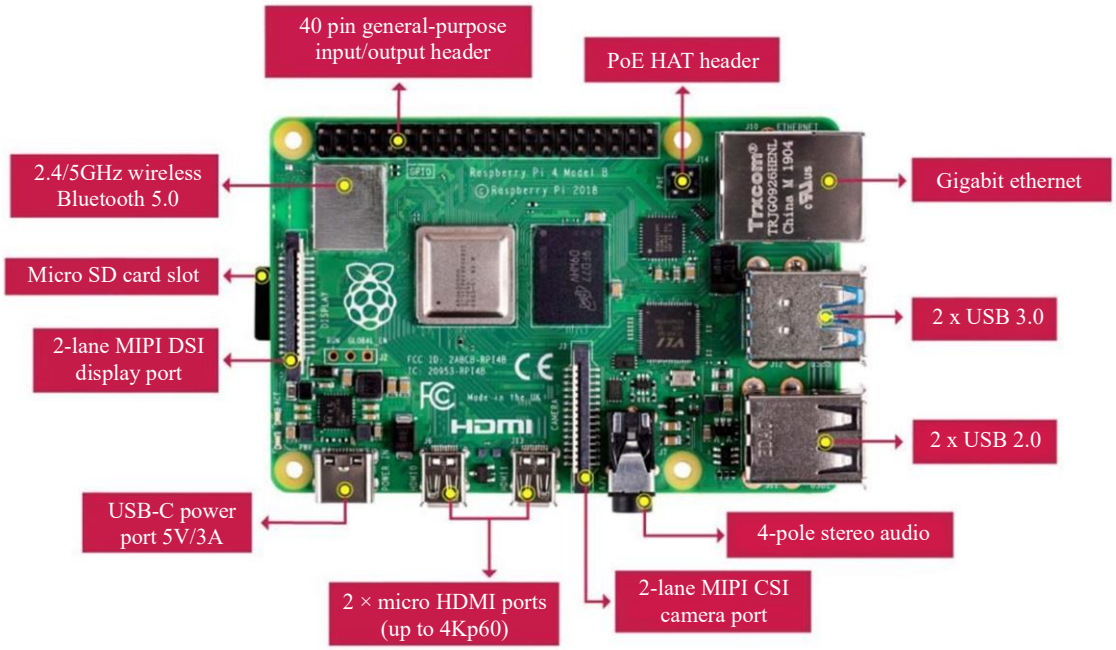

Figure 1. Raspberry Pi 4B.

Powering the system is a portable power bank, ensuring uninterrupted operation even in the absence of a direct power source. This feature makes the bot highly portable and reliable, reducing dependency on external power outlets. The energy-efficient design of the Raspberry Pi 4B, coupled with intelligent power management techniques, ensures that the Caretaker Bot can run continuously for extended periods without excessive battery drain.

Speaker

A small speaker is connected to the Raspberry Pi's audio output jack to provide voice-based emotional support and task reminders.

Buzzer

A buzzer is a small electronic device that produces a loud, high-pitched sound when activated. It is commonly used in embedded systems, robots, and IoT devices to provide auditory feedback or alerts. The buzzer is connected to a microprocessor using a digital output pin. When the pin is set high, the buzzer produces a sound, and when the pin is set low, the sound stops.

Power Bank

A Power Bank of 10,000 mAh is a portable battery pack used to power the Raspberry Pi 4B. It provides a reliable and long-lasting power source, allowing the Raspberry Pi to operate for several hours. The power bank's high capacity ensures that the Raspberry Pi remains powered even during periods of high usage. This makes it ideal for projects that require mobility and continuous operation.

SD Card

A 16 GB Class 10 SD Card is a high-speed storage device used to boot and store the operating system, programs, and data for the Raspberry Pi 4B. The Class 10 rating ensures fast read and write speeds, allowing for smooth performance and efficient data transfer. This SD card provides ample storage for the Raspberry Pi's operating system, programs, and data. It is a reliable and efficient storage solution for Raspberry Pi projects.

