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REFLECT AI: A SMART MIRROR

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Abstract

This project shows how Artificial Intelligence (AI) and the Internet of Things (IoT) are transforming today's digital era by the way we interact with technology. Reflect AI is a lucrative smart mirror that acts as a personalized assistant, giving real-time information through voice commands. Built using a Raspberry Pi, a two-way mirror, HDMI monitor with Python using a Generative AI API key, creates a smooth, hands-free experience that optimizes accessibility. Reflect AI offers functionalities like weather updates, temperature, and news, which dynamically render output, making it an ideal tool for time efficiency. This project aims to narrow the gap between technology and traditional uses by putting an end to physical interaction, boosting readiness, and smart home integration.

Keywords:

Smart Mirror, Lucrative, Personalized assistant, Raspberry Pi, Generative AI API key, Home integration

INTRODUCTION:

In today's high-speed modern era, smart technologies are becoming a crucial part of everyday life, considerably shaping the way we interact with both electronic systems and physical world. These advancements are in a wide range of devices which helps us to be connected, well-informed and productive smoothly. In these environments, people are in the need of tools that are smarter and that don't interrupt their routine. One such most advanced technology is smart mirror, which provides traditional use and interactive digital displays. Unlike traditional mirrors, smart mirrors enable users to get weather updates, time, date, and real-time information by providing a hands-free, comfortable user experience. Embedding a traditional mirror with a digital interface allows users to access and interact with technology without relying on physical touch.

Smart mirrors are built with a mix of advanced technologies like Artificial Intelligence (AI) and Internet of Things (IoT), which helps the mirror to be more high-functioning and responsive to user's demands. Smart mirrors are becoming progressively popular ranging from homes to workplaces, gyms, making everyday tasks easier and speedier. These are more efficient to provide personalized information too. They are not just about showing information; they enhance the overall user experience by providing a more natural and engaging way to interact with technology. Through voice recognition and natural language processing, these mirrors can deliver relevant updates, offer helpful reminders, and even help users with tasks, all while maintaining a streamlined, modern design. As the technology continues to improve, smart mirrors are becoming an important feature of modern homes and businesses, offering a glimpse into the future of personalized, interactive technology that blends into our daily lives effortlessly.

LITERATURE SURVEY:

Dr. C.K. Gomathy, Mr. R. Venkata Narayana, and Mr. T. Giridhar Reddy suggested a Raspberry Pi-based Smart Mirror driven by IoT in 2021. Though it had constraints in scalability and future feature expansion, their system used IoT technology to deliver basic information via a mirror interface [1]. In the same year, Bharath M, Vinayak G S, Harshith K, Undavalli RaviKiran, and Prof. Ravi Kumar MG designed and developed a Smart Mirror using IoT, though lacking sophisticated artificial intelligence integration and supporting only basic interactions like voice and proximity-based responses, their model sought to provide real-time information and interaction using Raspberry Pi and sensors [2]. Targeting modular information display, Suman Mallick, Tejpal Singh, and Soumik Podder created an IoT-based Smart Mirror in 2023 using a Raspberry Pi coded in Python. The lack of performance metrics, inadequate privacy policies, customization problems, and budgetary restrictions, among other things, limited the project [3]. Abdul Hafeez, Arati Chougale, Nikhil Chitte, and Aparna Shinde also built a Smart Mirror running Raspbian OS and JavaScript in 2024 using a Raspberry Pi. Although efficient in function, this design was costly because of the hardware involved and was mostly appropriate for tech-savvy consumers, which presented market scalability problems [4]. Focusing on educational and institutional settings, D. Hardiyanto et al. (2019) built a smart mirror using Raspberry Pi to operate as a laboratory information system. Though efficient for controlled settings, its use was restricted in adaptability for home users [5]. Using Raspberry Pi with IoT, Sneha et al. (2022) created a multi-function digital mirror offering news, weather, and calendar among other features. Though functional, the system had real-time responsiveness and power economy constraints [6]. Uddin et al. (2021) suggested MirrorME, a smart mirror based on IoT with facial recognition and individualised recommendation algorithms. Although creative, the system needed significant computing power and had no real-world deployment testing [7]. Using a multitasking strategy with Raspberry Pi to control digital display capabilities, Nwokoye et al. (2022) presented an interactive smart mirror system. Its voice command features and personalisation, though, were lacking [8].

