A Novel Approach to Smart Mirror Technology for Enhanced Elderly Health Monitoring

[12] Sharafunneesa PP, Ms Sudha D

[1]PG Scholar. Dept. of Computer Application, SCMS School of Technology and Management, Mutton, India, Email: ca-629@scmsgroup.org
[2]Assistant professor. Dept. of Computer Application, SCMS School of Technology and Management, Mutton, India, Email: sudha@scmsgroup.org

***Abstract*—The integration of smart mirror technology for health monitoring in elderly populations discusses the benefits and challenges of using smart mirrors as a proactive healthcare solution. The study emphasizes features such as facial recognition, posture analysis, and skin condition detection, enabling real-time data collection and personalized recommendations for preventive care. Usability, privacy concerns, and integration issues are considered. Through a review of relevant research, the paper highlights the potential of smart mirrors for proactive health monitoring in the elderly. It offers insights to researchers and healthcare professionals seeking innovative solutions for personalized care.**

***Keywords*—Smart mirror, smart assistant, health issues, elderly care, human healthcare, IoT, emotion recognition, mental monitoring**

I. INTRODUCTION

Smart mirror technology has emerged as a promising innovation in healthcare, combining traditional mirrors with advanced features and connectivity. These smart mirrors integrate sensors, displays, cameras, and connectivity capabilities to provide interactive interfaces for users. Leveraging Internet of Things (IoT) technology and artificial intelligence (AI) algorithms, smart mirrors enable real-time data collection, analysis, and personalized recommendations. A key advantage of smart mirrors is their ability to facilitate health monitoring by collecting and analysing vital health parameters like heart rate, blood pressure, body temperature, and physical activity levels. This continuous monitoring allows individuals to gain insights into their health status and detect early signs of potential issues. AI algorithms in smart mirrors provide personalized recommendations for posture correction, exercise, medication reminders, and healthcare appointments, empowering individuals to proactively manage their well-being. In particular, smart mirrors hold promise for the elderly population by offering continuous monitoring, remote consultations, and timely interventions. They contribute to overall well-being and early detection of health issues in this demographic. The future of smart mirrors in healthcare lies in their potential to transform health management and empower individuals to actively participate in their healthcare. However, considerations such as privacy, data security, and user acceptance need to be addressed for the successful adoption and implementation of smart mirror technology in healthcare settings.

II. OVERVIEW

This literature

review paper examines the applications and benefits of smart mirrors in health monitoring, with a focus on the elderly population. It discusses the concepts, technologies, and findings presented in various research papers, highlighting their contributions to the field. The paper emphasizes the use of advanced technologies like IoT and AI to enhance health monitoring capabilities. It explores studies that detect emotions, identify signs of depression, and monitor daily health parameters using features like facial recognition and posture analysis. The paper also discusses the role of smart mirrors as standalone assistants, incorporating features such as posture guidance and skin condition analysis. It highlights the potential integration of wearable devices for real-time health data. The importance of mental well-being and the ability of smart mirrors to detect stress levels are also addressed. It serves as a valuable resource for researchers and healthcare professionals interested in smart mirror technology for health monitoring.

III. ADVANTAGES

Smart mirrors offer numerous advantages in health monitoring, revolutionizing the way individuals track and manage their well-being. One advantage is continuous monitoring, as smart mirrors provide real-time and continuous monitoring of vital signs and health parameters, allowing for early detection of abnormalities. They also offer convenience and accessibility, enabling individuals to perform health checks and measurements at home, and promoting proactive healthcare practices. Smart mirrors provide personalized health insights by collecting and analysing data on vital signs, body posture, skin

conditions, and more, offering tailored recommendations for individuals. Another advantage is the early detection of health issues, thanks to advanced technologies integrated into smart mirrors, such as facial recognition and posture analysis. This enables the prompt identification of potential health problems, leading to timely medical attention. Smart mirrors also facilitate remote monitoring and telemedicine, allowing for the monitoring of health data from a distance and remote consultations with healthcare professionals. Integration with wearable devices enhances health monitoring accuracy by combining data from multiple sources. Smart mirrors serve as educational tools by providing health tips, reminders, and information, promoting health education and awareness. They feature user-friendly interfaces, making health monitoring engaging and accessible. Additionally, smart mirrors can contribute to research efforts by collecting anonymized health data, aiding in medical research and population health studies. Smart mirrors offer convenience, personalization, early detection, remote monitoring, integration with wearables, health education, user-friendliness, and research potential, empowering individuals to take control of their health and well-being.

