e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:03/March-2025 Impact Factor- 8.187 www.irjmets.com

IOT-BASED HEALTHCARE: A COMPREHENSIVE REVIEW OF VITAL SIGNS AND EMOTION MONITORING SYSTEMS

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DOI: https://www.doi.org/10.56726/IRJMETS70047

ABSTRACT

The convergence of Internet of Things (IoT) technologies and emotion recognition systems has transformed the healthcare sector through real-time tracking and individualized care. IoT devices, integrated with vital signs monitoring sensors, offer continuous monitoring of physiological metrics like heart rate, blood pressure, temperature, and oxygen saturation levels. Meanwhile, emotion recognition systems scan facial expressions, voice tone, and other non-verbal indicators to measure psycho- logical states. The integration of these two areas results in an extensive healthcare framework that addresses both physical and psychological health.

This review summarizes findings from various studies to demonstrate the developments, challenges, and future directions in the integration of IoT and emotion recognition technologies within healthcare. System architectures and paradigms of real- time data acquisition, processing, and analytics are discussed and highlighted for their potential to deliver improved patient outcomes. Challenges, such as security of data, interoperability, and computational power limitations of IoT devices, are presented alongside ongoing solutions like edge computing, federated learning, and lightweight artificial intelligence models.

In addition, the paper highlights gaps in present systems, including the absence of demographic diversity in emotion data sets and the poor scalability of present IoT implementations. It suggests directions for future work in the form of developing diverse data sets, ethical AI paradigms, and resilient, resource- efficient IoT systems. Through filling the gap between patient- centric care and technological advancement, the confluence of IoT and emotion detection systems promises to revolutionize the delivery of healthcare, making it more efficient, accessible, and compassionate.

I. INTRODUCTION

The medical industry is witnessing a paradigm shift, thanks to the confluence of emerging technologies, notably the In- ternet of Things (IoT) and Artificial Intelligence (AI). IoT has been at the forefront in fueling this revolution, allowing for seamless integration of devices and sensors that sense, analyze, and share data in real-time. This has made new avenues possible for patient care and monitoring as well as provision of healthcare, most notably in instances of ongoing monitoring, such as treatment of chronic conditions, geriatric care, and postoperative care [1], [2]. With IoT, healthcare systems can monitor vital signs such as heart rate, temper- ature, blood pressure, and oxygen saturation, hence allowing healthcare practitioners to make very well-informed decisions and respond ahead of potential medical emergencies [1], [3]. While physical health is still the major concern of conven- tional healthcare systems, the role of mental and emotional health cannot be overemphasized. Psychological well-being is a determining factor in the recovery rate, the progres- sion of chronic diseases, and quality of life. For example, chronic stress worsens hypertension and diabetes, whereas positive emotions are associated with higher immunity and healing rates [5], [14]. Emotion recognition systems are thus becoming vital tools for measuring and controlling mental health disorders. Such systems use technologies like facial ex- pression analysis, voice recognition, and physiological signal interpretation to identify emotional states such as happiness, sadness, anger, or stress. The intersection of IoT and emotion recognition systems represents a significant step towards com- prehensive healthcare. With a combination of psychological and physiological monitoring, healthcare systems can provide anticipatory, personalized care. As an example, emotion recog- nition can be supplemented with IoT-based monitoring such that stress or anxiety, manifested as changes in heart rate and blood pressure [5], [14], is identified. Through such an understanding, the provision of care is capable of stepping in where mental and physical

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care are needed, enhancing the well-being as well as outcome of the patient.This research paper integrates findings from different stud- ies on the development of IoT-integrated healthcare systems and emotion detection technologies. It describes basic sys- tem architectures, methods, and applications and determines challenges like data security, device interoperability, and the computational cost of running AI models on IoT devices [7], [9]. In addition, it determines emerging trends like edge computing, federated learning, and light-weight AI models as possible solutions to these challenges.

The discussion also points towards future research that should fill gaps in current paradigms. For example, emo- tion detection datasets of many are less diverse in terms of ethnicity, age, and cultural background, which results in biased outcomes [14], [16]. Similarly, hardware constraints and the absence of well-established communication protocols are hindrances to IoT-based healthcare system scalability [3], [7]. Overcoming such challenges and facilitating multidisci- plinary collaboration, IoT and emotion recognition systems have the potential to transform healthcare and make it more efficient, accessible, and empathetic. This review is meant to present a complete outlook of the current state of IoT and emotion recognition technology in health care. They describe their capabilities to transform the care of patients with some obstacles and opportunities for future innovation and research.