OPERATING SYSTEM AND SOFTWARE CONFIGURATION

The Care taker Bot is powered by the Raspberry Pi OS, a Debian-based operating system specifically optimized for Raspberry Pi hardware. This OS provides a stable and efficient platform for running Python scripts, managing hardware components and ensuring seamless communication between the bot and the mobile application. The installation of Raspberry Pi OS begins by downloading the official image and flashing it onto a microSD card using tools like Balena Etcher. Once the microSD card is inserted into the Raspberry Pi 4B and powered on, the installation process is completed through a guided setup. This step is crucial in preparing the bot’s core system, enabling it to execute AI-based voice interactions, task reminders, and mobile notifications effectively [4].

Since Python serves as the primary programming language for controlling the Caretaker Bot’s hardware and software functionalities, a dedicated Python environment must be set up. The first step in this process is to update the system’s package list using the command sudo apt-get update, ensuring that the latest software repositories and dependencies are available [5]. Next, Python 3 is installed using sudo apt-get install python3, as it is required for executing scripts that handle voice processing, GPIO-based hardware control, and data synchronization with the mobile app. Additionally, essential Python libraries such as gpiozero and serial are installed using sudo apt-get install python3-gpiozero python3-serial. These libraries enable for bot to interface with physical components, such as reading input from push buttons, controlling the speaker, managing the SD module for notifications, and logging daily tasks in the mobile App.

By configuring the Raspberry Pi OS and setting up the Python environment, the Caretaker Bot is equipped to perform its core functions, including emotional voice interactions, daily task reminders,

and real-time data logging. The optimized software setup ensures smooth execution, reliability, and flexibility, making the bot an effective and intelligent companion for elderly individuals.

The Raspberry Pi 4B runs on Raspberry Pi OS, a Debian-based operating system optimized for the Raspberry Pi hardware. The following steps outline the software configuration:

- *Step 1: Visit the official Raspberry Pi website*
  - Open a web browser and navigate to the official Raspberry Pi website:
- *Step 2: Click on downloads*
  - Click on the "Downloads" tab on the top navigation bar.
- *Step 3: Select Raspbian OS*
  - Click on the "Raspbian" tab.
  - Select the latest version of Raspbian OS.
- *Step 4: Choose the correct version:* Select the correct version of Raspbian OS for your Raspberry Pi 4B:
  - Raspbian Buster with desktop and recommended software.
  - Raspbian Buster with desktop.
  - Raspbian Buster Lite (command-line only).
- *Step 5: Download the OS image*
  - Click on the "Download ZIP" button to download the Raspbian OS image.
  - Wait for the download to complete.
- *Step 6: Verify the download*
  - Verify the integrity of the downloaded file by checking the SHA-256 checksum.
- *Step 7: Extract the OS image*
  - Extract the Raspbian OS image from the downloaded ZIP file using a file archiver like WinRAR or 7-Zip.
- *Step 8: Write the OS image to an SD card*
  - Use a tool like Etcher or Win32 Disk Imager to write the Raspbian OS image to an SD card.
  - Insert the SD card into your Raspberry Pi 4B.
- *Step 9: Boot up your Raspberry Pi 4B*
  - Connect your Raspberry Pi 4B to a power source and boot it up.
  - Follow the on-screen instructions to complete the installation process.

Python Sudo Commands

1. pygame: sudo pip install pygame.
2. RPi.GPIO: sudo pip install RPi.GPIO.
3. Time: time is a built-in Python module, so you do not need to install it.
   Note: If you are using Python 3, you can use pip3 instead of pip:
   a. pygame: sudo pip3 install pygame.
   b. RPi.GPIO: sudo pip3 install RPi.GPIO.

PROPOSED SOLUTION

The Caretaker Bot is a helpful device designed to support elderly individuals by offering emotional companionship, daily reminders, and a connection to a mobile app for monitoring their well-being. As more elderly people live alone or need assistance, this both helps by providing voice-based interactions and reminders for important tasks. It combines hardware and software to make it easy to use, interactive, and capable of real-time communication.

