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Integrating Emotional AI into Mobile Apps with Smart Home Systems for Personalized Mental Wellness

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Abstract
The global mental health decline, intensified by the pandemic, economic strain, and isolation, has led to increased anxiety and depression levels. The shortage of mental health services exacerbates this crisis, creating a significant care gap, especially for the underprivileged. In response, this project emerges with three primary objectives: to explore mental health elements, including emotional stability and stress management; to develop an artificial intelligence–driven home environment that reacts to the inhabitants' emotions to enhance mental wellness; and to create an auto-journaling system that captures users' emotions through user-friendly devices, encouraging self-reflection and prioritizing individual well-being. This project employs emotional data from users to enable smart home systems to utilize machine learning technology and artificial intelligence, crafting a living space tailored to each user's specific needs. A key component is the integration of a humanoid robot as a companion, pivotal to this user-centric framework. The participant group consists of urban students from diverse genders and educational backgrounds in arts and science, focusing on capturing varied emotional experiences with the AI system, although limited by a small sample size. This approach aims to empower individuals to manage their mental health effectively. By initiating this project, the goal is to stimulate conversation and foster ongoing research and innovation at the crossroads of technology and mental health. Ultimately, it seeks to contribute to the development of better interventions in an increasingly digitized society, addressing the urgent need for enhanced mental health support. In conclusion, the mental health and well-being app makes its attempt to address the global mental health decline by providing personalized support for underserved populations. Its success lies in the integration of an AI-driven smart home system, an auto-journaling feature, and a humanoid robot companion, all designed to empower users to manage their mental wellness. Statistical data demonstrates the app's positive impact on emotional well-being, highlighting its transformative potential in the evolving landscape of mental health technology.

Keywords Artificial intelligence · Mobile app · Smart home systems · Personalized mental wellness · Humanoid robot

Introduction

Well-being and mental wellness are multifaceted concepts explored across various disciplines, including psychology, sociology, and economics. Historically, Aristotle distinguished between hedonic happiness and eudaimonic well-being, favoring the latter as the ultimate human potential (Ryan & Deci, 2001). Contemporary efforts, such as the Global Wellness Institute's Mental Wellness Initiative (MWI), have expanded on these ideas, defining wellness as a lifelong process involving physical, social, occupational, spiritual, financial, and environmental well-being (Bodeker et al., 2018). This process enables individuals to live healthy, purposeful lives, cope with stress, work productively, and contribute to society. The Better Life Initiative of the Organization of Economic Co-operation and Development further categorizes well-being into three pillars: material living conditions (economic well-being), quality of life (non-monetary attributes), and sustainability of socio-economic and natural systems, highlighting the impact of human activities on various forms of capital essential for enduring well-being (Durand, 2015).

Mental health is increasingly recognized not merely as the absence of illness but as a state of well-being wherein individuals can realize their own abilities, cope with the

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normal stresses of life, work productively, and contribute to their community (Galderisi et al., 2015). This positive conceptualization of mental health underscores the importance of emotional, psychological, and social well-being as integral components of overall health. Evolving definitions highlight the shift from a focus on diagnosing and treating mental illness to promoting mental wellness and resilience (Manderscheid et al., 2009).

Mental wellness is a complex and multifaceted concept that encompasses an individual's psychological, emotional, and social well-being. Researchers have identified various factors that contribute to an individual's mental wellness, including self-acceptance, environmental mastery, purpose in life, autonomy, positive relations with others, and personal growth (Herrman and Jané-Llopis, 2012). The literature (Herrman and Jané-Llopis, 2012; Cowen, 1991) suggests that a comprehensive approach to the promotion of wellness requires addressing a variety of interconnected strategies. Competence, resilience, social system modification, and empowerment have been identified as key concepts that hold the potential for advancing a richer psychology of wellness. Widely used in clinical settings, FACS traditionally relies on observers who code expressions and analyze emotional states. Developed by Paul Ekman and Wallace V. Friesen, the Facial Action Coding System (FACS) provides a framework for coding facial expressions based on muscle movements (AUs) to infer emotions like happiness, sadness, or anger (EIAGROUP n.d.).

Achieving and maintaining mental health and wellness is not without challenges. Factors such as social inequality, discrimination, and stresses of modern life can significantly impact mental health, underscoring the need for holistic approaches to mental health promotion that address the social determinants of health and foster resilience and well-being across the lifespan (Herrman & Jané-Llopis, 2012). The pursuit of mental health and wellness is a dynamic and ongoing process that requires a comprehensive understanding of the factors that contribute to and detract from mental well-being. As research continues to advance, it is imperative to integrate these insights into practices and policies aimed at promoting mental health for individuals and communities alike. One valuable tool in this effort is the Positive and Negative Affect Schedule (PANAS), a self-report questionnaire developed by Watson, Clark, and Tellegen in 1988, widely used to assess emotional states.

Bodeker et al. (2021) found that meditation can have positive effects on mental health. Specifically, research on mindfulness meditation indicates that certain forms may promote telomere maintenance by reducing cognitive stress and stress arousal, as well as enhancing positive states of mind (Conklin et al., 2018; Epel et al., 2009). Additionally, the benefits of restoring health through contact with nature have been highlighted by Burls and Caan (2005).

The burgeoning field of artificial intelligence (AI) offers revolutionary prospects for addressing the intricate challenges of mental health and wellness (Bohr & Memarzadeh, 2020; Minerva & Giubilini, 2023; Shatte et al., 2019). With the increasing burden of mental health disorders globally, the integration of AI into mental healthcare presents a pivotal shift towards more accessible, personalized, and efficient care. The paper (Suyesha et al., 2024) introduces the multifaceted role of AI in transforming mental health services, underpinned by a synthesis of recent research findings. AI technologies, such as machine learning algorithms and natural language processing, are being harnessed to analyze vast amounts of data from electronic health records, social media interactions, and direct patient inputs. These analyses facilitate the early detection of mental health issues, offer novel insights into the underlying patterns of mental illnesses, and enable the prediction of treatment outcomes, thereby paving the way for a more proactive and tailored approach to mental healthcare (Fiske & Henningsen, 2019; Graham et al., 2019). Beyond diagnosis and treatment prediction, AI-driven tools are extending their utility to direct patient care through the development of virtual assistants and chatbots. These AI applications offer real-time, stigma-free, and personalized support to individuals, thereby democratizing access to mental health resources and interventions (D'Alfonso, 2020; Denecke, 2021). The integration of AI in mental health is not without challenges. Ethical considerations, data privacy, the potential for bias, and the importance of maintaining a human element in care are critical issues that need to be navigated carefully. Despite these hurdles, the promise of AI in enhancing mental health services and outcomes remains significant, necessitating ongoing research, ethical oversight, and cross-disciplinary collaboration to realize its full potential (Yadav, 2023).

Recent advancements in AI and machine learning (ML) are driving forward ambitious ideas for transforming healthcare (Johnson et al., 2021). The rise of personal health monitoring through mobile apps and wearables (Lattie et al., 2020), along with the growing use of electronic healthcare records (EHR), is generating vast amounts of personal health and behavioral data (Chekroud et al., 2021; Mohr et al., 2017). This data can be harnessed for assessing, monitoring, and treating health conditions. Enhanced computing power and cloud storage capabilities are fueling AI research and development, allowing sophisticated algorithms to analyze extensive datasets and uncover patterns previously unseen. These developments are paving the way for new insights into human behavior and enabling the prediction and optimization of health outcomes.

Healthcare systems face significant challenges in adopting AI systems (Lee et al., 2021). Recent research indicates that AI-based healthcare applications can equal or even exceed clinician performance for certain tasks, potentially

addressing global issues such as clinician shortages and healthcare access inequalities. However, the complexity of healthcare and the risk of technological failures leading to patient harm require new approaches to moral accountability and safety assurance. The implications of AI in clinical decision-making, particularly regarding moral accountability for patient harm and safety assurance, are critical. Habli et al. (2020) use an AI system for sepsis treatment as an example, discussing its benefits and harms and emphasizing the need to rethink blame assignment and safety practices. Practical suggestions are provided to address these issues in AI-driven healthcare.

AI can infer aspects of emotional health from facial expressions. Research indicates that facial expressions are integral indicators of emotional states, with specific patterns associated with various mental health conditions such as depression, anxiety, and schizophrenia (Vijay et al., 2016). Studies have demonstrated that AI algorithms can effectively analyze these expressions to discern subtle changes indicative of underlying psychological distress or mood disorders (Turcian & Stoicu-Tivadar, 2023). Techniques such as deep learning and facial recognition algorithms have shown promising results in accurately identifying emotional cues from facial features. By leveraging large datasets and advanced computational models, AI holds significant potential to augment traditional diagnostic approaches, facilitating earlier and more precise interventions in mental health care.

