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AI-Enhanced Smart Mirror for Real-Time Weather, Time, And Personalized User Interaction

Krishna Prasath V.T.[1],Sagar KumarC.[2],Uday KiranR.[3],Pavan Kalyan B.[4]
[1] Associative Professor, [2-4] UG Students, Department of Artificial Intelligence and Data Science,NehruInstituteofEngineeringandTechnology,AnnaUniversity, Coimbatore,TamilNadu,India.

E-mail:[1]nietkrishnaprasath@nehrucolleges.com,[2]sagarkumarchinnakotla0@gmail.com,[3]rayadurgamudaykiran@gmail.com,[4]bandipavnkalyan@gmail.com

ABSTRACT

The Smart Mirror project is a novel application of embedded systems, artificial intelligence, and IoT, aimed at integrating daily utility with cutting-edge technology. Built using a Raspberry Pi and a two-way mirror, this system transforms an ordinary mirror into a multifunctional digital assistant. Behind the reflective surface lies a display that seamlessly overlays information and interactive features without compromising the mirror's primary function. the mirror incorporates face recognition to identify users and personalize the displayed content based on user profiles. It utilizes emotion detection through facial expression analysis to trigger emotion-based audio playback, enhancing user interaction and creating a responsive environment. Additionally, the system is IoT-enabled, allowing it to fetch real-time data such as conferences, news. one of the standout features is the integration of an interactive ChatGPT assistant, providing users with a conversational interface for information retrieval, or general queries. It also includes the display of essential utilities like current date and time. The Smart Mirror exemplifies the fusion of AI, IoT, and user-centric design, offering a futuristic yet practical solution for smart homes and personal spaces. It not only enhances functionality but also creates a highly personalized and interactive experience for the user.

Keywords: Embedded systems, Raspberry-Pi, Smart two-way mirror, Operating system,AI, IoT.

1. INTRODUCTION

In the modern era of rapid technological advancement, the integration of intelligent systems into everyday objects has become increasingly common. As smart homes and connected devices redefine convenience and personalization, the concept of a Smart Mirror emerges as a compelling innovation that blends functionality with advanced technology. This project presents the development of a Smart Mirror using a Raspberry Pi and a two-way mirror, designed to function both as a conventional reflective surface and as a personalized digital interface. At the heart of the system is a Raspberry Pi, which powers a display positioned behind the mirror to show real-time content without disrupting its reflective purpose. The Smart Mirror is equipped with a variety of intelligent features, including facial recognition, which allows the system to identify individual users and present personalized content tailored to their preferences. Additionally, it employs emotion detection algorithms to analyse facial expressions and play mood-based audio, enhancing user interaction in a non-intrusive and emotionally aware manner. The mirror also connects to the internet to fetch real-time information such as weather updates, calendar events, and news headlines using IoT-based services. A standout feature is the integration of a ChatGPT-powered conversational assistant, enabling users to interact with the system through natural language, ask questions, get reminders, or simply engage in casual dialogue. This not only increases the system's utility but also introduces a level of interactivity that is intuitive and user-friendly. The Smart Mirror continuously displays essential information such as the current date and time, ensuring that even in passive mode, it remains a valuable tool in daily life. The system is designed with modular software architecture, allowing efficient communication between the input (camera and microphone), processing (facial recognition, emotion analysis, and AI interaction), and output (display and speaker) components. The choice of Raspberry Pi as the core computing platform ensures that the system remains cost-effective, compact, and accessible for further development or customization. In terms of real-world applications, this Smart Mirror can serve not only in residential settings but also in commercial environments such as retail stores, fitness studios, and hotels where personalized, real-time content can enhance user engagement. While developing the system, several challenges were addressed, such as ensuring real-time processing on limited hardware, maintaining user privacy, and achieving reliable facial and emotion recognition under varying lighting conditions. These challenges were met through optimized code, lightweight models, and privacy-focused data handling practices. Ultimately, the Smart Mirror exemplifies how AI, IoT, and embedded systems can converge to create an intelligent, adaptive, and aesthetically pleasing interface that supports modern lifestyles. It stands as a testament to how everyday objects can be transformed into multifunctional, interactive tools that not only enhance utility but also deliver a highly personalized and immersive experience to users.