The heart of the bot is the Raspberry Pi 4B, a small but powerful computer that controls different components such as a speaker, microphone, button interface, and a SD card module for mobile connectivity. The bot runs on a portable power bank, so it does not need to be plugged in all the time. Python programming is used to make the bot talk and respond to users, creating a friendly and engaging

experience. It also helps users stay on track with daily activities like taking medication, drinking water, and exercising [6].

The bot listens through a microphone and responds through a speaker, making conversations feel natural. A mobile app logs daily activities, so caregivers or family members can check on their loved ones remotely. The SD card module allows the bot to send SMS or notifications, even if there is no Wi-Fi at home.

The bot is lightweight and rechargeable, making it easy to carry and use throughout the day. It also has a button interface, so users can manually interact with it when needed, which is useful for those who may have difficulty with voice commands.

Overall, this smart companion improves the quality of life for elderly individuals by providing emotional support, helpful reminders, and an easy way to stay connected with caretakers, ensuring their health, safety, and well-being.

BLOCK DIAGRAM

The block diagram represents the hardware architecture of the care taker bot, a device designed to assist elderly individuals by providing emotional support, reminders for daily tasks, and data logging via a mobile app (Figure 2). The system is built around the Raspberry Pi 4B, which serves as the central processing unit for controlling various components [7].

Power Supply

The power supply is the primary source of energy for the Raspberry Pi 4B. Since the caretaker bot is designed for continuous operation, it requires a stable 5 V/3 A power source, which can be provided using a power bank or an adapter. A rechargeable battery can also be used to ensure portability and uninterrupted functioning. The power supply ensures that all connected modules receive the necessary voltage to function properly.

Raspberry Pi 4B (Central Processing Unit)

The Raspberry Pi 4B is the core component of the care taker bot. It is a powerful, compact single-board computer that processes input from sensors, button, and a microphone while controlling output devices such as a speaker, buzzer, and mobile notifications. The Raspberry Pi 4B has multiple GPIO (General Purpose Input/Output) pins that allow integration with various external devices. It runs on Raspberry Pi OS (Linux-based), which facilitates the execution of Python scripts to process commands, interact with sensors, and handle voice interactions.

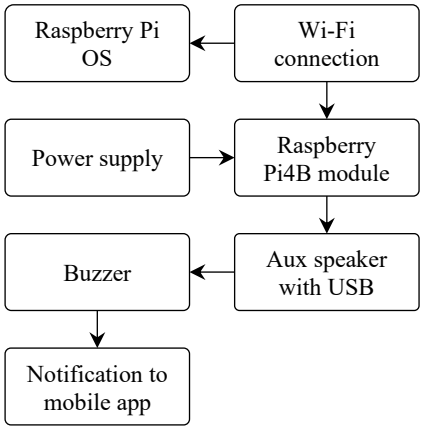

Figure 2. Block diagram.

SD Card (Storage and Operating System)

The SD card acts as the primary storage device for the Raspberry Pi 4B. It contains the Raspberry Pi OS, application scripts, recorded voice messages, and data logs relates to the elderly person's daily activities. The SD card ensures that the device can boot up properly and execute necessary programs without requiring external storage.

Speaker (Audio Output for Emotional Interaction)

The speaker is an essential part of the care taker bot, as it provides voice-based emotional support to the elderly user. The bot can play pre-recorded messages, generate real-time responses, and use Text-to-speech (TTS) functionality to communicate. Emotional support is achieved through human-like voice interactions, ensuring that the elderly feel less isolated and more engaged in conversations. The speaker is controlled by the Raspberry Pi through audio output connections.

Buzzer (Alert System for Notifications)

The buzzer is used to generate alert sound for important notifications such as medication reminder, emergency alerts, and task completion confirmations. The caretaker bot triggers the buzzer whenever a scheduled reminder is due, ensuring that the elderly user is aware of the notification even if they are not actively using the bot. This feature enhances safety and adherence to daily routines.