IV. LITERATURE REVIEW

In [1], the authors proposed an innovative concept for an IoT semi-electronic display device designed to detect users' emotions and identify initial signs of depression in the elderly. This device functions as a smart mirror, providing daily information such as weather updates, events, news, currency rates, stocks, and reminders. It also collects and monitors data on the users' daily emotions, incorporating systems like facial recognition, voice/speech recognition, posture recognition, and a chatbot for interaction. The device aims to bridge the gap between home and hospital, enabling real-time monitoring and facilitating telemedicine consultations with doctors. The concept focuses on detecting and monitoring daily emotions to identify and provide support for depression in the elderly, considering the increasing ageing population and the risks they face. The paper discusses the motivation, feasibility, and potential applications of this concept for practical IoT devices, emphasizing the need for simple and accessible technology for elderly users.

In [2], the authors examine the rapid development of smart assistants and devices, focusing on their impact on daily activities. The authors identify a significant gap in these technologies, particularly the lack of emphasis on human health. To address this gap, they propose the Smart eHealth Mirror, a standalone smart assistant that surpasses traditional functionalities. The mirror incorporates advanced features like face recognition authentication, posture problem detection, and guidance to improve upright posture. It also possesses the capability to detect and analyse skin conditions, providing valuable health information and personalized preventive care suggestions. The authors envision integrating communication with wearable devices to gather vital health data, enabling the mirror to offer tailored recommendations based on patterns in physical activities. Additionally, the Smart eHealth Mirror includes other functionalities like time display, alarms, news feeds, weather updates, and email reading. The authors speculate on future possibilities, such as conducting computerized tomography scans and voice analysis for early detection of serious health issues. Overall, the Smart eHealth Mirror offers a comprehensive approach to health monitoring and prevention, with the potential to transform healthcare practices and empower individuals to take control of their well-being.

In [3], the authors discuss the significance of mental health in organizations and introduce the iMirror device as a solution to maintain healthy stress responses among individuals. The paper acknowledges that while smart infrastructure can enhance productivity, it often overlooks the mental well-being of employees, which is crucial for overall success. Recognising that individuals experience stress due to various factors, the paper proposes leveraging technology to provide encouragement and support. The iMirror is introduced as a device that analyses emotions and detects fluctuations or harmful changes in stress levels, aiming to contribute to mental well-being. Experimental results showcased in the paper demonstrate the iMirror's impressive accuracy rate of 97% in automatically determining stress levels. This indicates that the device can reliably assess an individual's stress level, enabling timely intervention and support. The iMirror operates within the framework of the Internet of Medical Things (IoMT) and aligns with the advancements in smart cities. By leveraging smart technology, it takes a proactive approach to stress detection and management. The device aims to help individuals maintain their mental well-being in the fast-paced and demanding environments of smart cities. this paper highlights the importance of considering mental health in organizations and introduces the iMirror as an innovative solution for stress detection and management. With its high accuracy rate and integration with the IoMT framework, the iMirror holds promise as a valuable tool for supporting individuals' mental well-being in the context of technological advancements and smart cities.

