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Smart Mirror using Raspberry Pi

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Abstract: A smart mirror built with Raspberry pi offers display solution that supports real-time information. This paper presents a cost-effective smart mirror system developed using a Raspberry Pi and the MagicMirror² platform. The system supports the smart campus initiative by enhancing campus infrastructure with a digital real-time display. It shows live updates like weather, news headlines, Indian holidays, and events at the university using ICS calendar integration. To cut down the costs and to build a budget-friendly mirror, we replace the traditional two-way glass mirror with a one-way mirror film pasted onto an acrylic sheet to produce a mirror effect. The system serves as an easily deployable solution for digital information within the college campus.

Keywords: Raspberry Pi, Smart campus, One-way mirror film, Information system.

I. INTRODUCTION

Smart mirror with Raspberry Pi offers a cost-effective and modular solution aimed at enhancing information delivery in educational institutions as part of the smart campus initiative. This project focuses on developing an interactive display system using a Raspberry Pi and the MagicMirror² platform to provide real-time updates such as weather conditions, news headlines, Indian holidays, and university-specific events via ICS calendar integration. To keep the design budget-friendly, the mirror uses an acrylic sheet combined with one-way mirror film instead of traditional two-way glass, achieving a similar reflective effect at lower cost. Serving as a digital replacement for conventional notice boards, the smart mirror improves campus communication and demonstrates an easily deployable approach to modernizing campus infrastructure.

A. System Architecture

The smart mirror's structure is centered on a Raspberry Pi, which runs the software and fetches online data. An LED monitor is placed behind the acrylic sheet to allow information to be seen clearly with the help of one-way mirror film while retaining the reflective surface of the mirror. The fig 1 shows the system connections to the internet via Wi-Fi to access APIs for fetching the weather and calendar data. The software periodically refreshes the contents to ensure real-time display. All components are mounted within a wooden frame, giving an aesthetic finish to the project.

B. Problem Statement

The present systems available for sharing campus information (like notice boards and student portals) are not always effective. Important announcements may be missed or ignored by the users. There is also limited real-time content delivery. This creates a need for a system that integrates information updates into an everyday object like a mirror, making information readily visible without manual effort.

C. Proposed System

The proposed system is built around a Raspberry Pi that functions as the central processing unit. It is connected to an LED monitor, which is placed behind a two-way acrylic mirror to allow both reflection and digital display. The system utilizes the MagicMirror² platform to run modular applications that display a variety of real-time information. These modules include weather and time updates, a university calendar with public holidays and academic events, scheduled event reminders, daily greetings or motivational quotes, and live news headlines.

The MagicMirror² is an open-source framework for building smart mirrors created by Michael Teeuw in 2016 and made available on GitHub. It is meant to be compatible with devices such as the Raspberry Pi and offers an extensible interface to build custom smart mirrors with features such as displaying the time, weather, calendar appointments, and the news using modular elements. The framework is constructed using web technologies including HTML, CSS, and JavaScript and is flexible and accessible to developers and DIY enthusiasts. The modular design enables developers to extend and provide new features as well as integrating new features, which has led to an active contributor base offering third-party modules to enhance its feature set.