1.1 OBJECTIVES

- Provide quick and easy access to essential information.
- Tailor the experience to individual preferences and needs.
- Enable seamless user interaction through AI-powered voice commands.
- Effortlessly integrate with existing smart home ecosystems.

2. LITERATUREREVIEW

- The concept of smart mirrors has gained traction in recent years as researchers explore the intersection of embedded systems, artificial intelligence, and human-computer interaction. In the study by Singh et al. (2019), a smart mirror was developed using a Raspberry Pi and an LCD screen behind a two-way mirror to display weather and calendar updates. Their work focused on basic IoT functionality, laying the groundwork for integrating real-time data services in reflective interfaces.

- Similarly, Kumar and Gupta (2020) explored the use of Android-based APIs for updating mirror displays with weather and news feeds, although their system lacked personalization or AI-based interaction.
- Another notable project by Ramesh et al. (2021) incorporated voice commands using Google Assistant, offering limited user engagement but demonstrating the potential of voice-controlled interfaces in smart environments.
- Facial recognition as a feature was examined in the work of Zhao and Zhang (2018), who used OpenCV and Haar cascades for user authentication. Their study confirmed the viability of deploying lightweight face detection algorithms on Raspberry Pi with acceptable accuracy.
- Extending this idea, Patel et al. (2021) implemented a personalized smart mirror system that adapted content based on detected users, showcasing a practical application of face recognition for content filtering. However, these systems did not explore user emotion, which limits the depth of human-computer interaction.
- Emotion detection in human-computer systems was explored by Sharma et al. (2019), who utilized convolutional neural networks (CNNs) trained on the FER-2013 dataset to classify facial emotions. Although their system was not integrated into a smart mirror, it demonstrated real-time feasibility on embedded platforms. Likewise, Akhtar and Malik (2020) presented an emotion-aware system that altered music playback based on user sentiment, a concept highly relevant to enhancing user experience in interactive mirrors.
- IoT integration is another critical aspect, as demonstrated by Das and Roy (2020), who created a home automation system that displays and controls connected devices through a centralized interface. Their findings underline the importance of modular IoT design, which aligns with the proposed smart mirror's structure for real-time content updates. In another effort, Lee and Kim (2022) developed a smart mirror capable of displaying medical reminders and health data from wearable devices, pointing to future healthcare applications and reinforcing the need for seamless connectivity and user-specific interaction.
- Finally, AI-powered assistants were examined by Banerjee et al. (2022), who integrated a chatbot into a smart mirror to enable conversational interaction. Though limited in context understanding, their study demonstrated the benefit of combining natural language processing with reflective interfaces. More advanced dialogue systems like ChatGPT, which offer contextual and dynamic conversation, were not used in their study, highlighting the novelty of integrating large language models into smart mirrors as done in the present project.

Thedisadvantages of theexistingmethods:

- Lack of Personalization
- Limited Interaction
- No Emotional Intelligence
- Dependency on Multiple Devices
- High Cost of Commercial Smart Mirrors

- Minimal AI Integration

Toovercomethelack user interaction system,weshouldkeep developingstatic mirror into dynamic mirror.

3. PROPOSEDWORK

The proposed Smart Mirror system is a highly interactive, AI-integrated device built using a Raspberry Pi and a two-way mirror with a display behind it. It recognizes the user's face to display content, detects emotional states to play mood-based music, and connects to the internet to fetch real-time data like weather, news, and calendar events. A major enhancement is the integration of a conversational ChatGPT assistant, allowing natural language interaction through voice or text. The system is designed to be modular, cost-effective, andhighly customizable. It includes camera input for facial and emotion detection, audio output for feedback or music, and a clean, dynamic interface that overlays information without disrupting the mirror's reflective function. It also continuously displays the date and time for passive utility.