II. IOT IN HEALTHCARE

The use of Internet of Things (IoT) technologies in medicine has revolutionized conventional medical procedures by allow- ing patients to be continuously, remotely, and real-time moni- tored. IoT makes it easy to connect sensors, medical devices, and cloud platforms to facilitate smooth collection, processing, and transmission of important patient information to ensure timely intervention and customized treatment. This section discusses the primary applications, technologies, advantages, and limitations of IoT in healthcare.

1) Applications and Technologies

IoT in healthcare is a revolutionary strategy for enhancing patient care through the incorporation of advanced technologies into daily medical procedures. IoT works with the help of sensors, communication protocols, and cloud computing platforms to provide a variety of applications to be used for specific patient needs. Next, these applications as well as some of the underlying technologies they involve are examined.

1) Remote Monitoring: Surely remote monitoring is the most significant use of IoT on the healthcare side. In essence, it is the utilization of networked devices for monitoring of the patient health parameters over time continuously and irrespective of whether the patient is within or outside the care giving center. For instance:

- They include devices that are embedded with sensors measuring the vital parameters such as the heart rate, body temperature, blood pressure, and oxygen saturation levels. [1], [3].
- These devices are able to collect data wirelessly and transmit them to the cloud platforms where providers can view real time data through dashboards or mobile apps. [9].
- Remote monitoring limits the need for in person consultations in care for chronic diseases, post operative condition or mobility limitations.

Using eSmart as a platform, IoT has been integrated into remote monitoring, whereby the patients are able to proactively manage their health, while maintaining connection with healthcare providers. [1].

2) Emergency Alerts: Device that can detect anomaly in real time can trigger emergency alert when critical threshold is broached. Key features include:

- **Threshold-Based Alerts:** Sensors continuously monitor patient's data, and when a parameter such as heart rate, blood pressure, or body temperature changes from the normal range, the system generates automated alerts to the user. [2], [4].
- **Multichannel Notifications:** There are various channels to send Alerts, such as the SMS, email, or push notifi- cations, ensuring communication in time with healthcare providers, caregivers, or emergency responders [10].
- **Life-Saving Interventions:** Emergency alerts enable's rapid medical response, especially in cases of cardiac arrests, hypoxia, or febrile seizures, thereby improving survival rates and outcomes.

3) Fall Detection: Fall detection systems are critical for elderly and people with weak health , where falls are a leading cause of injuries and hospitalizations. IoT technologies contribute significantly in this area:

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- **Sensor Integration:** Accelerometers and gyroscopes attatched in wearable devices detect sudden changes in motion, which could indicate a fall [4], [7].
- **Location-Based Alerts:** GPS modules integrated into IoT devices provide the exact location of the patient in case of a fall, which helps caregivers or emergency services to respond quickly [7].
- **AI-Enhanced Accuracy:** Advanced algorithms process sensor data to differentiate between normal activities (like sitting down abruptly) and actual falls, minimizing false positives.

4) Wearable Technology: However, the current implementation of IOT to wearable devices has revolutionized healthcare because they enable continuous healthcare monitoring without impacting any daily activities. Examples of wearable technologies include:

- **Smartwatches and Fitness Bands:** These devices have sensors that allow their tracking to heart rate, physical activity, sleep patterns and SpO2 levels allowing preventive care and lifestyle management. [5], [12].
- **Chest Straps and Patches:** These devices were designed for those patients who need a more precise monitoring of ECG, respiration rate and blood pressure in real time [11].
- **Connectivity Protocols:** The transmission of data to connected smartphones or cloud systems for further analysis and visualization is done mainly through the use of technologies ranging from Bluetooth, ZigBee, to Wi-Fi.

Wearable technology enhances patient mobility, empowering users to manage their health proactively while providing healthcare professionals with a wealth of data for informed decision-making.

5) IoT-Integrated Medical Devices: The healthcare industry is getting specialized medical devices integrated into IoT which will help the healthcare be more accessible as well as efficient. Examples include:

- **Portable ECG Monitors:** Heart activity measured by these devices is then transmitted to healthcare providers for remote cardiac care. [9].
- **Pulse Oximeters:** Pulse oximeter with IoT enabled continuous SpO2 and heart rate measurement are useful for people with Respiratory diseases like COPD or sleep apnea. [13].
- **Glucose Monitors:** Telephones with IoT enabled glucometers regularly poll blood sugar levels and exchange data with mobile apps to assist their diabetic patient manage the condition thoroughly.