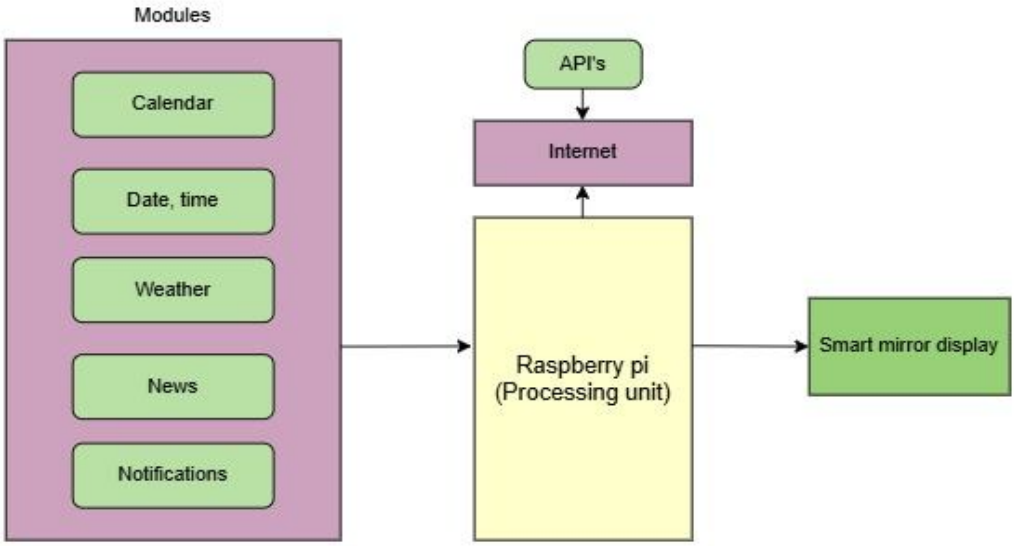

Fig. 1. System Architecture

II. RELATED WORK

[1] The Open WeatherMap "Current Weather Data" API, which is hosted by OpenWeatherMap.org as of 2024, is one of the most popular web services available and provides live weather data for any place on Earth. It provides a variety of data including temperature, humidity, wind speed, and weather conditions, which are all available through straightforward HTTP queries. This API is integrated into websites and applications to supply real-time weather conditions and forecasts. It is also helpful for developers who are designing features related to the weather on web and mobile applications, including on smart mirrors, dashboards, and IoT devices.[2]The Web Speech API, which is described by the Mozilla Developer Network as of 2024, is the browser-based API owned and maintained by the Mozilla Foundation that makes it possible to include either speech recognition and/or synthesis features in web pages. Developers can implement voice input and/or voice output for websites, which makes the application more accessible and interactive using natural language. It is possible to use the API to convert spoken words to written words (speech recognition) and written words to spoken words (speech synthesis), which makes the API appropriate for use in virtual assistants, voice-operated interfaces, and smart mirrors. It is implemented in modern browsers and is improving as the work to provide richer voice-enabled experiences to the web continues.[3]The Google Calendar API, offered by Google Developers in 2024, is a robust resource enabling developers to access and manage calendar events, appointments, and reminders programmatically in their own applications. It facilitates the creation, read, update, and delete of events on users' Google Calendars and the incorporation of scheduling features into different platforms including mobile applications, web services, and intelligent devices. With RESTful operation and OAuth 2.0 authentication, the API provides safe and flexible interaction with user data. It is particularly handy for productivity applications, personal assistants, and intelligent mirror devices that need to present or engage with calendar data in real-time.[4] The News API, which is documented on NewsAPI.org in 2024, is a RESTful web service that provides access to real-time headlines and articles from numerous reputable sources and blogs on the internet. The service provides users with the capability to search and filter the content of the news by keyword, source, language, and date published. The API returns the results in JSON, which is convenient to use with web and mobile applications, dashboard displays, and intelligent devices. The ability to provide timely events and break news is what makes the News API most useful for applications such as intelligent mirrors, news aggregators, and targeted content platforms.[5]The Raspberry Pi 4, described by the Raspberry Pi Foundation in 2024, is an inexpensive and miniature one-board computer primarily aimed at educational, hobbyist, and professional uses. It has an advanced Broadcom BCM2711 quad-core Cortex-A72 processor, provisions for 2GB, 4GB, or 8GB of LPDDR4 RAM, dual-output displays through micro-HDMI, Gigabit Ethernet, dual-band Wi-Fi, Bluetooth 5.0, and several USB ports. The system is compatible with various operating systems, including the Raspberry Pi OS, and accepts full desktop environments, with possible uses ranging from programming and robotics to domestic automation and smart home displays. Its energy-saving design and access to GPIO pins further extend its flexibility to hardware interfacing and embedded system programming.[6] The author, Seth Kenlon, discusses the technologies and tools with which voice-based interfaces may be implemented on Linux platforms in his July 2021 article on Opensource.com. The article covers the open-source alternatives to both the voice recognition and voice synthesis, including CMU Sphinx, Mozilla DeepSpeech, and Festival, and how one can integrate them into different applications. The author champions the increasing use of voice technology in the open-source space and offers direction on how to implement and utilize the tools on Linux platforms. The resource is of special benefit to developers who need to construct voice-enabled applications such as voice-enabled mirrors or voice assistants without using proprietary tools.[7]The journal article "Smart Mirror using Raspberry Pi" authored by P. Aher, P. Jadhav, P. Nikam, and M. Pawar and published in the June 2019 Vol. 6, Issue 6 edition of the International Research Journal of Engineering and Technology (IRJET) provides the design and implementation of the smart mirror system based on Raspberry Pi.