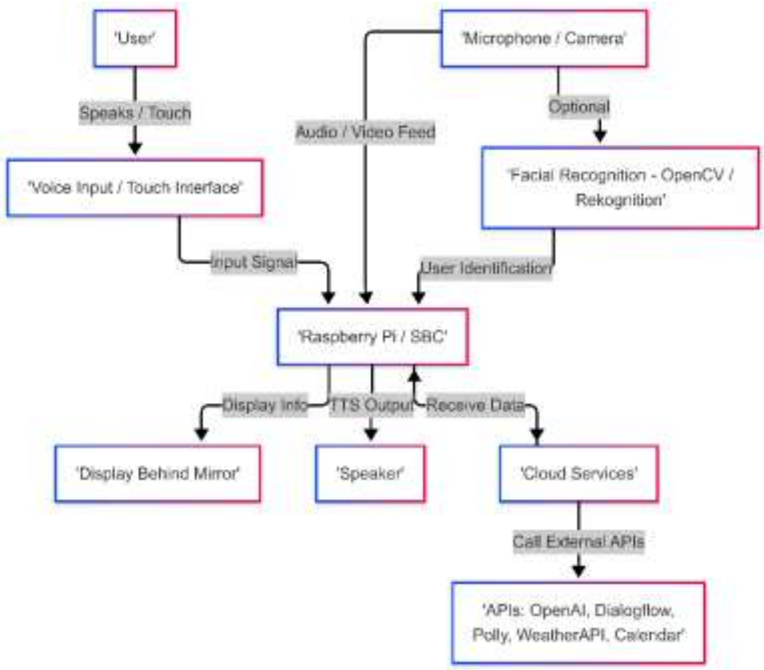


Fig1. BlockDiagram

Component	Specification	Recommended Model/Make
One-way Mirror	Acrylic or Glass, 50% reflective, 50% transparent	Acrylic Two-Way Mirror Sheet (12"x24")
Monitor/Display	Full HD or higher, 21"-27" recommended, slim bezel	Dell 24-inch Monitor (P2419H), LG 24MK400H
Microcontroller / SBC	Quad-core, 2GB+ RAM, GPIO support	Raspberry Pi 4 (4GB/8GB)
AI Assistant	Cloud-based AI assistant integration	Google Assistant, Amazon Alexa, OpenAI GPT (via API)

Camera (Optional)	HD Webcam with USB or Pi Camera, for face recognition	Logitech C270, Raspberry Pi Camera Module V2
Microphone	Far-field microphone or USB mic	Re-Speaker USB Mic Array, Samson Go Mic
Speaker	Compact with good sound clarity	Creative Pebble 2.0, JBL GO 3
Touch Layer (Optional)	Infrared Touch Frame or Touch Film	Zytronic IR Touch Frame, Film Touch Overlay (USB)
Frame/Enclosure	Wooden/Plastic/Aluminum frame, Wall-mount or table stand	Custom Wooden Frame
Operating System	Linux-based or Android (based on SBC)	Raspberry Pi OS, Ubuntu, Android Things (discontinued)
Voice Assistant SDK	For interaction, TTS/STT	Google Dialogflow, Amazon Lex, Microsoft Azure Bot Framework
TTS (Text to Speech)	Converts AI responses to speech	Google Cloud TTS, Amazon Polly, Festival TTS
Cloud Backend	AI processing, storage, custom logic	AWS, Google Cloud Platform, Microsoft Azure
Facial Recognition	(Optional) On-device or cloud-based facial ID	OpenCV + Dlib, AWS Recognition, Azure Face API
Weather/Time APIs	RESTful APIs for external data	OpenWeatherMap API, WeatherAPI.com, World Time API
Internet Connectivity	Wi-Fi, LAN, or Mobile tethering	Raspberry Pi Wi-Fi Module, USB Wi-Fi Adapter (for PCs)

Table1. Components&Specification

ArduinoUNO R3

A brain of the roboticarmisknownasArduino.Itisresponsibleforanymovementshappeningwhileexecutingthe command. Arduino’s flexibility allows customization and integration of additional features which areneeded. This mapping is very essential for quick and accurate execution of robotic arm movements. It involves associating each command with the appropriate servoor motion action.Fig 2. showsthe Arduino UNOR3.