Wi-Fi Module

The Wi-fi module enables the Raspberry Pi 4B to connect to the internet and a mobile application. This connectivity allows the bot to send data logs, receive remote commands, and interact with cloud-based services. The internet connection is crucial for real-time updates, it allows the bot to send data logs, receive remote commands, and interact with cloud-based services.

Raspberry Pi OS (Operating System for Bot Control)

Raspberry Pi OS is the main software environment where all system operations are executed. It provides support for Python-based automation, voice recognition, and artificial intelligence applications. The OS manages background tasks such as data logging, communication with the mobile app, and voice interaction execution. With Raspberry Pi OS, developers can customize the bot's behavior and integrate additional features over time.

Mobile App

The mobile application serves as a bridge between the caretaker bot and caregivers or family members. The app receives real-time notifications, logs daily activities, and provides a user-friendly dashboard to check reminders, medical history, and emotional interaction statistics.

CIRCUIT DIAGRAM

The hardware setup for the Caretaker Bot consists of essential components that enable its functionality, including a Raspberry Pi 4B, a portable power bank, and a laptop for programming (Figure 3). The Raspberry Pi 4B acts as the central processing unit of the bot, equipped with a quad-core Cortex-A72 processor, multiple USB ports, an HDMI port, an Ethernet port, and 40 GPIO pins for connecting external buttons [8].

Algorithm

The caretaker bot is designed to provide emotional support to elderly individuals through voice-based interaction while ensuring continuous monitoring of their well-being. The algorithm starts by initializing key libraries, such as Pygame for handling audio playback and GPIO (General Purpose Input/Output) for managing hardware interactions (Figure 4). When powered on, the system loads pre-recorded voice messages that offer comfort and companionship. These messages are played through a speaker connected to Raspberry Pi 4B, creating a soothing and engaging experience for the user.

Figure 3. Circuit diagram.