MQTT (Message Queuing Telemetry Transport) offers several benefits that make it ideal for IoT applications. It is lightweight and efficient, designed to minimize bandwidth usage and conserve energy in resource-constrained environments. MQTT operates on a publish/subscribe model where clients (devices) publish messages to topics on a broker, which then distributes these messages to subscribed clients. This asynchronous communication model supports scalability and reliability through its three levels of Quality of Service (QoS), ensuring messages are delivered efficiently according to the application's needs—whether it is at most once, at least once with acknowledgment, or exactly once. This simplicity, combined with its ability to handle intermittent connections and low overhead, makes MQTT a preferred choice for connecting IoT devices and facilitating real-time data exchange across distributed systems. Therefore, MQTT technology has been widely used in various medical applications such as blood pressure monitoring systems (Priya et al., 2023) and health monitoring of an intensive care unit patient (Ragavan et al., 2023). This advanced connectivity ensures efficient and real-time communication between the app and the robot, significantly enhancing the user experience while placing user's mental health at its utmost priority.

This study has three primary objectives. Firstly, it seeks to provide a comprehensive consideration of various factors influencing mental health, including emotional well-being, psychological resilience, and the ability to navigate stress and life challenges. By examining these dimensions collectively, the aim is to offer a nuanced understanding of individual mental wellness. Secondly, the research proposes the development of an AI-driven responsive home environment that dynamically adapts to users' emotions. Central to this objective is the incorporation of a humanoid robot that intuitively responds to users' emotional states, creating an adaptive ecosystem designed to enhance overall well-being. Lastly, the study aims to deliver an easily accessible and comprehensive AI-integrated system dedicated to maintaining personal well-being. Envisioned as user-centric, this system offers a seamless interface for individuals to proactively manage their mental health, integrating Emotional AI into mobile apps and smart home systems to provide personalized tools and resources tailored to their emotional needs. This project adds to the ongoing conversation surrounding technology-driven mental health interventions by introducing a novel framework that integrates Emotional AI with mobile applications and smart home systems. The envisioned result is a revolutionary system that empowers individuals to navigate the challenges of contemporary life while emphasizing their mental well-being. The expected results of this study aim to encourage additional investigation and dialogue within the realm of technology and mental health.

Methods

This project aims to create a comprehensive ecosystem for enhancing mental well-being through the integration of three innovative components: an Artificial Intelligence–Infused Mental Health App, Emotional AI Whole-Home Orchestration, and Interactive Empathetic Companion. Each component plays a unique role, collectively addressing the diverse needs of users and ensuring a holistic approach to mental health support.

The collaborative interplay between the Artificial Intelligence–Infused Mental Health App, Emotional AI Whole-Home Orchestration, and Interactive Empathetic Companion creates a comprehensive, supportive, and adaptive framework for enhancing mental well-being. In the following subsections, the functionality of each component will be explored in greater detail.

An Artificial Intelligence–Infused Mental Health App

Addressing global mental health challenges, the mindfulness mobile app strives to provide a personal and easily accessible avenue for individuals, regardless of their educational background, to assess their mental well-being. With a focus on promoting mental wellness, early issue detection, and

facilitating access to appropriate support, the app features stress relief activities, happiness exercises, and resources designed to destigmatize mental health. Noteworthy features include Sakura Therapy, Faciality, i-Listener, AI Priorix, Mindful Gyms, and Community Help, as illustrated in Fig. 1. Through personalized insights, interactive exercises, and meditation features, mindfulness mobile app encourages users to actively manage their mental health, aiming to contribute to the creation of compassionate and inclusive societies that foster mental health awareness for a healthier and happier world.

Sakura Therapy

Incorporating essential stress relief practices like breathing exercises and meditation is crucial for maintaining mental well-being. Sakura Therapy, an innovative feature within the application, offers users a unique way to rejuvenate their mental health by tracking their physical activity using motion-tracking artificial intelligence. Users are prompted to engage in movement to catch falling virtual Sakura flowers, symbolizing the delicate balance between physical activity and mental wellness. This approach combines time-honored mindfulness techniques with cutting-edge technology, empowering individuals to take proactive steps in managing their mental health.

i-Listener

i-Listener promotes emotional self-awareness and helps users build a harmonious relationship with their emotions. By recognizing and acknowledging emotions instead of suppressing them, users can experience greater calmness, confidence, mental flexibility, and overall well-being. The auto-journaling feature enables users to track their daily moods, fostering a deeper connection with their emotions and supporting emotional health.

i-Listener incorporates PANAS to measures two distinct dimensions of mood: Positive Affect (PA) and Negative Affect (NA), assessing how frequently a person experiences positive and negative emotions over a specified time period (e.g., right now, today, past week).

In clinical studies, participants rate 20 emotions to calculate Positive Affect (PA) and Negative Affect (NA) scores. Higher PA scores reflect stronger positive emotions like enthusiasm and excitement, while higher NA scores indicate more intense negative emotions such as distress and irritability. Scores are analyzed separately, allowing researchers to assess emotional trends across various contexts.

Scores for PA and NA are calculated separately, offering researchers and clinicians reliable insights into emotional trends and overall emotional well-being across various contexts and populations.

Faciality

The Facial Action Coding System (FACS) is a widely recognized method for analyzing and categorizing facial expressions by tracking the movements of facial muscles, known as action units (AUs). In Faciality, the app tests users' tendency to laugh when they encounter a funny joke, an adorable picture, or a delightful scenario. Notably, the muscles around the mouth exhibit the fastest motor control for emotional expressions, making laughter a key indicator of emotional and mental well-being. A healthy tendency to laugh in response to humor is generally seen as a positive sign of mental and emotional health.

Fig. 1 The key features and values of the mindfulness mobile apps

Faciality offers a range of features designed to promote well-being, including mood logging and personalized insights powered by AI analysis. The AI also interprets users' moods based on their responses and adjusts task prioritization accordingly. Through facial feature analysis, the app measures response times, providing further insights into the user's mental state. Users can choose between three different modes within the Faciality feature: Joke, Scenario, or Cute Image, as described below:

(i) Joke Mode: In this mode, the app presents humorous content such as jokes or funny anecdotes to the user. The AI analyzes the user's reaction time, facial expressions or a worded response when exposed to these jokes. Typically, users may react with expressions of amusement, such as smiling or laughing. The app then uses these reactions to infer the user's current mood and emotional state.

(ii) Scenario Mode: This mode involves presenting users with various hypothetical scenarios or situations. These scenarios could range from everyday life events to more imaginative or challenging situations. The AI monitors how users react to these scenarios based on their facial expressions and response times. Different scenarios may evoke different emotional responses, such as surprise, concern, or joy, which the AI interprets to gauge the user's emotional well-being.

(iii) Cute Image Mode: In this mode, the app displays images or visuals designed to be cute, endearing, or heartwarming. These images are chosen to elicit positive emotions such as happiness or affection. The AI observes how quickly and positively users respond to these cute images through their facial expressions. Reactions like smiles, expressions of warmth, or even laughter can indicate a positive emotional response, which helps the AI assess the user's emotional health and mood.

Figure 2 illustrates the facial points utilized in detecting various facial expressions. If the user's reaction aligns with the data of a happy person, they receive a rating on a scale of 1 to 10. Similar modes operate in the same way, using different stimuli to elicit user reactions and determine emotional health.

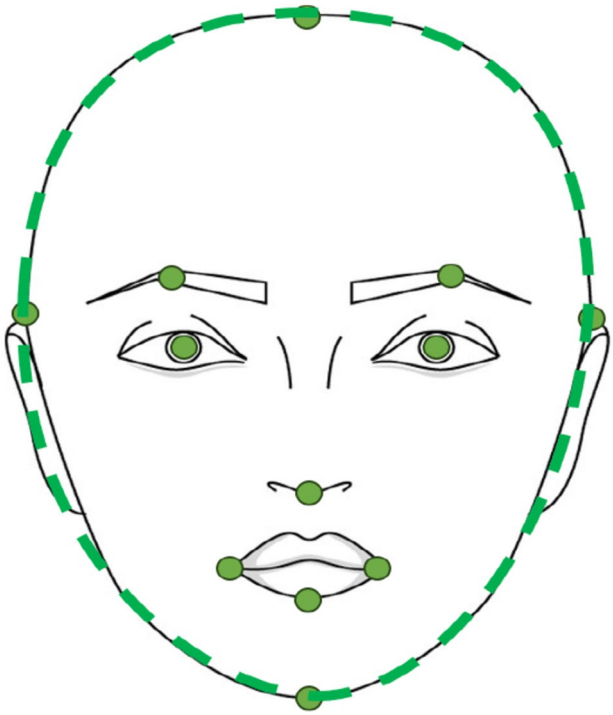


Fig. 2 Facial points that are used for detecting different facial expressions

AI Priorix

AI Priorix equips users with effective strategies for managing challenging situations, particularly in task prioritization. This functionality is crucial for reducing stress and increasing productivity, thereby supporting mental well-being.

Mindful Gyms

Mindful Gyms provide a platform to seamlessly incorporate the enduring benefits of meditation into everyday life. Users can customize their experience by selecting the duration, background music, and guided voice for their meditation sessions.