Particularly for under served areas, these IoT integrated medical devices are extremely helpful where traditional healthcare facilities are out of reach.

6) Telemedicine and Virtual Health: Technology using IoT is crucial for improving the telemedicine services by offering and enabling remote diagnosis and treatment. Features include:

- **Data Sharing:** They help collect and transmit the real- time health data of the people to Telemedicine platforms for the diagnosis of the doctors during the virtual consultations. [3].
- **Integrated Diagnostics:** Advanced IoT systems take advantage of the use of AI tools to provide insights into a diagnosis because healthcare professionals can use these to identify potential health issues.
- **Rehabilitation and Therapy:** IoT devices can also be used by the patients undergoing rehabilitation to track their performance and give the therapists an update in the ensured adherence to the prescribed regimens.

7) Advanced Communication and Data Handling: Communication technologies and handling capabilities in the data in healthcare IoT are both very sophisticated:

- **Communication Protocols:** These technologies include ZigBee, Bluetooth Low Energy (BLE) and 5G that enables smooth and hassle free data exchange between IoT gadgets and cloud servers. [8].
- **Cloud Computing:** Patient data is being stored, processed, and analyzed at centralized cloud systems and patient health trends were being seen through comprehensive insights of healthcare providers. [9].
- **Edge Computing:** Emerging trends in the edge computing allows IoT devices to process data locally and reducing latency and dependence on the cloud infrastructure.

However, when these applications and technologies are combined in IoT in healthcare, they enable a greater number of opportunities in the improvement of patient care, better outcomes, and lower healthcare costs.

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Comprising the hall- mark of current healthcare innovation, IoT systems possess the versatility as well as scalability — which enables IoT solutions to be applied in various healthcare scenarios.

2) Advantages and Challenges

IOT integration into the healthcare systems has numerous benefits and enhances the transformation of the service delivery in the healthcare sector. But they have some challenges that we should be able to overcome in order to take this worldwide. In this section below we have looked into the pros and cons of IoT in healthcare.

2) Advantages: Among the advantages brought by IoT in healthcare is the improvement of patient care, operational efficiency, and accessibility. Key benefits include:

- **Improved Patient Outcomes:** Healthcare provider's can detect abnormalities in real time and intervene before it becomes a complication and better outcomes for patients. [1], [8].
- **Cost Reduction:** IoT enabled systems enable hospitals to reduce healthcare costs with their patients through minimizing the need for regular visits and profound stays. [8].
- **Accessibility for Underserved Populations:** Refer to IoT technologies to provide remote consultations and monitoring, which lead to healthcare services being avail- able for people living in rural and underserved areas. [1].
- **Enhanced Preventive Care:** It allows patients to be continuously monitoring their vital signs and be alerted before any possible health issue. [3].
- **Data-Driven Decision Making:** It's a huge amount of data that the IoT device generates to help the healthcare providers to take informed decisions based on the trend and predictive analytics. [9].
- **Patient Empowerment:** IoT wearables and mobile apps allow patients to have more control over their health with insights and personalized recommendations. [5].

3) Challenges: While the benefits of IoT in healthcare are numerous, adopting it comes with a few challenges that subsequent downsize its full reach:

- **Data Security and Privacy:** Sensitive health data is transmitted and stored and hence exposed to risk of being breached and unauthorized access. Encryption and anonymization of data are essential that must be robust and guarantee privacy and security. [7].
- **Interoperability Issues:** Compatibility of diverse systems is easily complicated with a lack of standardization of IoT devices and platforms. [3].
- **Power Efficiency:** As IoT limit battery life, wearables and portable monitor are heavily affected, especially during an extended period of use. [5], [9].
- **Scalability and Infrastructure:** The investments in infrastructure for IoT solution implementation on large scales are in terms of network bandwidth and storage capabilities. [4].
- **Accuracy and Reliability:** And when it comes to the most critical cases, there are sensors variation, data reliability — and all that could jeopardize quality of care. [10].
- **Ethical and Regulatory Concerns:** There are ethical questions related to collection and usage of health data and there must be the compliance with HIPAA and GDPR regulations to be safe. [7].
- **-Adoption Barriers:** Healthcare provider resistance to change, combined with a learning curve of technologies like IoT will probably cause the takeup to lag. [3].