The authors explain the fusion of the hardware and software elements to develop an interactive mirror reflecting real-life information including the weather, news, calendar events, and the clock. The system is built using a two-way mirror, the screen, and different APIs to provide the user with the content, with the intent to provide greater convenience and automation to everyday tasks. The article also discusses the advantages of using the Raspberry Pi because of its low cost, small size, and flexibility and because it is an optimal platform for the applications of smart home.[8]The paper entitled "Smart Mirror for Smart Life" authored by Venkatesh, A. Sundararajan, and K. A. Prasad and published in the International Journal of Computer Applications (IJCA) in April 2018 (Vol. 180, No. 39, pp. 23–26) examines the idea and design of the creation of an intelligent mirror to contribute to day-to-day living through the integration of technology. The authors depict the mirror as an interactive system which can provide personalized information including weather information, news, date, and time, along with user schedules showcased on a reflecting screen. The article details the application of Raspberry Pi as the main controller along with other sensors and APIs to provide the functionality. The system is expected to provide an intelligent and networked setting and demonstrate the prospects of the use of the mirror as an element of the Internet of Things (IoT).[9]The article "Design and Development of a Smart Mirror Using Raspberry Pi" by B. Rao and S. Nithya at the September 2021 International Conference on Smart Electronics and Communication discusses the design and implementation of an intelligent mirror using the Raspberry Pi system. The authors outline how the system consists of hardware components including a two-way mirror, screen, and sensors and the corresponding software elements that provide personalized information such as the time, weather, calendar events, and breaking news. They stress the flexibility of using Raspberry Pi to develop an affordable and customizable smart mirror and the need to employ open-source software as well as APIs for real-time update capabilities. The article also discusses applications in personal and professional settings to maximize user convenience and interaction.[10]

III. IMPLEMENTATION

A. Implementation

The implementation of the Interactive Smart Mirror involves integrating various software modules on the MagicMirror² platform to display real-time data through a visually appealing interface. When powered on, the Raspberry Pi boots the Raspberry Pi OS and automatically initializes the MagicMirror² interface with the Electron framework. The application is coded in HTML, CSS, and JavaScript, allowing for a customizable and responsive layout on the display. Each modules, such as weather, date and time, calendar events, notifications, and greetings is set up using configuration files. Data for these modules is retrieved through third-party APIs, including weather conditions and calendar information, and is refreshed periodically using cron jobs or internal refresh timers. The output is projected on a 16.1-inch LED display placed behind a two-way acrylic mirror which preserves the reflective characteristic while allowing digital content visibility. The system is passive and does not depend on user actions but instead aims at automated content provision to ensure low maintenance and ongoing performance.