Community Help

Acknowledging the importance of social support in mental health, Community Help fosters community interaction. Recognizing that humans are inherently social beings, this feature provides a space for individuals to connect, share, seek advice, and find comfort during emotional challenges. A robust support network profoundly affects emotional well-being, and Community Help ensures users have access to the social support they need.

Emotional AI Whole-Home Orchestration

This project transcends the boundaries of traditional smart homes, aiming to compose a harmonious symphony of well-being that unfolds organically in response to user needs. At its core, the system revolves around the automatic adjustment of surroundings based on the user's mood, creating an immersive and emotionally supportive environment.

Smart home systems utilize a combination of Raspberry Pi, MQTT (Message Queuing Telemetry Transport), IoT technology, cloud computing, Emotional AI, and machine learning to enhance living environments and support emotional health. IoT devices equipped with sensors like temperature and motion detectors continuously monitor the home environment. These devices communicate efficiently through MQTT, ensuring rapid data exchange and synchronization within the smart home network.

Cloud computing serves as a centralized platform for storing and analyzing data. User inputs from the mental health app are securely transmitted to the cloud, where AI algorithms process this data. Machine learning models trained on historical and real-time emotional data can detect patterns and predict emotional states based on various inputs, including anonymized audio data captured by smart home devices (Fig. 3).

Interactive Empathetic Companion

The humanoid robot serves as the ultimate virtual companion, seamlessly connecting with the mindfulness mobile app via the fast Message Queuing Telemetry Transport (MQTT) protocol. Its introduction adds a unique layer of support by offering real-time interactions, companionship, and empathetic engagement. Fully integrated with key app features like Sakura Therapy, Faciality, AI Priorix, and i-Listener, the robot significantly enhances the user experience.

Equipped with advanced AI, multiple emoji displays, and voice command recognition, the humanoid robot establishes rapid MQTT connections with the app, creating a cohesive synergy that elevates both the app's functionality and the robot's role as a responsive, empathetic companion. This harmonious blend of intuitive technology and human-like qualities enriches user interaction, making the robot a truly engaging partner in emotional well-being (Fig. 4).

Results

The integration of an AI-infused mental health app, emotional AI for home orchestration, and an interactive empathetic companion creates a comprehensive mental health care system, leveraging technology to enhance users' quality of life. By addressing diverse preferences—whether through digital support, physical companionship, or environmental adjustments—this approach ensures that a broad range of needs are met. Recognizing the multifaceted nature of mental health, it offers holistic support by considering emotional, social, and environmental factors. The system's 24/7 accessibility provides users with immediate help, fostering a sense of security and encouraging

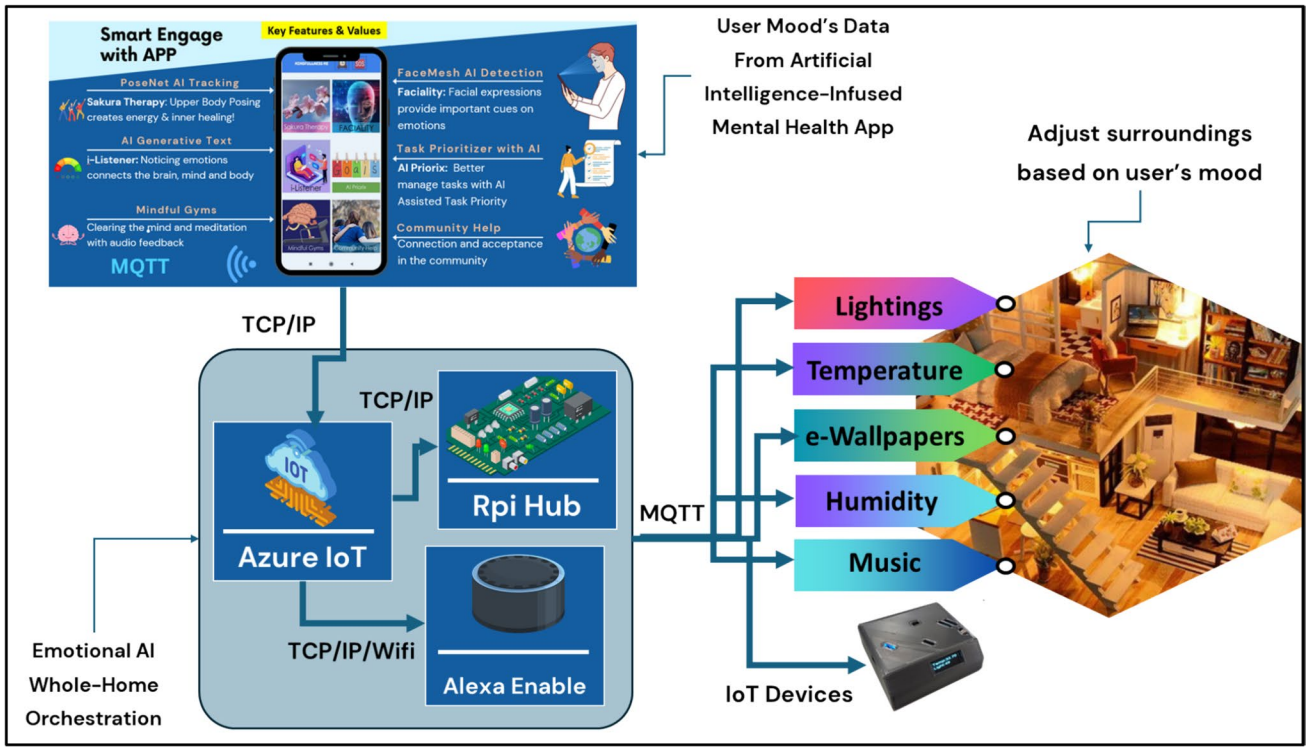


Fig. 3 Flow chart of the "Emotional AI Whole-Home Orchestration" receiving User Mood's data from "Artificial Intelligence Infused Mental Health App"

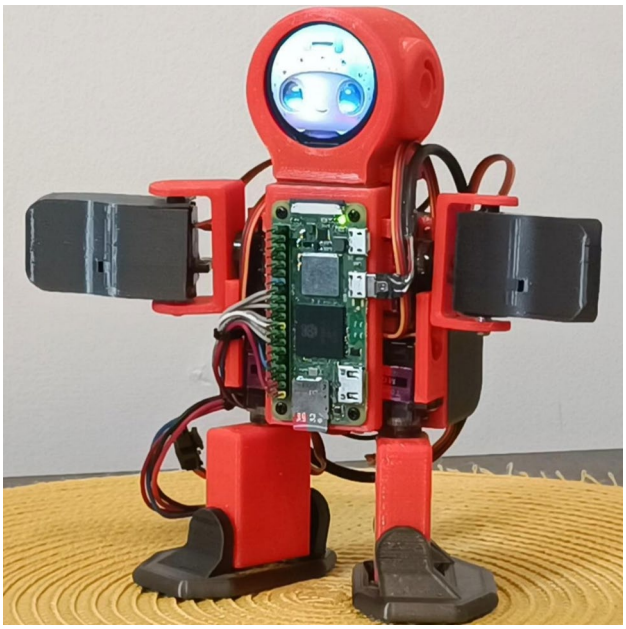


Fig. 4 Humanoid robot companion, also known as "Emogen," in its startup default mode

proactive engagement with their mental well-being. Ultimately, this interactive model promotes self-awareness, emotional resilience, and long-term personal growth.

Artificial Intelligence–Infused Mental Health App

The mental health app serves as a central hub for users, providing immediate access to mental health resources, mood tracking, and personalized coping strategies. Leveraging artificial intelligence, the app can analyze user data to offer tailored recommendations and interventions based on individual emotional states. This ensures that users receive support that is relevant to their specific circumstances, promoting engagement and fostering a sense of agency in managing their mental health.

Existing mental health assessments in the public domain employ personalized questionnaires and scoring systems for different mental health issues. In this project, rather than relying on lengthy and complex questions to understand someone's emotional well-being, a scoring system based on facial expressions, emotion selections, chatbot interactions, and reaction speed on a daily basis is implemented. This approach creates an emotional health index, saved daily for automatic journaling, enabling users to track their emotional health over time while recording major events that trigger emotional changes through artificial intelligence.

Sakura Therapy

In my project, Sakura Therapy is incorporated to connect individuals with nature, leveraging the therapeutic effects of natural environments. Sakura Therapy recognizes the multifaceted benefits of exercise that extend beyond physical health, significantly impacting mental well-being. Regular exercise can reduce stress, enhance memory, improve sleep, and elevate mood, addressing conditions such as depression and anxiety. Sakura Therapy offers a unique approach by channeling energy through simple upper body movements, symbolizing the act of reaching for a beautiful sakura flower. This symbolism enhances the therapeutic experience, making it both engaging and beneficial for users.

i-Listener

i-Listener reduces reliance on clinical assessments by enabling users to make independent evaluations. The "i-Listener vs. Conventional PANAS" study compares AI-based assessments with traditional PANAS self-assessment methods. Participants, aged 17–21 from urban areas in Kuala Lumpur and Petaling Jaya, come from diverse educational backgrounds and ethnic groups, including Chinese, Malay, and Indian. This diversity provides insights into how different cultural, social, and environmental factors influence emotional experiences. However, a key limitation of the study is the small sample size, which may affect the generalizability of the results.