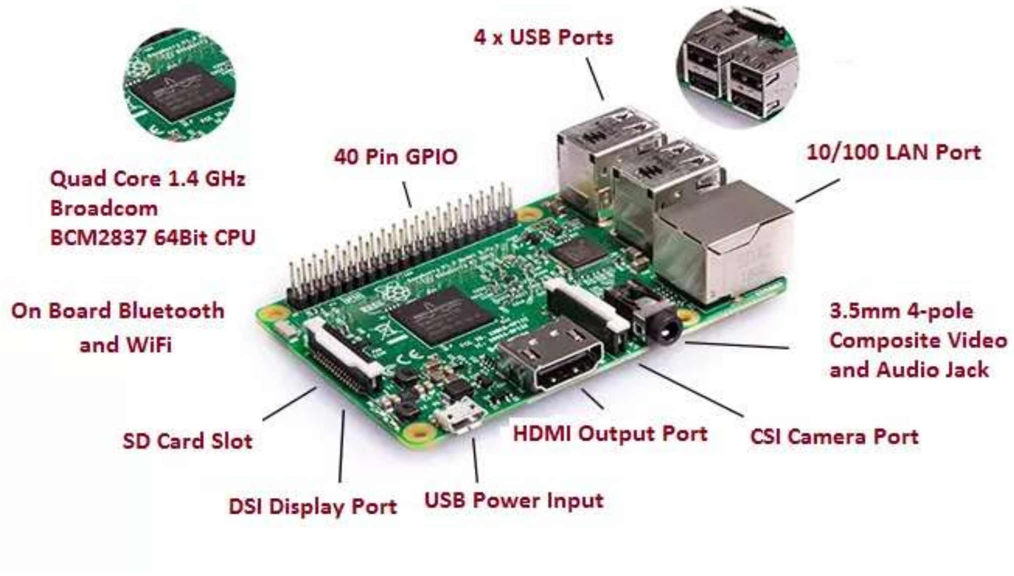


Fig2. ArduinoUNOR3

Histogram Extraction:

At the end of this LBP process, we have a new image which represents better the characteristics of the original image. After this we extract the histograms of regions as shown below:

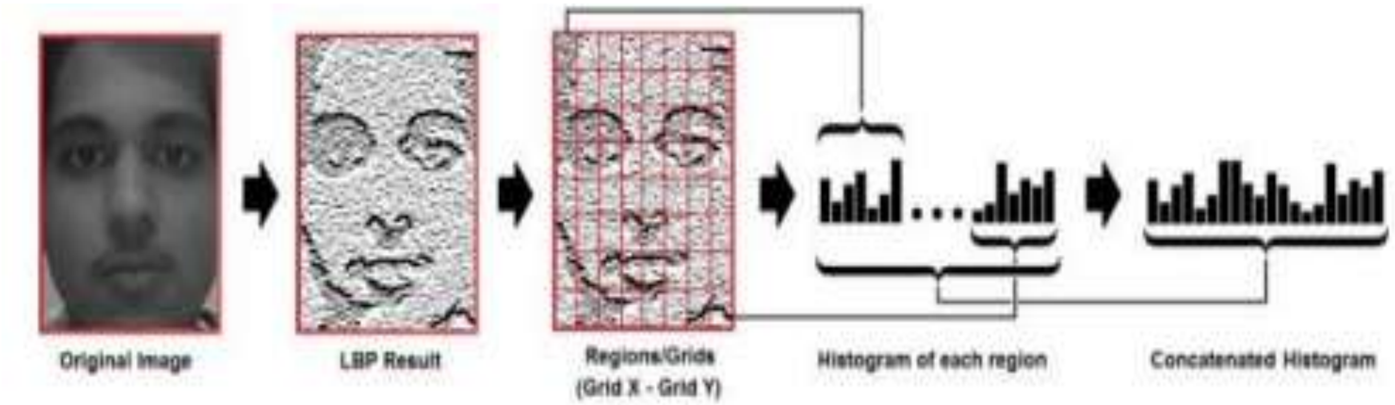


Fig: 3.4 Histogram extraction and concatenation

F

$$D = \sqrt{\sum_{i=1}^{n} (hist1_i - hist2_i)^2}$$

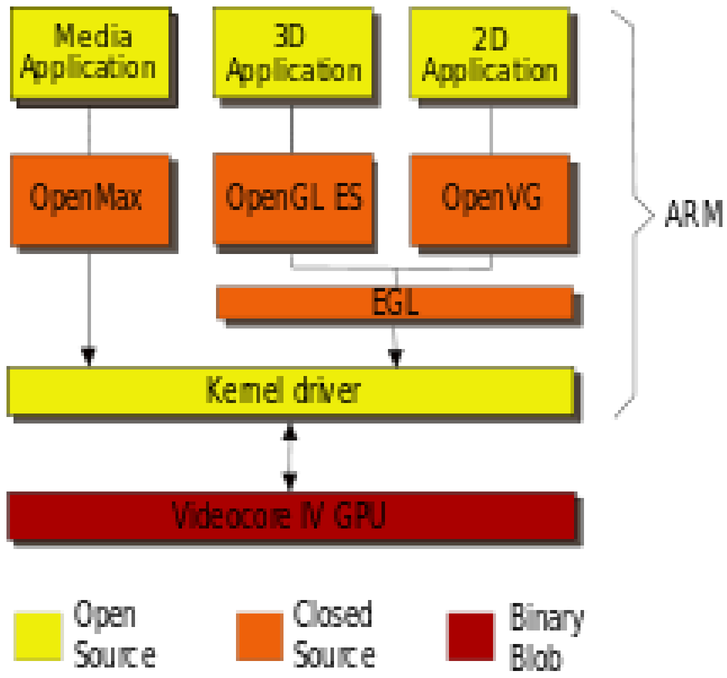
Hist1: Value of histogram which is created from trained dataset images.

Hist2: Value of histogram which is obtained at the recognition step. D: Distance between Hist1 and Hist2.

Planned operating systems

Windows 10 – Microsoft announced February 2015 it will offer a free version of the to-be-released Windows 10 running natively on the Raspberry Pi [102]

Driver APIs



Scheme of the implemented APIs: Open-MAX, OpenGL ES and Open-VG

Raspberry Pi can use a Video Core IV GPU via a binary blob, which is loaded into the GPU at boot time from the SD-card, and additional software, that initially was closed source. This part of the driver code was later released, however much of the actual driver work is done using the closed source GPU code. Application software uses calls to closed source run-time libraries (Open-Max, OpenGL ES or Open-VG) which in turn calls an open-source driver inside the Linux kernel, which then calls the closed source Video Core IV GPU driver code. The API of the kernel driver is specific for these closed libraries. Video applications use Open MAX, 3D applications use OpenGL ES and 2D applications use Open-VG which both in turn use EGL. Open-MAX and EGL use the open-source kernel driver in turn.

OpenCV:

OpenCV (*Open-source computer vision*) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then It see (which was later acquired by Intel). The library is cross-platform and free for use under the open-source BSD license.OpenCV supports some models from deep learning frameworks like TensorFlow, Torch, Py-Torch (after converting to an ONNX model) and Caffe according to a defined list of supported layers.

The first alpha version of OpenCV was released to the public at the IEEE Conference on Computer Vision and Pattern Recognition in 2000, and five betas were released between 2001 and 2005. The first 1.0 version was released in 2006. A version 1.1 "pre-release" was released in October 2008.

The second major release of the OpenCV was in October 2009. OpenCV 2 includes major changes to the C++ interface, aiming at easier, more type-safe patterns, new functions, and better implementations for existing ones in terms of performance (especially on multi-core systems). Official releases now occur every six months and development is now done by an independent Russian team supported by commercial corporations.