B. Module description

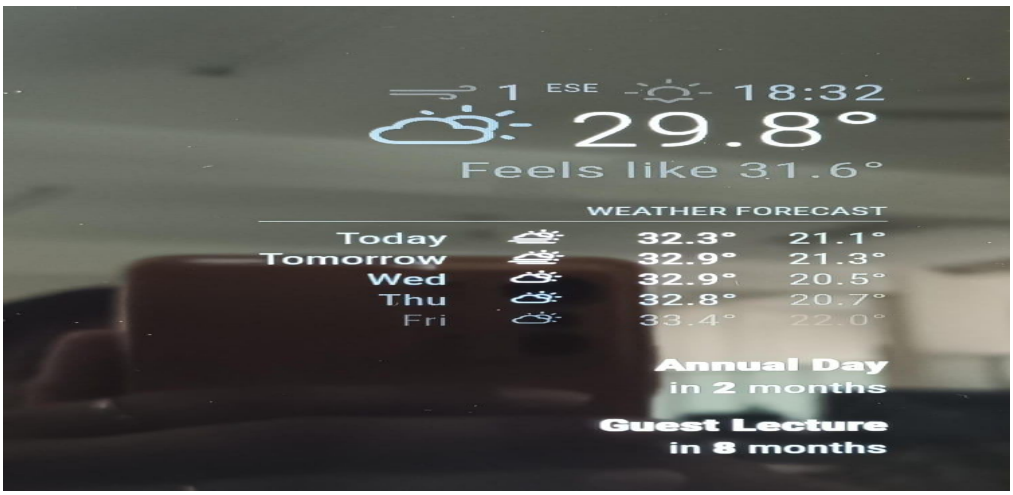

Fig. 2. Weather Module

1. The Fig 2 Weather Module retrieves real-time atmospheric data using online APIs displays current temperature, humidity, wind speed, and general weather conditions based on the configured location. The information is refreshed at regular intervals to ensure that users receive real-time weather forecasts. This module enhances the utility of the smart mirror by providing timely and essential environmental information immediately.
2. The Fig 3 *Notification Module* displays daily greeting or motivational quote, as well as the latest news headlines and campus announcements through RSS feeds and APIs. It auto-refreshes to provide real-time updates, keeping users updated and engaged. This module helps make the Smart Mirror a low-maintenance, user-friendly, and effective information display system for the educational environment.
3. The Fig 4 Calendar Module integrates both national and university-specific academic calendars. It displays upcoming holidays, semester breaks, exam schedules, and important institutional deadlines. The module supports the import of calendar data through iCal or custom event files, ensuring that all relevant academic events are visible to students and staff. This feature promotes better time management and planning.