Table 1 presents data from 10 participants, each providing ratings for 10 positive and 10 negative emotions on a 1 to 5 scale. The conventional PANAS method necessitates external assessment, requiring significant time and effort to evaluate the final state of emotions based on the Positive and Negative Affect scores. This process underscores the efficiency and potential benefits of utilizing AI systems like i-Listener for emotional assessment and support.

Using the i-Listener AI integrated assessment, post-data is collected through an AI-assisted self-assessment PANAS with 24 emotion elements via a smartphone. This method generates the final evaluation of the emotional state independently, eliminating the need for external assessment. Additionally, the system provides generative AI DALL-E abstract art as a conclusion on the user's emotional state, offering both text explanations and pictorial representations.

Figure 5 shows a screenshot of the i-Listener-generated AI result based on the user's input. Figure 6 presents a bar chart of i-Listener assessments from November 2023 for 10 individual users, detailing their emotion scores and generated assessment statements. This chart, created using Power BI and Microsoft Azure data, demonstrates the integration of i-Listener with Data Analytics Power BI.

Table 1 Conventional PANAS data

Participant	List of emotions																			Positive Affect	Negative Affect
	Interested	Excited	Strong	Enthusiastic	Proud	Alert	Inspired	Determined	Attentive	Active	Distressed	Upset	Guilty	Scared	Hostile	Irritable	Ashamed	Nervous	Jittery	Afraid	
I	4	5	3	1	2	4	2	5	4	3	1	2	5	1	3	1	4	2	4	3	**33**	**26**
II	2	1	4	2	5	3	5	3	1	4	3	5	1	2	4	5	2	1	3	1	**30**	**27**
III	5	4	2	5	3	1	4	1	2	5	2	1	4	3	2	3	5	4	1	4	**32**	**31**
IV	3	3	5	4	1	5	1	4	5	2	4	3	2	5	1	4	3	5	2	1	**33**	**35**
V	1	2	3	1	4	2	3	2	5	1	5	4	3	4	2	3	1	2	5	3	**24**	**34**
VI	5	5	4	3	1	3	2	5	2	3	3	5	2	1	4	1	5	3	1	2	**33**	**27**
VII	4	1	2	4	5	5	3	1	3	2	1	2	3	4	5	2	4	1	3	4	**30**	**29**
VII	3	2	5	2	4	4	1	3	5	1	2	1	4	5	3	5	2	4	2	1	**30**	**34**
IX	2	3	1	5	3	2	5	4	2	4	4	3	1	2	4	3	5	1	5	2	**31**	**30**
X	1	4	3	2	5	1	4	3	4	5	3	4	5	3	1	2	1	3	2	4	**32**	**28**

Figure 7 provides an overall data analysis for a participant, labeled "Person1," over a 60-day period. Similarly, Fig. 8 details the mental health index analysis for "Person1" across the same duration. This long-term data recording and evaluation capability is valuable for clinical studies, as it forecasts a person's overall mental health based on accessible long-term records.

To ensure data security, the mental health data is stored in Google Sheets using encrypted API protocols upon the user's app input. User privacy and confidentiality are protected by not displaying or storing real names alongside the data; instead, each user is assigned a unique number. This approach ensures personal identities remain confidential while enabling effective data management and analysis. This method adheres to stringent privacy standards and safeguards, ensuring that sensitive information is handled responsibly and ethically in line with best practices for data protection in mental health research and service provision.

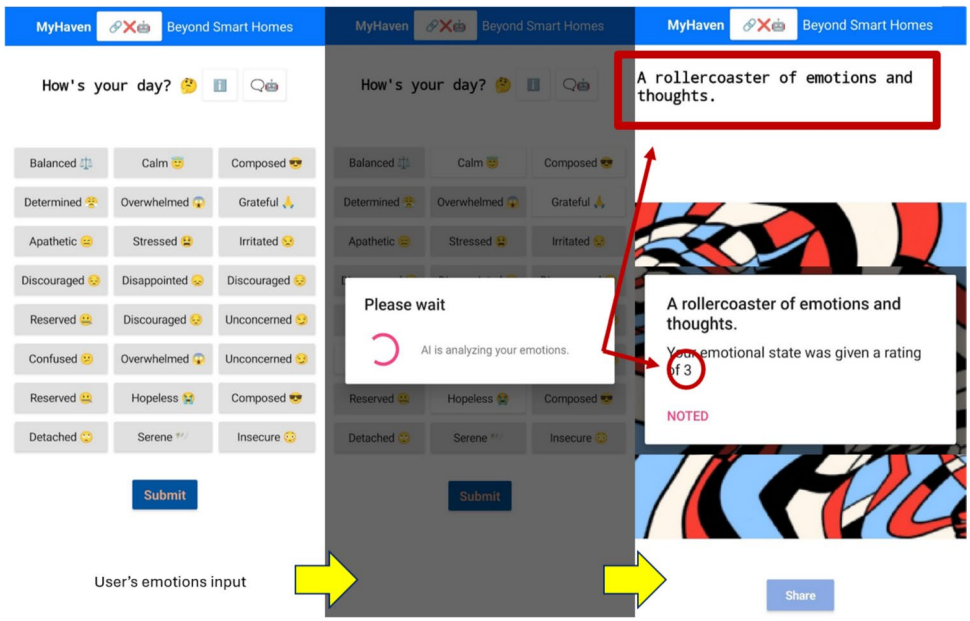
Usability surveys will assess participants' experiences with the AI system, including ease of use, satisfaction, and any challenges encountered, helping us understand the system's user-friendliness and identify areas for improvement. Usability surveys will evaluate participants' experiences with the AI system, focusing on ease of use, satisfaction, and any challenges encountered. While these insights will help us assess the system's user-friendliness and identify areas for improvement, the findings may be limited due to the relatively small number of participants, which could affect the generalizability of the results.

Faciality

This project leverages AI-powered facial recognition using Google's MediaPipe FaceMesh model, which detects over 468 facial landmarks with high accuracy to perform the FACS coding expressions. Optimized for real-time use, MediaPipe excels in predicting 3D facial landmarks from 2D images, making it ideal for applications like facial expression analysis, AR, and health monitoring.

Faciality enhances traditional methods with AI, offering instant feedback by analyzing facial expressions in real time. AI also gauges users' emotional states and manages task priorities, making the app more responsive. Its advanced AI capabilities, combined with hardware support, provide a competitive edge in mental health management. In Table 2, a summary of results from three participants is presented alongside detailed observational data, facilitating the interpretation and analysis of facial expressions with an observer present.

In Faciality, traditional observational methods are enhanced with AI-driven facial recognition technology. The app utilizes advanced algorithms to analyze facial expressions in real time, providing instant feedback to the user.



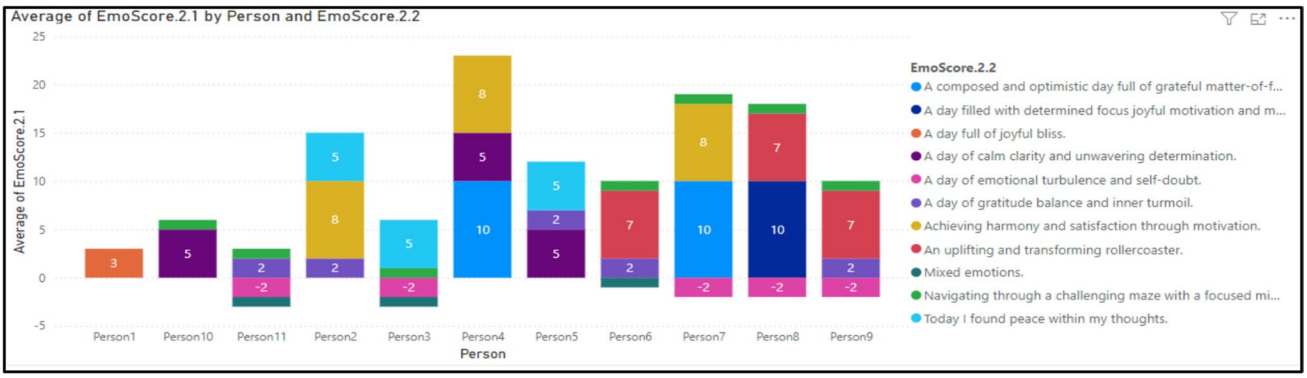


Fig. 5 Screenshot of i-Listener generated AI result upon user's input

Fig. 6 Bar chart of i-Listener assessments in November 2023 on 10 individual users with their emotion scores and assessment statements generated. The chart is generated on Power BI using Microsoft Azure data

The Joke Mode When Faciality is launched, the FaceMesh AI detection system initiates. Once loaded, it tracks the mouth opening as "Laughable Magnitude." By clicking the "Joke" button, the app assesses the user's mental state: a healthy mental state often correlates with an easy laugh response. A summary of the expression is generated alongside as illustrated in Fig. 9.