HARDWARE AND SOFTWARE REQUIREMENTS:

A. Hardware Components:

Raspberry Pi:

Raspberry Pi is the primary component used in the smart mirror for controlling the display and interacting with the internet to provide user-specific information on the monitor. It is a microprocessor-based minicomputer (SBC) that runs code with a fully functional operating system called Raspberry Pi OS (previously known as Raspbian OS). The Python programming language was used to write the code, which also enables the monitor to show current data like the temperature, time, and date. It acts as the central processing unit, which takes the help of a Generative AI API key to fetch the data from the internet. The Raspberry Pi module has a Wi-Fi module to connect to the internet to accomplish this. Voice recognition is achieved through a microphone connected via USB port to a Raspberry Pi. This arrangement allows the user to give voice input to the smart mirror to set up timely conversations.

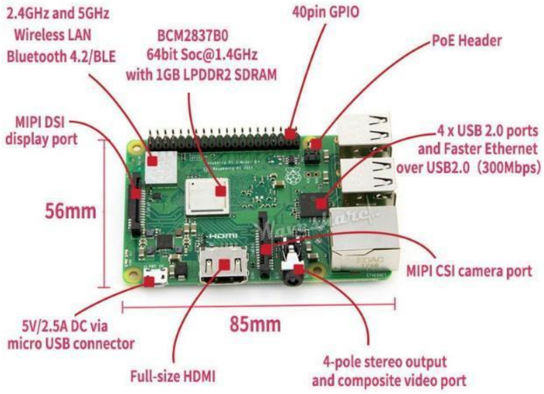

Fig.1: Raspberry Pi

Microphone:

In a Raspberry Pi-based smart mirror, a microphone is typically connected to the Raspberry Pi via a USB connection. It is used to give voice input to the mirror. The system operates with great robustness and dependability thanks to voice input.Voice captured will be used by the Raspberry Pi to interact with various services and applications by accessing the Generative AI API.

Fig2.USB microphone

HDMI Cable:

In a smart mirror, the HDMI cable is used to transmit an audio signal from the Raspberry Pi to the monitor. It is a key connector for displaying real-time information on the monitor.

Fig3.HDMI cable

Micro SD Card:

SD card is used as the storage medium for the operating system (Raspbian) and software applications running on the Raspberry Pi. It contains the necessary software, configurations, and any additional applications or scripts required for the smart mirror functionality. It is physically connected to the Raspberry Pi via a microSD card slot on the bottom of the device.

Fig.4: SD card

Two-way mirror:

In a smart mirror setup, a two-way mirror is a reflective surface that looks like a regular mirror. But it allows light to pass through on one side, which is transparent, and we will see our reflection on the other side. The transparency of the mirror is achieved through a principle called half-silvering or semi-transparent coating, applied to one side of the glass. In a smart mirror, this not only functions as a traditional mirror but also displays digital information. Thus, it flawlessly integrates into the environment, providing both elegance and practicality.

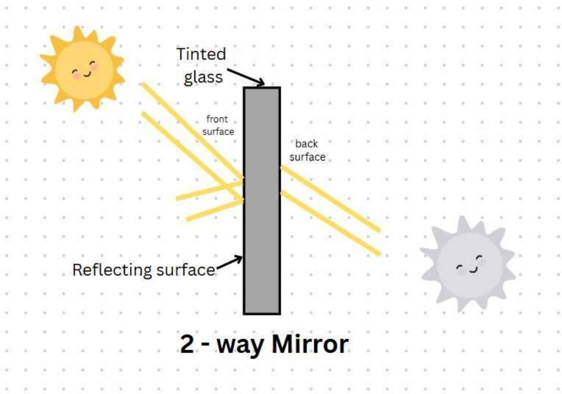

Fig.5: A two-way mirror

Monitor Display (HDMI-compatible):

In a smart mirror, an HDMI-compatible monitor is placed behind the two-way mirror and connected to a Raspberry Pi using an HDMI cable.