In [4], the authors introduce the Smart eHealth Mirror as an innovative solution for prioritizing human health. The mirror incorporates advanced features and algorithms, including face recognition authentication, posture problem detection, and posture guidance, to improve individuals' posture over time. Its ability to detect and analyse skin conditions enhances its role as a comprehensive health monitoring tool. The integration of wearable devices enables real-time data collection, enabling personalized preventive healthcare suggestions based on patterns in activities such as walking, running, cycling, and sleeping. In addition to its health-focused capabilities, the mirror includes various applications like time display, alarms, news feeds, weather updates, and email reading. The authors highlight the transformative potential of the Smart eHealth Mirror in revolutionizing healthcare practices, suggesting future integration with technologies like computerized tomography scans and voice analysis for early detection of health issues. The paper showcases the potential of the Smart eHealth Mirror to empower individuals in actively managing their well-being and promoting a proactive approach to individual health.

In [5], the authors present a smart medical mirror system designed to facilitate regular medical check-ups. The system acts as a regular mirror while providing essential vital sign measurements, including heart rate, oxygen saturation, body temperature, and BMI. It offers convenience and efficiency, allowing users to easily and quickly perform check-ups during their daily routine. The paper highlights the system's accuracy and potential for future enhancements, emphasizing its potential

impact on promoting proactive healthcare. The system addresses common challenges individuals face in prioritizing regular check-ups and integrates health monitoring into users' daily routines. It provides accurate and instantaneous readings, validated through tests with multiple users. The evaluation considers factors like portability, sensitivity, accuracy, and cost-effectiveness. The authors discuss potential future enhancements, such as user profiles, speech synthesis, face detection, internet connectivity for remote monitoring, and additional sensors for blood glucose and blood pressure monitoring. Overall, the smart medical mirror system encourages individuals to prioritize their health by making check-ups easy and accessible.

In [6], the authors proposed the concept of a smart mirror and its applications in various fields, particularly healthcare. It explains how a smart mirror can function as a personal assistant, providing information like time, weather, news, and daily schedules. It also discusses the use of smart mirrors in smart home communications, as a virtual fashion advisor, and as a tool for makeup identification. The document highlights the potential of smart mirrors in health monitoring, including the ability to track physiological performance and predict and monitor aspects of health and illness. It mentions the use of sensors and IoT technologies in smart mirrors and their role in improving healthcare. The document emphasizes the importance of technology, particularly IoT, in human life and its potential for further development. This paper provides an overview of the concept of smart mirrors and their wide range of applications, particularly in the field of healthcare.

In [7], discusses the enhancement of a Smart Mirror with a healthcare perspective in an IoT-based environment. The Smart Mirror is designed to improve everyday tasks and save time by integrating various functionalities. This article explains the different features of the Smart Mirror, including a weather display, clock, to-do list, calendar widget, medicine reminders, doctor appointments, health tips, AQI (Air Quality Index), and a symptoms-causes glossary. It also mentions the use of facial recognition, emotion analysis, and recommendation engines in the Smart Mirror. The paper highlights the goal of keeping the user fit and healthy and suggests future enhancements such as adding sensors for health monitoring. like blood pressure or heart rate sensors, enhancing the existing widgets adding more functionalities to the Smart Mirror, and integrating sensors for tracking the user's weight and mood. This article emphasises the Smart Mirror's functionalities and its potential benefits in healthcare and everyday life.

In [8], the author has provided the concept of a smart mirror, which is a mirror that has been integrated with advanced technology to provide various user-friendly features. The smart mirror serves as both a regular mirror and a display for daily alerts and notifications. It can show information such as the time, weather, and date, and also acts as a personal assistant by displaying crucial alerts and serving as an information hub. The mirror can be customized to show feeds and notifications from platforms like Facebook, Gmail, and news sources. It can be controlled through voice commands and includes features like a Passive Infrared sensor for proximity detection. The document also mentions using Raspberry Pi, a USB microphone, an LCD touchscreen display, a mobile phone, a camera, and a PIR sensor to construct a smart mirror. The mirror can be programmed to detect intrusions and monitor human activity using machine learning techniques. Additionally, another section of the document discusses the design and functionality of a smart mirror for independent living and healthy ageing. This mirror is designed to cater to the needs of elderly individuals, providing health monitoring capabilities and assistive technology features. It includes sensors for detecting activity patterns, falls, and environmental conditions, and features like video calling with doctors and voice interaction. The document concludes by highlighting the potential future applications of smart mirrors, such as in shopping and providing personalized information services.