Cute Image Mode This mode gauges the feeling of warmth and assesses facial action units (AU) for a big smile when viewing "adorable" pictures. The images are created by DALL-E Generative AI through random adorable prompts.

The chart in Fig. 10, the "Laugh Meter," shows that a high magnitude equals a bigger mouth opening. This provides a visual cue of the user's mental state tendency over approximately 50 s. These records can be employed for long-term clinical observation, allowing for continuous monitoring and analysis of emotional expressions and trends. By capturing data from both the app and smart home systems, a line chart is generated over time, illustrating users' emotional ratings on specific days. Augmented by artificial intelligence, a personalized daily summary is also crafted, offering users insights into their daily experiences, as illustrated in Fig. 10. This auto-journaling system provides a comprehensive view of emotional well-being and encourages valuable self-reflection. This auto-journaling system holds a pivotal role, enabling smart home systems to dynamically adapt settings based on users' feelings and needs. Leveraging machine learning, the system strives to optimize the living experience and environment for the user, creating a more responsive and adaptive support system.

The app's personalized insights play a crucial role in empowering users to actively manage their mental well-being as illustrated in Fig. 11. Tailored recommendations and support foster a sense of ownership over their mental health journey, potentially revolutionizing proactive engagement and self-care.

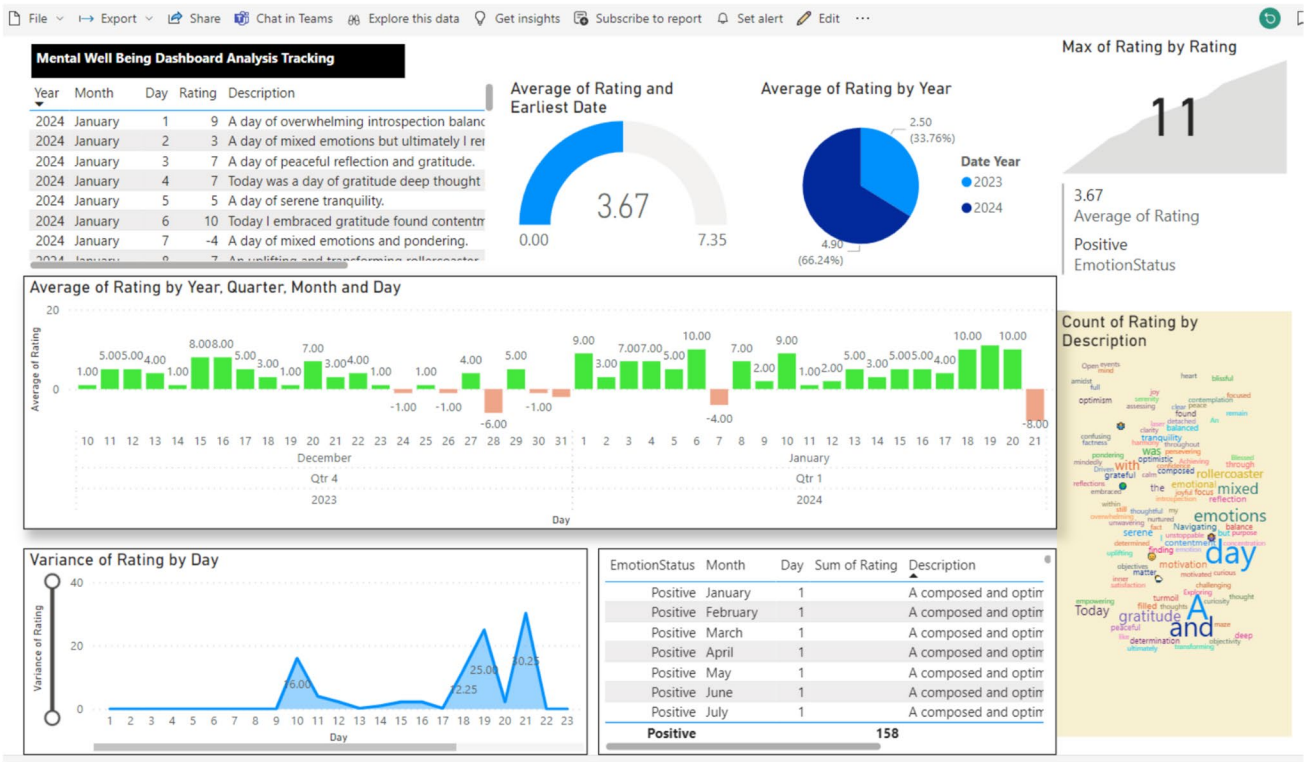


Fig. 7 Overall data analysis across one participant "Person1" across 60 days

Fig. 8 Data analysis of mental health index of participant "Person1" across 60 days

Table 2 Result summary of three participants alongside detailed observational data, facilitating interpretation and analysis of facial expressions in front with an observer

Participant	AU1 (frequency)	AU2 (intensity)	AU3 (duration)	AU4 (frequency)	Facial summary
Participant 1	12	3	5 s	8	Expressive with moderate intensity and varied duration
Participant 2	5	2	3 s	4	Minimal expression with low intensity and short duration
Participant 3	8	4	7 s	6	Expressive with high intensity and longer duration

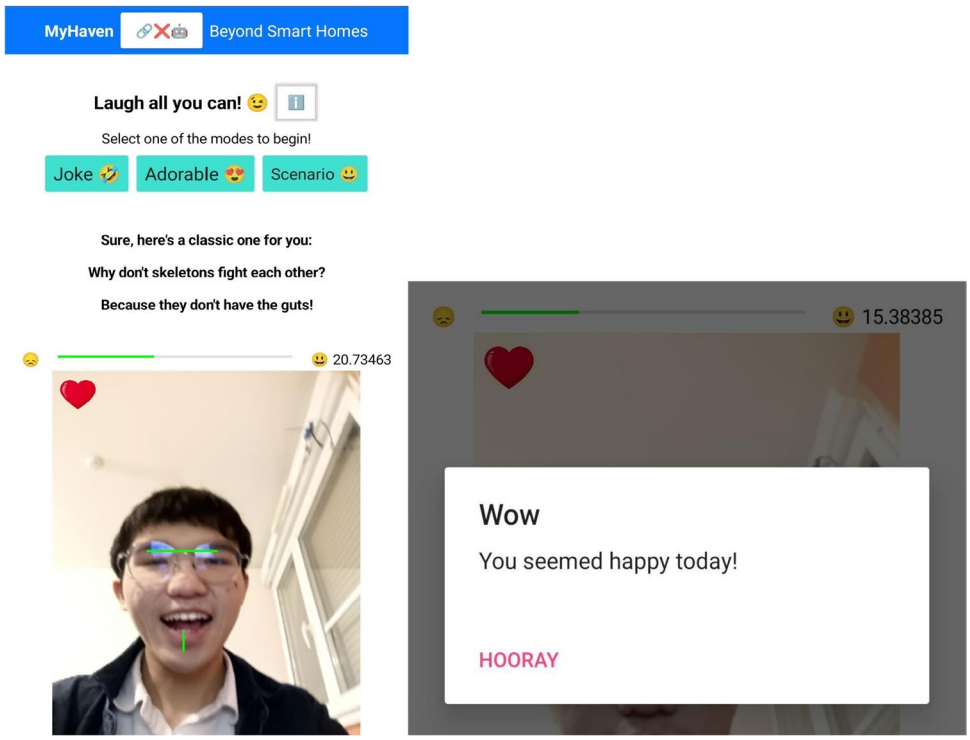


Fig. 9 Screenshot during Faciality—Joke Mode

Faciality enhances traditional methods with AI, offering instant feedback by analyzing facial expressions in real time. AI also gauges users' emotional states and manages task priorities, making the app more responsive. Its advanced AI capabilities, combined with hardware support, provide a competitive edge in mental health management. Beyond its features, the app promotes mental health awareness, inclusivity, and compassion, aligning with broader societal goals for a healthier, happier world.

AI Priorix

AI Priorix provides users with practical strategies for managing difficult situations, especially in task prioritization. By applying the Eisenhower Principle, AI Priorix, in conjunction with Assisted AI, helps users effectively organize and rank tasks based on urgency and importance. This streamlined approach is essential for reducing stress and boosting productivity, which in turn supports overall mental well-being. The integration of this functionality highlights the app's capacity to not only aid in mental health management but also improve users' daily organizational skills and stress management.

Mindful Gyms

Mindful Gyms offer a platform to integrate the extensive and lasting benefits of meditation into daily life. Meditation reduces stress, enhances self-awareness, fosters social connections, sharpens focus, and promotes self-compassion. By providing a structured environment for practicing mindfulness, Mindful Gyms help users harness these advantages and improve their overall mental health.