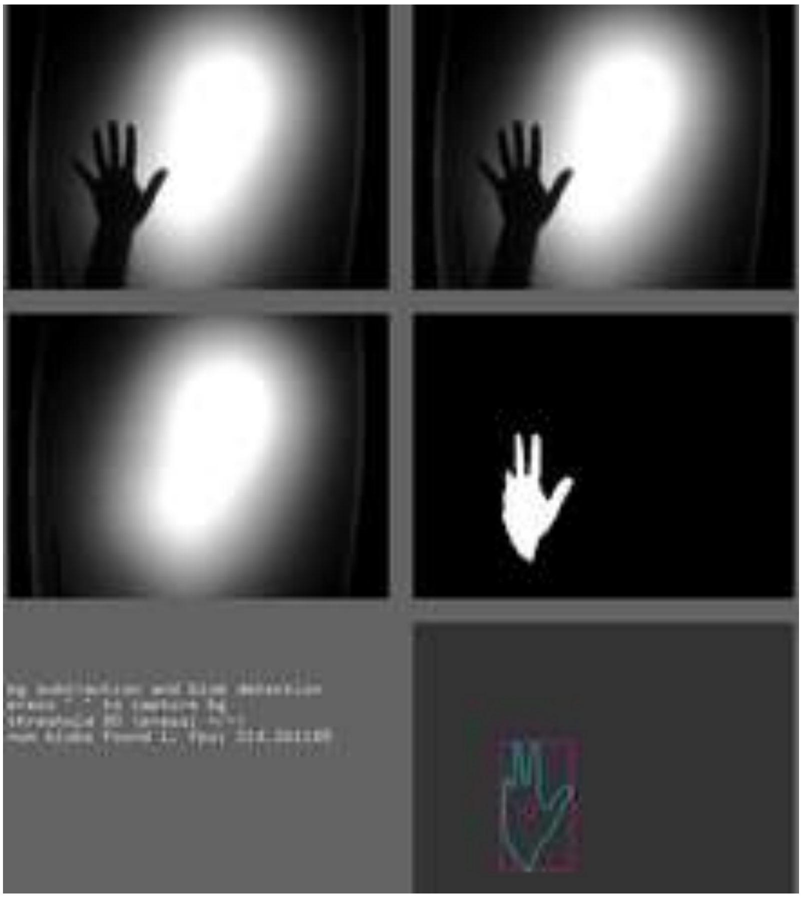


FIG:open Frameworks running the OpenCV add-on example

4. WORKINGPRINCIPLE

The exploration of interactive robotic arm control begins with a detailed breakdown of its operational process,components,andsafetyfeatures,offering acomprehensiveunderstandingofitsfunctionality.Initially,theusercommunicates commands through voice inflections into a microphone. These commands are then transmittedwirelessly to the robotic arm via a Bluetooth module like the HC-05, enabling seamless connectivity withexternal devices such as smartphones or tablets. The Bluetooth module plays a critical role in the system byfacilitating remote control without the limitations of wired connections, thereby enhancing flexibility and userconvenience.Fig 8. shows the flow chart ofVoiceRecognition.

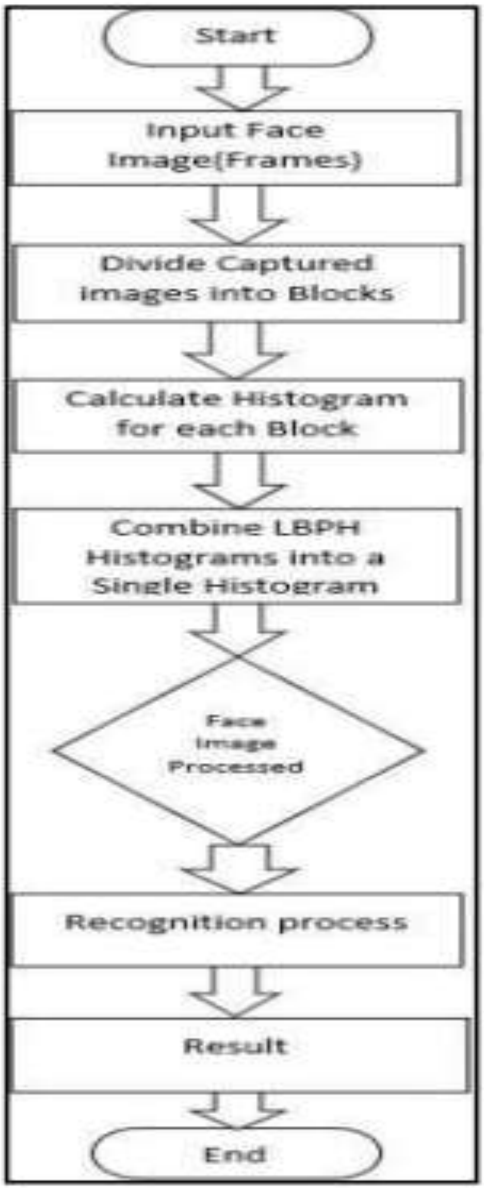


Fig8. Flow ChartofVoiceRecognition

USB CAMERA:

A **cam** is a video camera that feeds or streams its image in real time to or through a computer-to-computer network. When "captured" by the computer, the video stream may be saved, viewed or sent on to other networks via systems such as the internet, and email as an attachment. When sent to a remote location, the video stream may be saved, viewed or on sent there. Unlike an IP camera (which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptops. The term 'webcam' (a clipped compound) may also be used in its original sense of a video camera connected to the Web continuously for an indefinite time, rather than for a particular session, generally supplying a view for anyone who visits its web page over the Internet. Some of them, for example, those used as online traffic cameras, are expensive, rugged professional video cameras.