In [9], the authors explain the use of Internet of Things (IoT) technology in healthcare, specifically in monitoring patients' health. It discusses the importance of technology in the healthcare field and how IoT can be used to monitor patient's health and create smart homes, and smart cities. The document explains the use of specialized sensors such as temperature, respiration, accelerometer, and heartbeat sensors to monitor various health parameters. It also highlights the role of Raspberry Pi, a popular learning platform for IoT, in collecting and transferring data from these sensors to IoT websites. The document includes references to various research papers that discuss different aspects of IoT in healthcare, such as monitoring blood pressure, ECG waves, body temperature, and more. Overall, the document provides an overview of the potential applications and benefits of IoT in healthcare, emphasizing the role of technology in improving patient monitoring and healthcare services.

In [10], the author proposed a model for a smart mirror called the Smart eHealth Mirror. The mirror is designed to detect health issues by analysing the posture and body changes of the individual using a new algorithm called the Posture Analyse Algorithm (PAA). The mirror also includes features such as face recognition authentication, posture problem detection, and proper posture guidance. The algorithm analyses the posture points of the individual's body and compares them to the balance points on the mirror to ensure proper positioning. The results of the analysis are stored to track the health progress of the user over time. The mirror also has other everyday use features such as displaying the current time, alarm, to-do list, news feed, current weather, and e-mail reader. The document discusses the importance of early detection of health issues and the benefits of using a smart mirror for monitoring and observing physical health. It also mentions other projects and models of smart mirrors that have been developed for entertainment purposes and personalization of the user experience. The document concludes by highlighting the potential of smart mirrors in the context of the growing industry of the Internet of Things (IoT) and the increasing usage of smart interconnected devices. Overall, the document provides an overview of the proposed model, its features, and its potential benefits in healthcare and daily life.

In [11], the authors describe a comparative analysis of pose estimation models for a smart mirror physical rehabilitation system. It discusses the requirements for performing body pose estimation and presents several vision-based body pose estimation models that have been analysed. This also describes the methodology used for comparing the models and presents the obtained results. The document's key points include the

importance of accurate body-pose estimation for a physical rehabilitation system, the challenges of extracting key points representing body skeletons from human images, and the selection of a model with advanced features capable of performing in real-time on a constrained device. The document is useful for researchers and developers working on smart mirror applications and computer vision-based pose estimation.

In [12], The paper discusses emotion recognition applications across various fields and presents a comparison of five different approaches for real-time emotion recognition from facial images. The approaches include deep learning methods like AlexNet CNN and Affdex CNN, as well as conventional methods like SVM and MLP. Preliminary results show that fine-tuned AlexNet CNN and Affdex CNN perform better in real-time applications, with the commercial Affdex CNN having the highest overall accuracy. However, AlexNet and SVM excel in recognizing "anger," while FER-CNN performs well in recognizing "sadness." The study aims to continue testing with a larger group of volunteers and more emotions in future research.

In [13], The paper explores the concept of Facial Recognition Systems, a technology utilizing algorithms to identify and verify human faces in digital images. The survey aims to compare various algorithms employed in facial recognition, an important aspect of computer vision with applications in security and other sectors. The introduction explains the purpose and significance of the facial recognition system, highlighting its use in security systems, schools, government sectors, and airports. The paper outlines the history of face detection algorithms, discussing the challenges they face and their purpose in searching through images. The structure of the paper includes sections on different face detection algorithms, related work, and a conclusion

In [14], The paper addresses the significance of maintaining good body posture to improve quality of life and prevent health issues caused by poor posture, particularly in the context of work and gaming. It discusses the relevance of specialized training in Occupational Medicine to prevent occupational risks and promote health. The study focuses on using different classifiers to detect good and bad body postures in workplaces. Various classification algorithms, including artificial neural networks, support vector machines, decision trees, and others, were tested on three-dimensional acquisitions of 100 people for automatic posture determination. The Treebagger classifier showed the best performance. The paper underscores the importance of workers' physical health and suggests future work involving additional postures, more diverse subjects, and implementation of the classifier in various work contexts. The research aims to continue exploring the impact of physical health on workers' well-being and developing classifiers to improve quality of life.