Community Support

The app's core value lies in early detection and prevention, using interactive assessments to help users identify

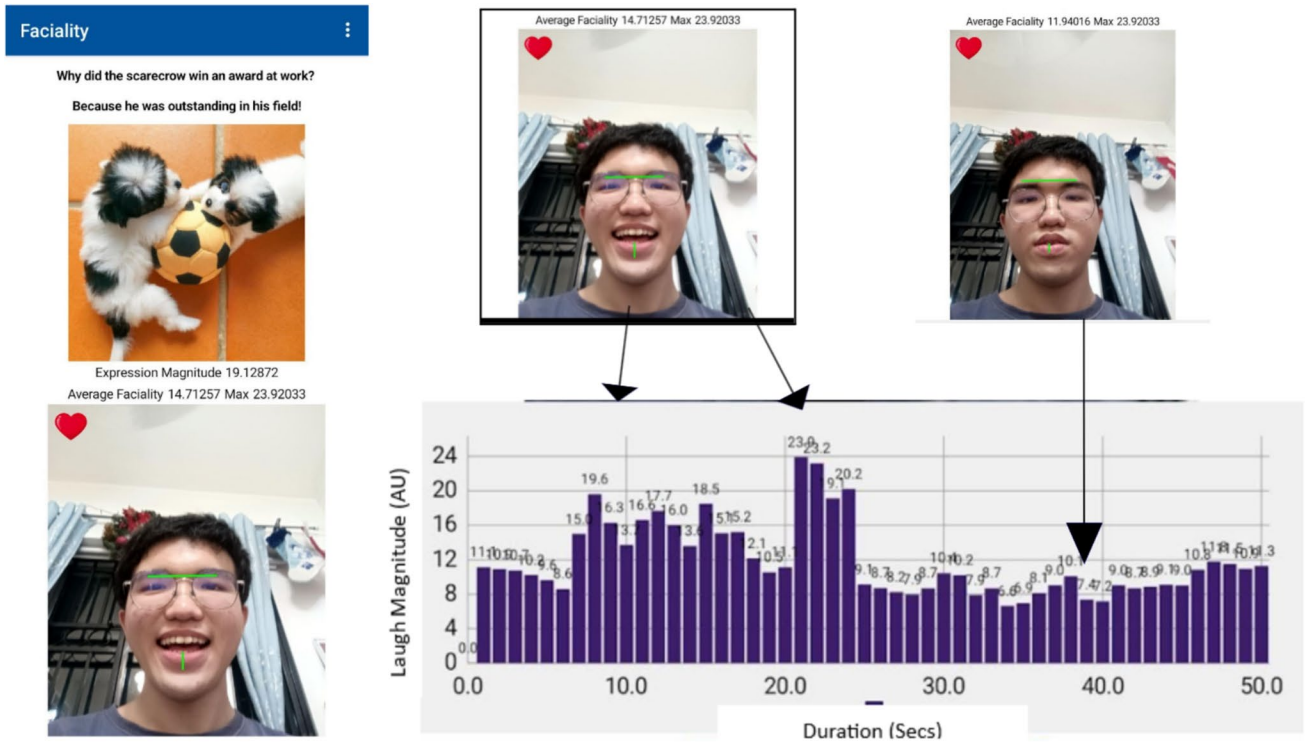


Fig. 10 Faciality records and analyzed facial expression with AI over time while in cute image mode

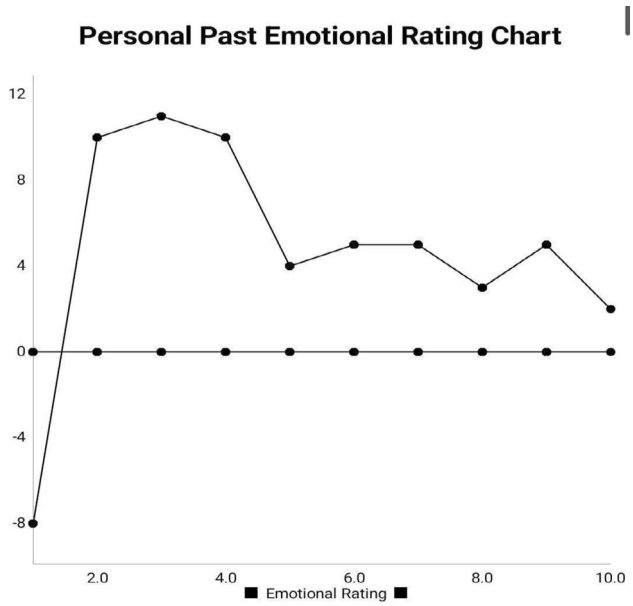


Fig. 11 Sample visual representation in app illustrating historical personal emotional ratings

and address mental health issues before they escalate. This proactive approach improves outcomes and reduces long-term suffering. Integrated stress relief and happiness activities offer practical tools to manage stress and enhance well-being.

As an educational resource, the app combats stigma and fosters connections through social features. It analyzes mental health data to detect potential crises, such as severe mood changes, and triggers emergency alerts to provide immediate access to hotlines, professionals, or local services. Personalized support resources and community groups are recommended based on users' location and age. Additionally, the app includes emergency resources, progress tracking, physical exercises, and mood sensing, encouraging social interaction and self-improvement. With data visualization and timely alerts, it offers a comprehensive, personalized mental health support system that promotes emotional well-being and connection within the community.

Emotional AI Whole-Home Orchestration

The smart home system features a personalized dashboard, allowing users to adjust parameters conveniently via the Internet. Utilizing Internet of Things (IoT) and Message Queuing Telemetry Transport (MQTT) technology, the Raspberry Pi serves as the hub, establishing connections with designated devices and issuing commands based on the user's emotional state. The intuitive dashboard, as illustrated in Fig. 12, enables users to manually fine-tune settings as needed. Behind the scenes, the emotional AI processes the user's emotional data to enhance the living environment seamlessly. Current customizable home adjustments include temperature, lighting, music, humidity, and control of a

humanoid robot, providing a user-centric and emotionally responsive habitat. Figure 12 demonstrates the Node-Red programming implementation flow for the "Emotional AI Whole-Home Orchestration." This flow receives the user's mood from the app and various home sensors, making appropriate mood changes for the smart home environment.

Figure 13 shows the Node-Red online dashboard for both manual and autonomous smart home system and emotional

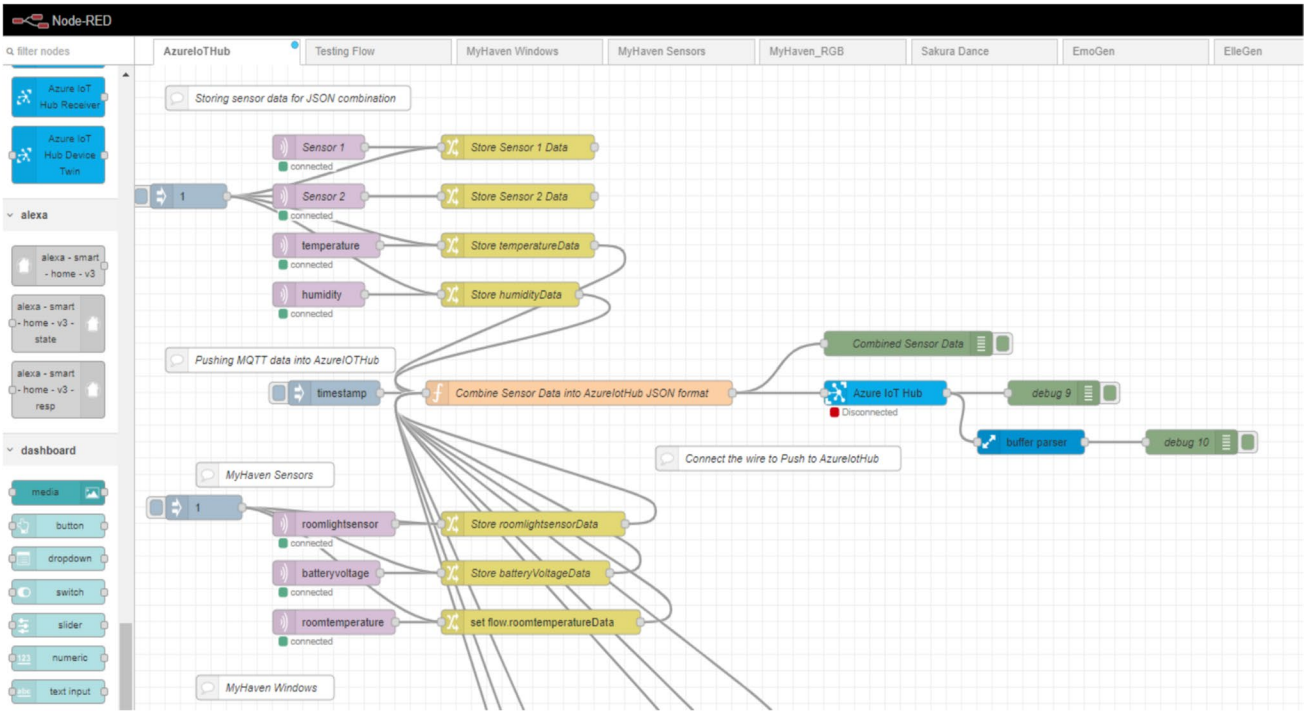


Fig. 12 This is the Node-Red programming implementation flow for "Emotional AI Whole-Home Orchestration" which receives the user's mood from the apps and various home sensors and makes appropriate mood changes for the smart home environment