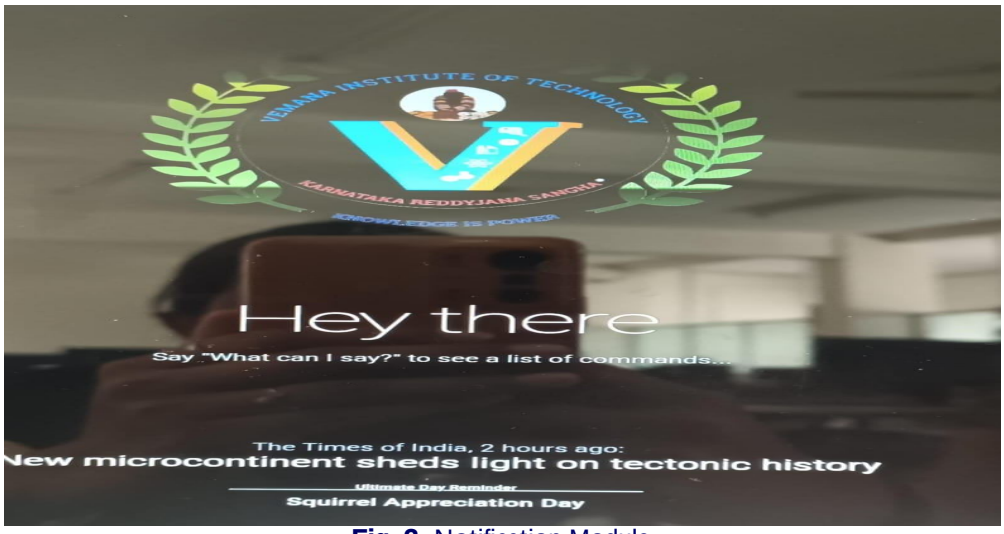

Fig. 3. Notification Module

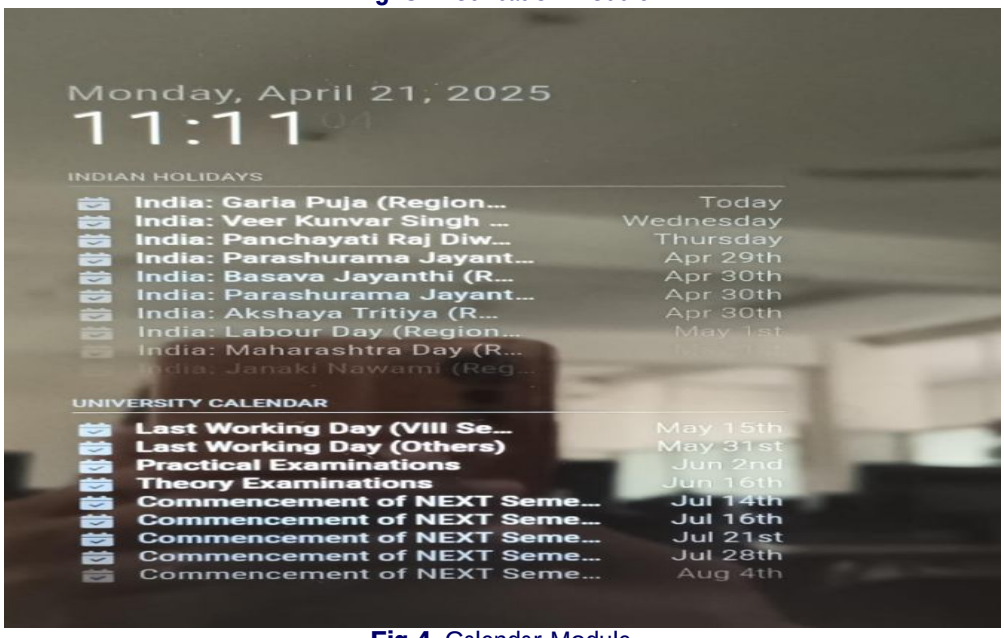

Fig.4. Calendar Module

III. METHODOLOGY

The development of the Interactive Smart Mirror follows a modular and layered approach to ensure scalability, maintainability, and ease of integration. The system is powered by a Raspberry Pi 4, which runs the Raspberry Pi OS and serves as the core computing unit. Upon booting, the operating system automatically launches the MagicMirror² platforma Node.js-based framework that facilitates the creation and management of custom display modules.

A. Hardware components required:

1. Raspberry Pi 4: Acts as the main computing unit.
2. LED Monitor: Used to display the data or texts.
3. Two-way Acrylic Mirror: Displays the content while also maintaining the mirror effect.
4. Power Supply and Frame: Power supply used for the smart mirror to function uninterruptedly and the frame to support the other components while giving a pleasant look.
5. Micro HDMI to HDMI Cable: Used to connects the Raspberry Pi to the monitor to display the output.
6. MicroSD Card (32GB): Stores Raspberry Pi OS and smart mirror software.

B. Software components required

1. Operating system: Raspberry Pi OS Bookworm(32-bit)
2. Electron Framework: To run the MagicMirror software as a desktop application.
3. npm (Node Package Manager): Acts as a command-line interface to manage JavaScript packages.
4. Node.js(v20): JavaScript runtime for MagicMirror modules.

IV. RESULTS AND EVALUATION

The Fig 5 Output for Interactive Smart Mirror project was evaluated based on the successful execution and performance of its functional modules. Each core component was individually tested for responsiveness, accuracy, and usability in a campus environment. The following are the observed outcomes:

A. Real-time Weather, Date & Time Display

1. Successfully fetched and displayed real-time weather conditions, including temperature, humidity, and wind speed.
2. The system accurately displayed the current date and time using Raspberry Pi and online APIs.
3. The periodic refresh mechanism ensured up-to-date information without user intervention.

B. Calendar Integration

1. The smart mirror accurately synchronized and displayed both:

a. Indian national and regional public holidays.

b. University-specific academic events such as exam dates and semester breaks.

2. Custom file support for syncing personalized or department-specific schedules was successfully tested.

C. News and Notifications

1. The mirror effectively fetched live news headlines through API integration.
2. Important reminders and greetings were displayed promptly with auto-refresh capability.
3. Daily summaries ensured students/faculty remained updated with minimal effort.

D. Voice Command Recognition

1. The USB microphone successfully captured user's voice commands.
2. Commands like “show weather” or “what's the news?” were recognized and executed.

E. Limitations Observed

1. Voice Output Functionality: This feature failed during testing and requires additional debugging and integration.
2. Internet Dependency: Real-time features heavily rely on continuous internet access.
3. Customization: Initial user setup for modules like calenar and news may need simplification for non-technical users.

Fig. 5. Output

CONCLUSION

The Interactive Smart Mirror effectively incorporates real-time data provision into an everyday object, repurposing an ordinary mirror as an active information hub. Leveraging the use of a Raspberry Pi and MagicMirror² interface, the system provides critical updates including the weather forecast, event alerts, and university calendar details. Even without sophisticated features such as voice interaction or camera-based personalization, the design offers an inexpensive and efficient solution to campus communication and personal productivity enhancement. The implementation of future features such as gesture control or voice aids has the potential to broaden its application range as an effective and versatile tool for both academic and personal settings.

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