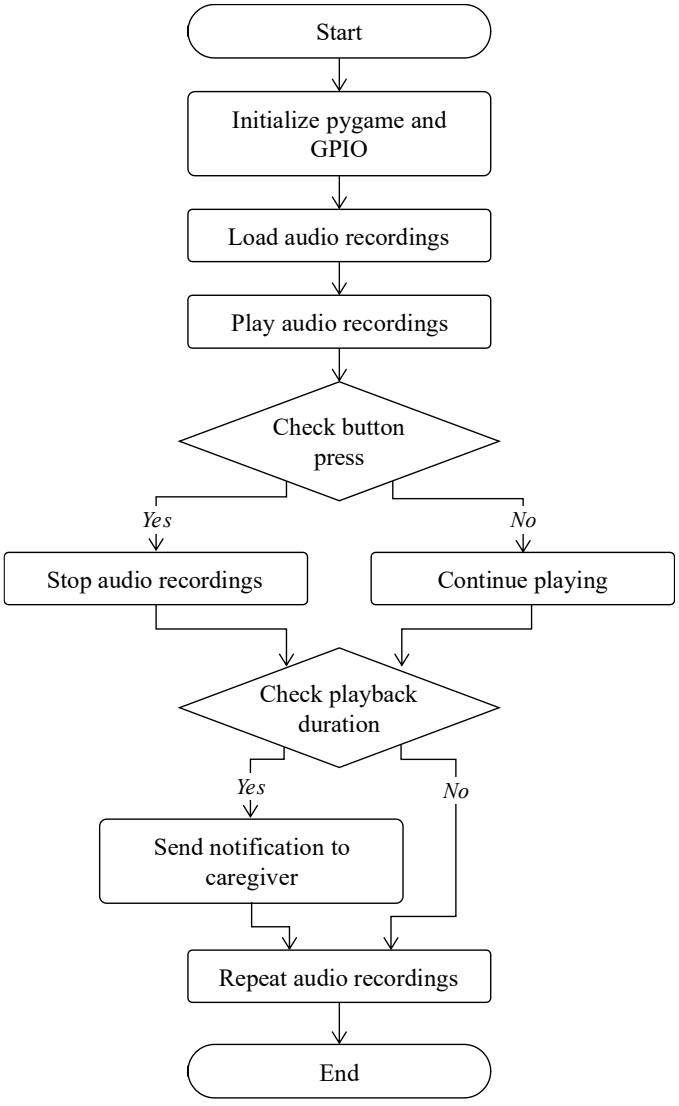

Figure 4. Algorithm for bot.

The algorithm governing the Emotional Touch Caretaker Bot's audio interaction system is designed to manage voice-based communication, user input handling, and caregiver notifications. The process begins by initializing essential software and hardware components:

Pygame (a Python library for multimedia applications) is activated to handle audio playback, while the GPIO (General Purpose Input/Output) pins of the Raspberry Pi are configured to interface with external hardware, such as the tactile button [9]. Once initialized, pre-recorded audio files stored for tasks like emotional voice responses, reminders, or instructions are loaded into memory. The bot then enters a loop to play the audio recordings, which may include daily task reminders or comforting messages tailored for elderly users. During playback, the system continuously monitors for button presses via the GPIO-connected button. If the button is pressed (e.g., to acknowledge task completion or request assistance), the current audio playback is immediately halted, and the system proceeds to the next step. If no button press is detected, the audio continues playing until its full duration is reached.

After playback concludes or is interrupted, the algorithm checks whether the playback duration met the predefined threshold (e.g., the audio played completely without interruption). If the duration criterion is satisfied, a notification is sent to the caretaker's mobile app via the SIM card module, confirming task adherence or signaling the need for follow-up. If the duration is not met (e.g., the audio was stopped prematurely), the system repeats the audio recordings to ensure the user receives the message, creating a loop until the interaction is resolved [10].

This cycle continues until the user or caregiver terminates the process, ensuring persistent support and real-time updates. The algorithm prioritizes user interaction by allowing immediate input via the button while maintaining seamless communication with care takers through automated notifications, thereby balancing emotional engagement with functional reliability.

FUTURE SCOPES

- *Connecting with smart devices:* The Caretaker Bot can work with smartwatches or fitness trackers to check the elderly person's health, like heart rate and movement, and give real-time updates.
- *Medication reminders:* The bot can remind the elderly person to take their medicine on time and keep track of whether they follow their schedule.
- *Fall detection and safety:* The bot can detect if the elderly person has fallen and quickly send an alert to caregivers or emergency services for help.
- *Staying connected:* The bot can help the elderly person make video calls or send messages to family and friends, reducing loneliness and making them feel more connected.
- *Health tracking and reports:* The bot can use sensors to check health signs like blood pressure, blood sugar, and weight. It can also provide reports and insights to caregivers.
- *Talking with the bot:* The bot can understand and respond to voice commands, making it easy for elderly users to interact with it.
- *Smart learning and predictions:* The bot can learn from the elderly person's habits and health data to detect unusual changes and give personalized advice.
- *Smart home connection:* The bot can work with smart home devices like lights, thermostats, and security systems to make the home safer and more comfortable.
- *Online doctor visits:* The bot can connect with telehealth services, allowing healthcare professionals to monitor the elderly person and provide remote consultations.
- *Use in more places:* The bot can be used in nursing homes, assisted living facilities, and home care settings, making it helpful for more people.

CONCLUSION

The Caretaker Bot is an innovative solution designed to provide emotional support and care to elderly individuals. Equipped with a Raspberry Pi 4B module, speaker, and mobile app connection, the bot can

play audio recordings that provide daily task reminders, medicine schedule instructions, and emotional support. The bot's ability to interact with elderly individuals in a human-like voice has the potential to improve their quality of life and reduce feelings of loneliness and isolation.

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