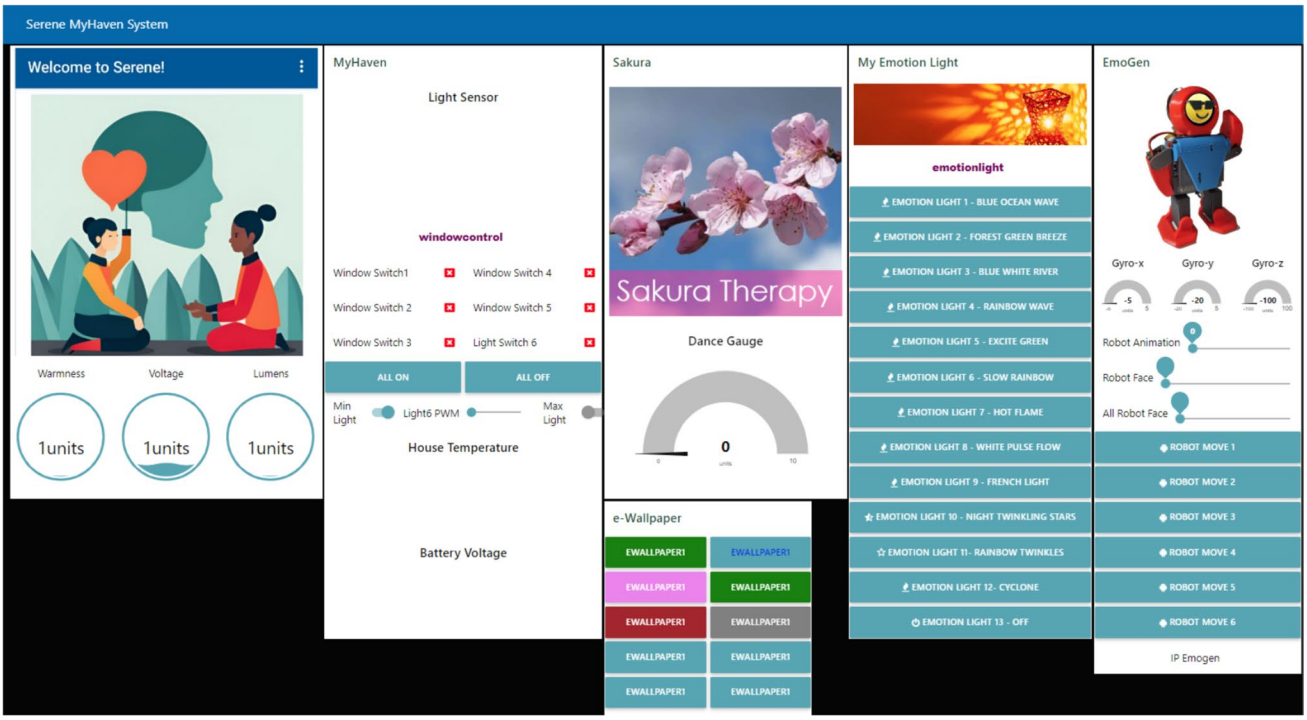


Fig. 13 NodeRed Online Dashboard for manual and autonomous Smart Home System and Emotional AI

AI adjustments. Figure 14 illustrates how sensors feed data into the Raspberry Pi hub, which is then recorded into Microsoft Azure and analyzed using Data Analytic Power BI, creating emotionally supportive environment records. A prototyping concept using a miniature house was developed to demonstrate the Emotional AI Whole-Home Orchestration. Figure 15 illustrates a common house setup with single lighting per chamber, showcasing the smart home control capabilities.

Figure 16 depicts the e-Wallpaper changing still images, with the lights turned off, while Fig. 17 shows the curtains opening to create more natural, soothing lighting. These features collectively offer a smart home system that not only enhances the living environment but also responds dynamically to the user's emotional state, thereby fostering a supportive and adaptive living space.

The Emotional AI Whole-Home Orchestration component integrates with smart home technology to create an environment that responds to users' emotional needs. By utilizing sensors and AI algorithms, the system monitors changes in emotional states and adjusts the home environment—such as lighting, music, or temperature—to foster a calming atmosphere. This integration enhances

Fig. 15 Using a miniature house to show how smart home control can improve lighting and display e-Wallpaper that changes images or videos based on the user's mood

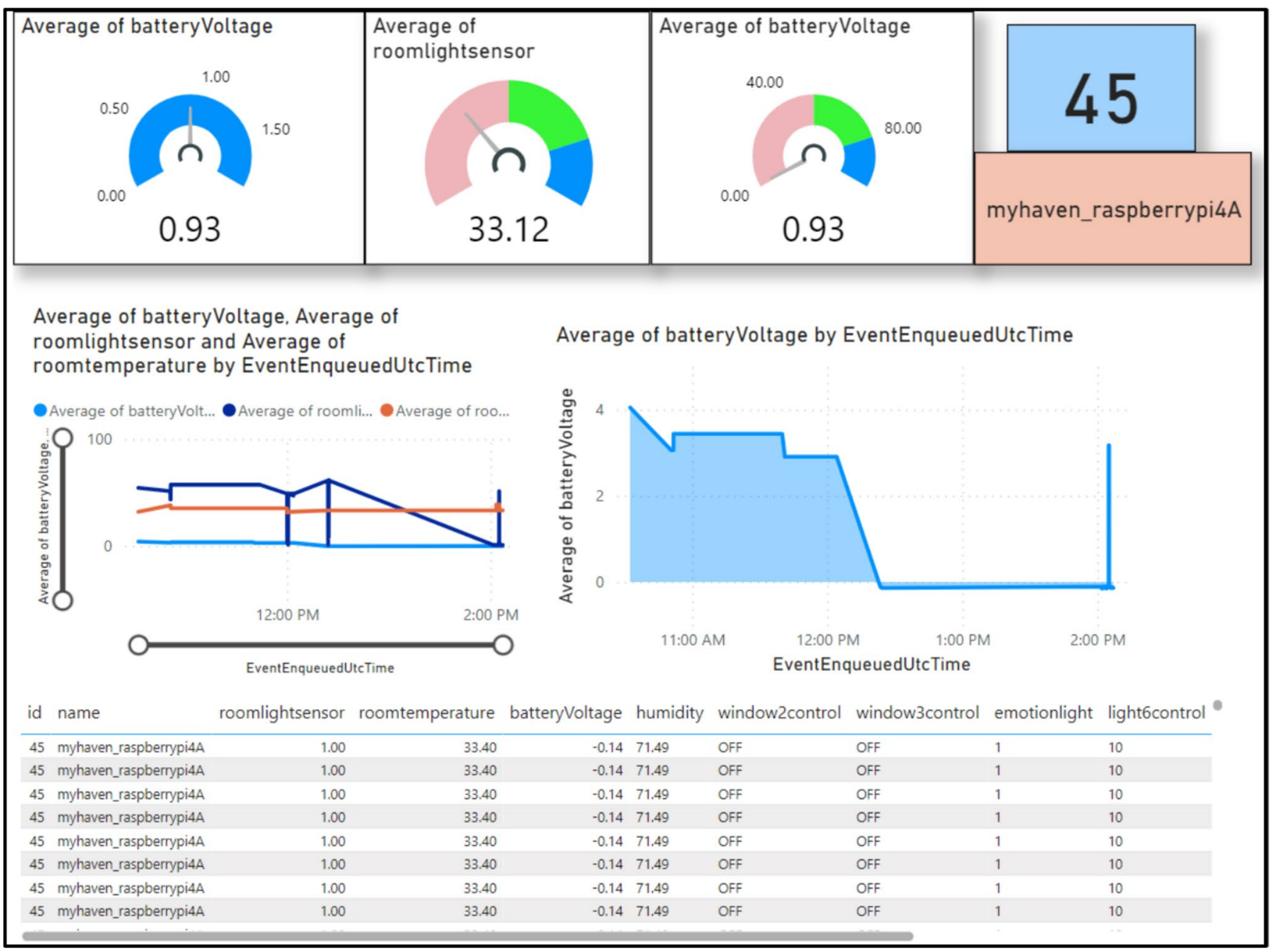


Fig. 14 Sensors feed into Rpi Hub, which later record into Microsoft Azure and analyze using Data Analytic Power BI creating emotionally supportive environment records

Fig. 16 e-Wallpaper changing still images. Lights are off at this moment

Fig. 17 Curtain open to create more natural soothing lighting

daily life by making emotional support readily accessible, significantly reducing stress and anxiety while promoting overall mental well-being.