Power Supply:

In a smart mirror, a power supply is the source of electric current to power the components. Generally, it is a 5V 2.5A DC adapter or higher, which is plugged into a wall outlet and then into the Raspberry Pi. It helps the Raspberry Pi to function, connect to the display (via HDMI), and communicate (via Wi-Fi).

B. Software Components:

Operating System:

The official operating system for Raspberry Pi computers is Raspberry Pi OS, formerly known as Raspbian. It is based on Debian. It is pre-installed for the Raspberry Pi on a microSD card, which is then inserted into the Pi to boot the OS.

Python 3.x:

The coding language used to display real-time information in this paper is Python of version 3.0 or higher. It is primarily used for developing the software system that drives their functionality, which includes accessing external real-time information through APIs, managing the various modules and features of the mirror.

Voice Processing Libraries:

The voice processing library SpeechRecognition is used in this paper.

- **PyAudio:** It is used to capture audio input from a microphone, allowing voice commands. A speech recognition engine receives the audio.
- **Speech Recognition:** It works with the help of a microphone to capture audio input, which is then processed by a speech recognition engine (Generative AI) to convert it into text. This text is analyzed and performs corresponding actions (display real-time information).

Display:

In a smart mirror, Pygame is used as a graphical interface for providing visuals as time, date, weather updates, or real-time information on a screen. It is used to create a full-screen window by drawing this data using fonts, images, and custom layouts. It listens and responds accordingly to every event, exhibiting an engaging and functional smart mirror interface.

AI integration:

The OpenWeatherMap and Google Generative AI API keys are used in this paper. Google Generative AI API Key functions voice-based interaction, enabling the smart mirror to answer all the queries using AI-generated responses. The OpenWeatherMap API Key is used to get the real-time weather updates and display them on the screen.

I. DESIGN AND IMPLEMENTATION:

System Architecture:

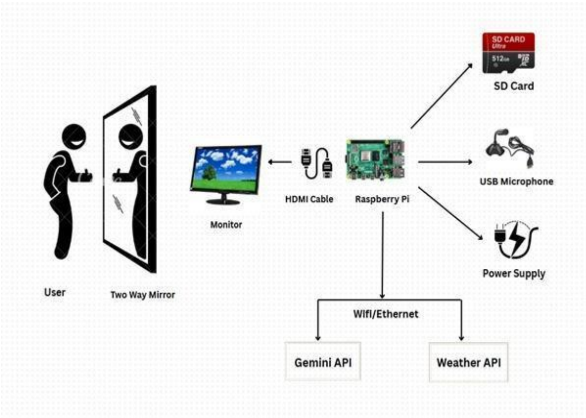

Fig.6: System Architecture

Implementation:

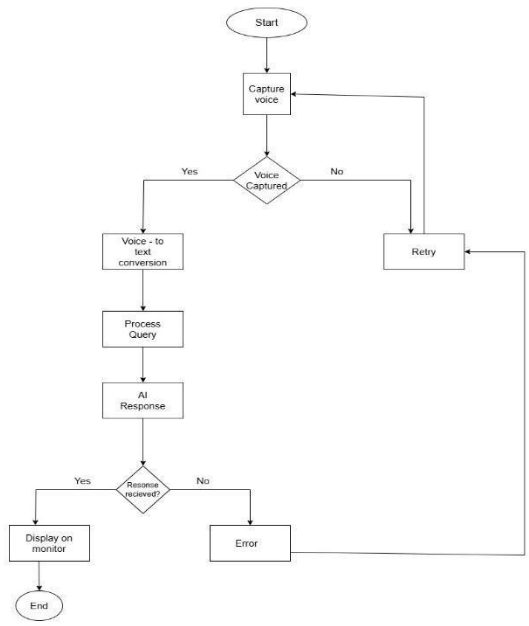

Fig. 7: Flowchart

Smart mirror runs some modules like voice input, AI query, and display.