5. RESULTS

Theproposedmodel ofour projectisdisplayed below.Fig 14.Showsthe proposedmodel

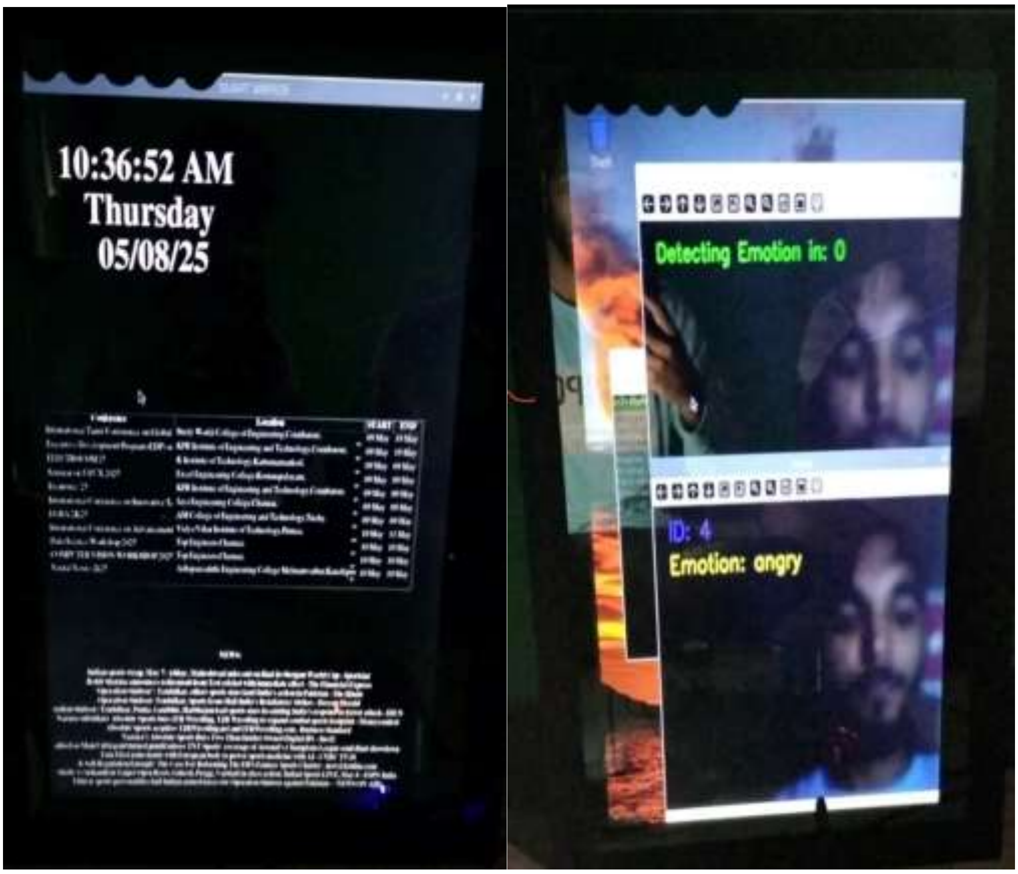


Fig14. Proposedmodel

6. DISCUSSSION

The AI Smart Mirror is a sophisticated fusion of hardware and software that transforms a traditional mirror into an intelligent, interactive interface. At the heart of this system lies the user interaction layer, where individuals engage with the mirror through voice commands or, optionally, via a touch interface. A built-in microphone captures spoken commands, while a camera—if included—enables facial recognition to personalize responses based on the detected user.

The core processing is handled by a Raspberry Pi or a similar single-board computer (SBC), which functions as the central brain of the system. It manages all input signals, processes them either locally or by routing them to cloud services, and controls output delivery. The Raspberry Pi is chosen for its balance of performance, size, cost, and support for a wide range of sensors and peripherals.