AI and machine learning enable smart homes to better understand user emotions. Natural Language Processing (NLP) algorithms analyze speech patterns and sentiment, providing insights into emotional states. This data allows homes to dynamically adjust settings in real-time, such as changing lighting or suggesting mood-enhancing activities. Robust privacy and security measures, including encryption for data transmission and storage, safeguard sensitive emotional information. This comprehensive integration transforms the home environment from simple automation to a personalized, emotionally responsive living space that actively supports users' emotional wellness.

Interactive Empathetic Companion

The interactive empathetic companion has been successfully developed as a 3D-printed humanoid robot equipped with nine degrees of freedom (DOF), enabling a wide range of fluid and expressive movements. This innovative robot has been designed to enhance emotional engagement and provide supportive interactions, showcasing its potential as a valuable tool in mental health care. Demonstrations have effectively highlighted the robot's capabilities, leveraging the MQTT control activation protocol from the AI-infused mental health app. This allows for real-time communication between the app and the robot, ensuring responsive and adaptive interactions tailored to user needs.

Figure 18 illustrates the robot performing a "side moonwalk," a playful and engaging movement initiated through commands sent from the app using the MQTT protocol. This not only showcases the robot's agility but also its ability to respond to emotional cues in an interactive manner. Figures 19 and 20 depict the seamless integration of the humanoid robot within the Emotional AI Whole-Home Orchestration system, demonstrating how the robot can adapt its behavior based on the user's emotional state and environmental context. This integration underscores the potential of combining robotic companions with smart home technologies to create a responsive living environment that prioritizes emotional well-being.

The humanoid robot features an interactive multi-emoji display and advanced artificial intelligence, including Alexa-enabled capabilities, allowing it to intuitively understand and respond to users' emotions. More than just a technological device, the robot serves as a perceptive and empathetic companion, finely attuned to the nuances of human emotions. This synergy between the app and the humanoid robot creates a dynamic support system that enriches the user's mental health journey through personalized and empathetic engagement.

The interactive empathetic companion adds an extra layer of emotional support. It engages users in conversation, offers companionship, and provides encouragement through its empathetic interactions. Leveraging advanced natural language processing and emotional recognition, the companion responds in a personal and supportive manner. Its physical presence helps alleviate feelings of loneliness and isolation, particularly for individuals hesitant to seek help. Through these innovations, the interactive empathetic companion represents a promising development at the intersection of robotics and mental health, opening new avenues for emotional support and engagement in daily life.

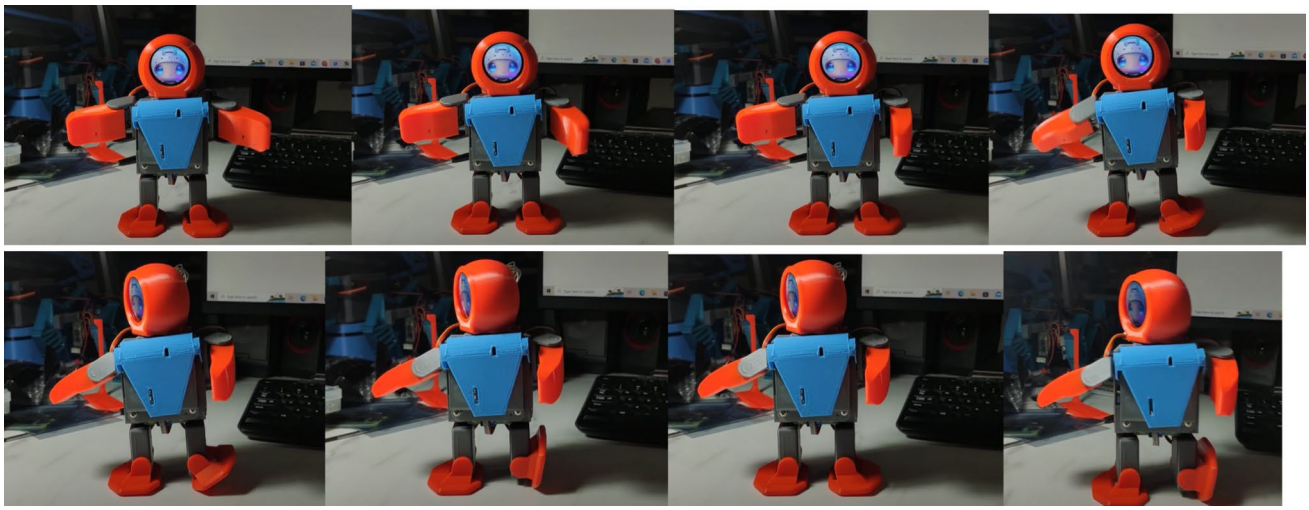


Fig. 18 The robot performs a "side moonwalk" using commands from the AI-infused mental health app via MQTT

Fig. 19 Humanoid robot integration with Emotional AI Whole-Home Orchestration

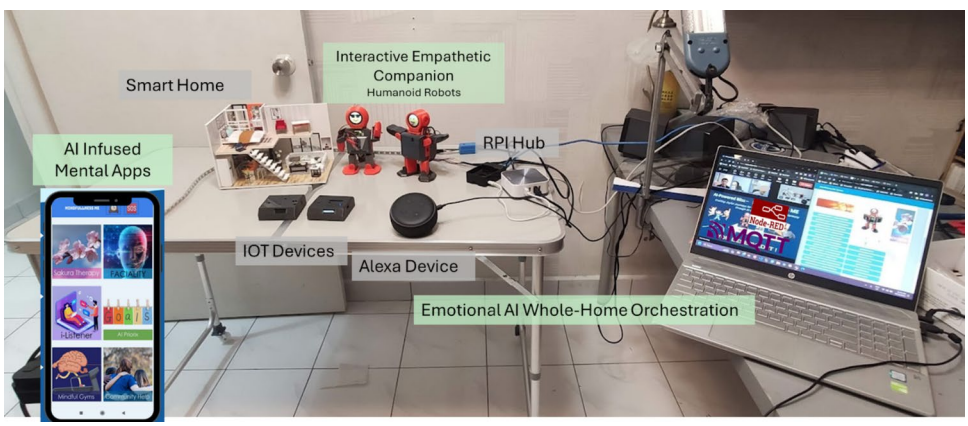


Fig. 20 Successfully built and integrated the entire system AI Infused Mental Apps + Smart Home + Humanoid

Conclusions

The integration of a mental health and well-being app into the broader healthcare landscape marks a significant advancement in technology and a crucial step toward addressing the complex challenges of mental health. The app's mission to provide value to the community is grounded in a deep understanding of mental health issues and the transformative potential of personalized, accessible support.

By leveraging the latest advancements in AI and machine learning, this mobile app aims to revolutionize how we tackle mental health challenges. It offers tools for early detection, intervention, and ongoing support, democratizing access to mental health resources while enhancing care quality through personalization. In a time when mental health issues are on the rise and stigma often deters individuals from seeking help, the app plays a vital role in breaking down barriers to care and fostering a culture of understanding and compassion. However, integrating AI into mental health care comes with ethical challenges, particularly in preserving the human element of care. It is essential to navigate these challenges with a commitment to ethical principles, ensuring that AI technologies respect individual privacy, promote equity, and enhance human interactions. By doing so, the app can model how technology can improve mental health outcomes while maintaining a compassionate and human-centric approach.

This innovative project addresses the global decline in mental health, intensified by the pandemic, economic struggles, and social isolation, aiming to bridge the significant care gap for underserved populations. By blending technology with human compassion, the app fosters inclusive, effective, and personalized support. Key components include an AI-driven smart home system that adapts to emotional states, an auto-journaling system for self-reflection, and the integration of a humanoid robot as a companion, empowering individuals to take charge of their mental well-being.

While the study involves a small sample of urban students from diverse backgrounds, it captures a wide range of emotional experiences, highlighting the project's relevance in tackling various mental health challenges. This endeavor not only aims to stimulate dialogue and ongoing research at the intersection of technology and mental health but also aspires to contribute to the development of effective interventions in an increasingly digitized society.

The success of the mental health and well-being app lies in its comprehensive approach, integrating smart home technology, auto-journaling features, and empathetic companionship to provide personalized support. Statistical data demonstrates the app's positive impact on users' emotional well-being, underscoring its transformative potential in the evolving mental health landscape. As we progress, this project represents a significant step toward enhancing mental health support, fostering resilience, and cultivating well-being within our communities.

In conclusion, the incorporation of statistical data further substantiates the AI system's effectiveness in enhancing emotional wellness, emphasizing the app's transformative potential. As the field of mental health technology evolves, it is imperative to uphold ethical standards and prioritize human connection. By stimulating ongoing conversation and research at the intersection of technology and mental health, this project seeks to address the urgent need for enhanced support, paving the way for a healthier and more compassionate world.

Data Availability The data that support the findings of this study are available from the author upon reasonable request and with permission.

Declarations

Competing Interests The authors declare no competing interests.

Disclaimer The views expressed in this presentation are those of the author and do not necessarily reflect the position or policy of the US Department of Veterans Affairs or the United States government.

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