The Reflect AI system is operated by a Raspberry Pi, typically a Raspberry Pi 3 Model B, which acts as the central processing unit for the smart mirror. The Raspberry Pi runs on Raspbian (Raspberry Pi OS), which is installed on a microSD card (preferably 32GB or higher, Class 10). This SD card contains the Raspbian OS along with the Reflect AI software, including Python scripts and necessary libraries. When the system boots up, it loads the API key from a file (api_key.txt). This key is required for accessing the Google Generative AI API, and if it's missing, the system shuts down to prevent unauthorized or failed API calls.

For audio input, a USB microphone is connected to one of the Raspberry Pi's USB ports. This microphone captures the user's voice and streams it through the speech recognition pipeline. The speech_recognition library handles ambient noise adjustment and sends the audio to Google's Speech-to-Text service. The recognized text is then forwarded to the Google Generative AI API, which processes the query and returns back the response. This response is made brief using a custom function and then displayed visually.

The visual feature of the smart mirror is handled using a monitor or display screen connected to the Raspberry Pi via an HDMI cable. The display is set to full-screen using the Pygame library, which also manages font rendering and screen updates. Behind a two-way mirror, which is placed in front of the display, users can see both their reflection and the digital information displayed on the screen. The mirror allows light from the display to pass through while still reflecting ambient light, creating the illusion of text floating on the mirror surface.

Weather information is fetched using the OpenWeatherMap API. The script includes a dedicated function that sends an HTTP request to the API with the specified city name and retrieves the current temperature. This weather data, along with the current date and time, is constantly displayed in the top-right corner of the screen for easy viewing.

Power for the entire setup is supplied through a 5V/2.5 A DC adapter connected to the Raspberry Pi. Some displays may require their own power source or may be powered via USB from the Raspberry Pi if they have low power requirements. All these components are mounted within a frame or enclosure, with the display screen placed directly behind the two-way mirror. The HDMI cable ensures high-quality video output from the Raspberry Pi to the display, completing the visual pipeline.

The system operates in a cycle, listening for voice commands, generating responses, and updating the display accordingly. After each interaction, there is a 60-second delay allowing the user to read the response before the next listening session begins.

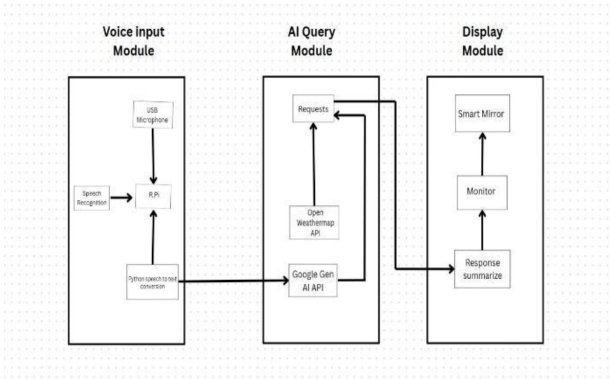

Fig.8: Module Split-up

Date and Time: Date and time are constantly displayed on the top right of the screen using the datetime module from Python's standard library. The datetime.datetime.now() function retrieves the current system date and time from the Raspberry Pi. The .strftime() method converts the date and time into formatted strings (e.g., 15 May 2025 for date and 15:23:04 for time). These formatted strings are then displayed on the smart mirror, updating in real time.

Temperature: Temperature is constantly displayed on the top right of the smart mirror using the OpenWeatherMap API. The Python script sends an HTTP request to the API using the API key and the city name. This API returns real-time weather data, through the current temperature is extracted by the script. The script updates the data at regular intervals to keep it**.**

Real-time information: The user, whenever required, asks the query through voice, which is captured by a microphone, converted to text using speech recognition powered by Generative AI. This text is sent to the Google Generative AI API, which analyses and returns an AI-generated response. This response is displayed on the monitor through an HDMI-connected monitor.

Algorithm:

Step1: Start

- The process begins.

Step 2: Capture Voice

- The system tries to capture the user's voice input (microphone).

Step 3: Check if the voice is captured

- If yes, go to the next step (step 4).
- If No retry (goes to step 9).

Step4: Voice-To-Text Conversion

- If voice is captured, then it is converted into text.

Step 5: Process Query

- The system processes the text to understand the user query.

Step 6: AI Response

- The system generates the response using AI.