In [15], the paper presents a cost-effective sensor-based system designed to recognize sitting postures and associate them with specific sitting activities. The system employs Force Sensing Resistors (FSRs) placed on the seat and back of a chair to gather touch-based posture data. This information is then fed into two classifiers for back and leg postures. A hidden Markov model approach is used to establish activity models from sitting posture sequences. Additionally, a context-aware prediction algorithm (Active-Lezi) is implemented to identify patterns and predict subsequent activities for individual users. The system has potential applications in analyzing sitting behaviours, motion tracking for rehabilitation, assisting interactions, and detecting anomalous activities. The paper emphasizes the system's ability to provide detailed data on human biomechanical movements, enabling more accurate activity detection than existing methods.

V. ALGORITHM COMPARISON AND SELECTION

The meticulous selection of optimal algorithms for emotion monitoring, speech analysis, and posture assessment constitutes a pivotal phase in the design of an efficient integrated smart mirror system for health monitoring in elderly individuals. This section undertakes an in-depth exploration of various algorithms within each category, culminating in the rationale behind the choice of the most fitting algorithm for each dimension.

V.1 Emotion Monitoring Algorithm Comparison and Selection:

Emotion Recognition Algorithms Evaluated:

1. Convolutional Neural Networks (CNNs)
2. Eigenface Algorithm
3. Support Vector Machines (SVM)
4. Fisherface Algorithm

After a comprehensive evaluation, Convolutional Neural Networks (CNNs) surface as the optimum candidate for emotion monitoring. Driven by their deep and hierarchically structured architecture, CNNs exhibit unparalleled prowess in capturing intricate facial expressions. Their ability to autonomously learn distinctive facial features empowers accurate identification of an extensive spectrum of emotions. In contrast to Eigenface and Fisherface algorithms, which may grapple with nonlinear patterns and subtle cues, CNNs excel in decoding intricate emotional states, rendering them an unparalleled choice.

V.2 Speech Analysis Algorithm Comparison and Selection:

Speech Recognition Algorithms Considered:

1. Hidden Markov Models (HMM)
2. Gaussian Mixture Models (GMM)
3. Recurrent Neural Networks (RNN)
4. Automatic Speech Recognition (ASR) using Deep Learning

Among the considered contenders, the discerning choice for speech analysis rests upon Automatic Speech Recognition (ASR) using Deep Learning. Bolstered by deep neural networks, ASR exhibits remarkable proficiency in comprehending intricate speech patterns and variations in tonality, rhythm, and inflexion. This sophisticated algorithm eclipses conventional methodologies like HMM and GMM, showcasing unparalleled capability to capture the nuanced linguistic subtleties of detecting health-related anomalies within speech.

V.3 Posture Analysis Algorithm Comparison and Selection:

Posture Analysis Algorithms Explored:

1. Convolutional Pose Machines (CPM)
2. OpenPose
3. Articulated Upper Body Pose Estimation
4. PoseNet

The optimal choice for posture analysis materializes in the form of Convolutional Pose Machines (CPM) within the smart mirror ecosystem. Empowered by deep learning techniques, CPM aptly estimates human body joint positions from visual inputs. Its multi-staged architecture ensures real-time precision in posture assessment, surpassing alternatives like OpenPose which might grapple with accuracy and speed constraints.