On the output side, a standard display is mounted behind a two-way mirror. This configuration allows digital content such as weather forecasts, time, news, or calendar events to appear seamlessly on the mirror surface without disrupting its reflective function. A speaker is also integrated to provide audio feedback using text-to-speech (TTS) technology, allowing the mirror to "talk" to the user.

For AI-powered functionalities, the system connects to various cloud services. These include OpenAI or Dialog-flow for natural language processing (NLP), Amazon Polly or Google TTS for converting text to speech, and public APIs like Open-Weather-Map and News-API for fetching real-time information. The cloud infrastructure enhances the mirror's intelligence, enabling it to understand and respond to complex queries beyond what local processing can handle.

7. CONCLUSION

The Smart Mirror project represents a significant advancement in the fusion of artificial intelligence, IoT, and embedded systems to create an intelligent, user-friendly, and interactive personal assistant. By leveraging a Raspberry Pi, two-way mirror, and various software technologies, the system not only retains the basic functionality of a traditional mirror but also evolves it into a dynamic and responsive smart interface. Features such as face recognition allow personalized content delivery, while emotion detection enables the system to adapt audio playback to the user's mood, enhancing emotional engagement. IoT integration ensures the availability of real-time data and news updates, all of which are seamlessly presented in a clean, non-intrusive format.

REFERENCE

[1] Kumar, P., & Gupta, S. (2020). Design and implementation of a smart mirror using Android APIs and Raspberry Pi. International Journal of Scientific Research in Computer Science, 8(2), 101–105.

[2]Singh, A., Verma, R., & Sharma, M. (2019). IoT-based smart mirror using Raspberry Pi. International Journal of Computer Applications, 177(42), 12–15.

[3]Ramesh, V., Thomas, N., & Joseph, M. (2021). Voice-controlled smart mirror using Google Assistant. Proceedings of the International Conference on Smart Systems and Technologies, 204–209.

[4]Zhao, Y., & Zhang, H. (2018). Face recognition on Raspberry Pi using OpenCV and Haar cascades. Journal of Embedded Systems, 5(1), 33–38.

[5] Patel, K., Joshi, M., & Mehta, R. (2021). A personalized smart mirror interface based on face detection and user preferences. International Journal of Innovative Research in Technology, 7(4), 41–47.

[6] Sharma, R., Kapoor, A., & Kaur, D. (2019). Real-time facial emotion detection using deep learning on embedded platforms. Journal of Artificial Intelligence and Applications, 6(2), 55–60.

[7] Akhtar, I., & Malik, F. (2020). Emotion-based music recommendation system using facial expression analysis. International Journal of Engineering Research and Applications, 10(6), 88–93.

[8] Das, S., & Roy, P. (2020). IoT-based smart home display system with centralized control. Journal of Internet of Things and Smart Technologies, 3(1), 26–30.

[9] Lee, J., & Kim, S. (2022). Healthcare integration in smart mirrors: A patient-centred approach. Journal of Medical Internet Research, 24(9), e31372.

[10] Banerjee, T., Ghosh, R., & Sinha, A. (2022). Development of a chatbot-enabled smart mirror for interactive environments. Proceedings of the International Conference on Human-Computer Interaction, 134–139.

AUTHORBIOGRAPHY

Mr.Dr.V.TKrishna Prasath,Associative Professor (HOD),
DepartmentofArtificial IntelligenceandDataScience,Nehru Institute of Engineering and Technology,Coimbatore, India.
ExpertiseinAI, ML.

Mr. Sagar KumarC, UGStudent,
DepartmentofArtificial IntelligenceandDataScience,Nehru Institute of Engineering and Technology,Coimbatore, India.
Passionate in AI Space scientist.

Mr. Uday KiranR, UGStudent,
DepartmentofArtificial IntelligenceandDataScience,Nehru Institute of Engineering and Technology,Coimbatore, India.
PassionateinArtificialIntelligenceand DataScience.

Mr. Pavan Kalyan B,UG Student,
DepartmentofArtificial IntelligenceandDataScience,Nehru Institute of Engineering and Technology,Coimbatore, India.
PassionateinDataScience