Step 7: Check if Response Received

- If yes, go to the next step (step 8).
- If No Error (goes to step 10).

Step 8: Display on the monitor

- If the response is received, it is displayed on the monitor.

Step 9: Retry (if voice is not captured)

- The system retries to capture the voice and continues from step 2.

Step 10: Error (if no response received)

- If an error occurs, it goes back to step 2 to try again.

Step11: End

- The process ends after displaying the response

II. RESULTS:

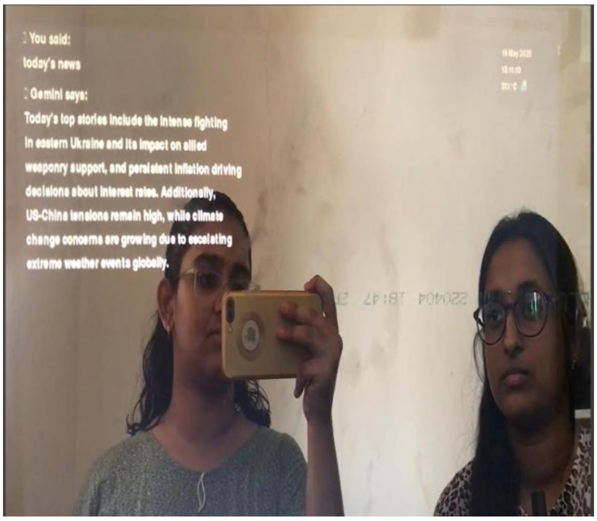

Fig.9: Query displayed on the two-way mirror. Fig. 10: Gemini's response on the mirror display

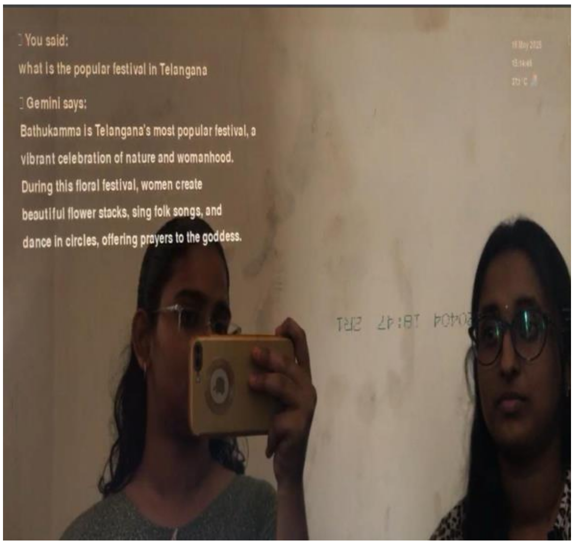

Fig.11: Query displayed on the two-way mirror

VI. CONCLUSION:

We have shown that the Reflect AI system has successfully demonstrated the integration of hardware and software to create a responsive, hands-free, and intelligent user interface that seamlessly enhances frequent conversations. With a Raspberry Pi as its main processor, along with peripherals like a USB microphone, an HDMI-compatible monitor, and a two-way mirror, the system turns a traditional mirror into a smart assistant capable of comprehending and responding to natural human speech. Real-time AI responses through Gemini API, speech recognition, weather updates through OpenWeather API, and a visually embedded display are the key features that have truly pulled off a smooth, non-intrusive user experience. Testing, like unit, integration, and acceptance phases, confirmed the system’s reliability in diverse conditions. Our system stands as a successful blend of AI and IoT, offering a responsive, affordable solution, setting the stage for future breakthroughs in system automations and new technologies.

FUTURE SCOPE:

Smart mirrors are known for their enriched user experience by displaying real-time information and interactive conversations, all from a traditional use to smart applications. These are flexible to integrate with large systems for home automation, personal assistant, a part of exchange of information. This paper primarily focuses on voice-based interaction to fetch user-specific information with ease. Features like date, time, weather updates, and up-to-date information by AI integration can be displayed on a two-way mirror. As for future work, the system can be made multilingual, with customized user profiles for personalized interactions. Implementing gesture recognition would have more potential as an alternative control method and can be advanced by incorporating visual try-ons. This smart mirror can be made more accessible and popular by adding an offline mode

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