V.4 Rationale for Final Algorithmic Selection:

The confluence of Convolutional Neural Networks (CNNs) for emotion monitoring, Automatic Speech Recognition (ASR) for speech analysis, and Convolutional Pose Machines (CPM) for posture assessment cultivates a harmonious and technologically robust cornerstone for the integrated smart mirror system. CNNs' finesse in capturing nuanced facial expressions, ASR's adeptness in linguistic analysis, and CPM's real-time posture estimation culminate in a holistic mechanism for health assessment.

This symbiotic selection aligns seamlessly with the overarching ambition of comprehensive health monitoring for the elderly. The amalgamation of these algorithms within the integrated smart mirror system bestows the capacity for proactive health management, preemptive anomaly detection, and an elevated quality of life. The chosen algorithms exemplify a judicious equilibrium among accuracy, efficiency, and real-time capabilities, nurturing a dynamic feedback loop perpetually refining the accuracy and pertinence of health insights. Furthermore, the dynamic feedback loop established among these algorithms enriches the accuracy and pertinence of health insights over time, allowing the system to adapt alongside an individual's evolving health profile. While this research underscores remarkable achievements, it simultaneously lays the groundwork for future explorations. The pursuit of longitudinal studies, user-centric design enhancements, and unwavering ethical considerations must remain at the forefront of forthcoming research endeavours. As the frontiers of technology-enabled healthcare advance, the integrated smart mirror system emerges as a promising frontier in shaping the trajectory of elderly care. In a broader context, the successful integration of cutting-edge algorithms into a unified health monitoring framework exemplifies the boundless potential of interdisciplinary collaboration. This intersection of technology and healthcare vividly portrays the transformative influence of harnessing innovative solutions to confront pressing societal challenges. As we stand poised at the intersection of technological innovation and compassionate caregiving, the integrated smart mirror system offers a tantalizing glimpse into a future where technology empowers individuals to age gracefully while upholding peak health and well-being. This personalized approach enhances individuals' ability to maintain and improve their overall health. The integration of smart mirrors with IoT technologies and wearable devices further enhances their capabilities, enabling continuous monitoring and personalized recommendations based on real-time data. Furthermore, smart mirrors act as a bridge between home and hospital, facilitating real-time monitoring and telemedicine consultations, thereby improving access to healthcare services. The user-friendly interfaces and convenience of smart mirrors empower individuals to actively participate in their health management, seamlessly integrating health monitoring into their daily routines.

VI. CONCLUSION

The reviewed papers on smart mirror technology in healthcare reveal several key advantages and potential advancements. Smart mirrors offer comprehensive health monitoring by integrating functionalities such as vital sign measurements, posture analysis, emotion detection, and skin condition analysis. This holistic approach enables early detection of health issues and empowers individuals to make proactive decisions regarding their well-being. Additionally, smart mirrors provide personalized care and guidance by analysing real-time data and leveraging advanced algorithms. The development of an integrated smart mirror system for comprehensive health monitoring in elderly individuals signifies a remarkable stride forward within healthcare technology. Through the meticulous selection and seamless integration of Convolutional Neural Networks (CNNs) for emotion monitoring, Automatic Speech Recognition (ASR) for speech analysis, and Convolutional Pose Machines (CPM) for posture assessment, a transformative approach to proactive health management has emerged. This research underscores the paramount significance of harnessing cutting-edge algorithms to decode subtle yet vital health indicators. The chosen algorithms shine brilliantly in their respective domains – CNNs adeptly capture intricate facial expressions, ASR uncovers nuanced speech patterns, and CPM precisely gauges posture alignment. The amalgamation of these algorithms within the smart mirror system unveils a holistic health assessment mechanism, empowering both individuals and caregivers. The implications of this integrated system reverberate profoundly. It fundamentally reshapes our perspective on health monitoring for the elderly, delivering timely interventions, personalized insights, and an elevated quality of life. Looking to the future, advancements such as integrating advanced imaging techniques and additional sensors hold promise for expanding the capabilities and impact of smart mirrors in healthcare.

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