Raising our expertise to grasp these challenges will enable the healthcare industry to fully take advantage of the promise of IoT technologies to accomplish efficient, patient-centric care, and ensure security, reliability and equity.

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Table 1: Comparison Of Iot Healthcare Systems

Paper ID	Sensors / Devices Used	Communication Protocols	Key Features	Challenges	Accuracy / Results
[1]	SpO2, Temperature, Blood Pressure sensors	Bluetooth (HC-05)	Remote monitoring, alerts via app	Limited coverage, lacks emotional state monitoring	High accuracy for vital signs
[2]	Pulse, Temperature, SpO2	Wi-Fi, GSM	Continuous monitoring, cloud storage, SMS alerts	Missing blood pressure monitoring	Real-time monitoring, reduced response time
[3]	MAX30100, BMP180, LM35, INA219	Wi-Fi (NodeMCU)	Consolidates six health parameters	No emotional state in- tegration	Minimal error rates for vital signs
[4]	Pulse, Temperature (LM35), ECG, GPS	Wi-Fi (ESP8266), GSM	Location-based fall de-tection, real-time moni-toring	Sensor calibration, de- vice miniaturization	Reliable real-time monitoring
[5]	Pulse, Skin Tem-perature, Skin Con-ductance	ZigBee	Combines physical and emotional health moni-toring	Limited emotional state categories, durability issues	67% emotion recognition accuracy
[8]	CCTV Cameras (Camera-PPG)	Local Network	Non-contact monitoring of HR and BR in ICUs	Privacy concerns, sensitive to lighting changes	HR: 94.5%, BR: 96.7%
[9]	Pulse, Body Tem-perature, ECG, BP, Position	Raspberry Pi, Wi-Fi	Seamless remote access to vital data	Network dependency, initial setup costs	Accurate vitals monitoring
[13]	MAX30100 Pulse Oximeter Module	Wi-Fi (ESP8266)	Cost-efficient SpO2 and HR monitoring with IoT capability	Limited parameter monitoring	Matches commer-cial oximeters

III. EMOTION DETECTION IN HEALTHCARE

It is important to integrate emotion recognition in the healthcare area to understand the psychological part of patient treatment. Physical health is hugely affected by emotions and can tell you more about a person's well-being than anything else and lead to more customised and comprehensive care solutions. Next, emotion detection techniques and datasets that can be put to use with challenges faced within their application are discussed.

A. Importance of Emotion Detection

It is important to integrate emotion recognition in the healthcare area to understand the psychological part of patient treatment. Physical health is hugely affected by emotions and can tell you more about a person's well-being than anything else and lead to more customised and comprehensive care solutions. Next, emotion detection techniques and datasets that can be put to use with challenges faced within their application are discussed.

- **Mental Health Monitoring:** Emotion recognition helps in recognizing early signs of mental health conditions, and provisions for timely intervention and customized therapy plan. [8], [14].
- **Rehabilitation Support:** Caregivers can adjust treatments to adjust to maximize patient rehabilitation

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through monitoring of emotional states during rehabilitation.[5].

- **Enhanced Telemedicine:** Emotion detection within that virtual consultation provides doctors the ability to detect a patients mental state, leading to empathetic, effective communication. [14].
- **Holistic Care:** Physiological data combined with emo- tional insights brings a holistic view of patients' health, and helps in the diagnosis and the treatment of the patients. [8], [14].

B. Techniques and Datasets

Emotion detection systems employ various methodologies, ranging from traditional machine learning approaches to ad- vanced deep learning techniques. These systems rely on an- notated datasets to train models for accurate emotion classifi- cation. Key techniques and datasets include:

1)**Traditional Machine Learning Techniques:** Classic ma- chine learning algorithms like Support Vector Machines (SVM) and K-Nearest Neighbors (KNN) have been exten -sively employed for emotion recognition. These algorithms derive handcrafted features such as Histogram of Oriented Gradients (HOG) and Principal Component Analysis (PCA) to recognize emotions [14], [15]. Although good for simple tasks, their performance is restricted when applied to complex or subtle emotional states.

2)**Deep Learning Techniques:** Deep learning models, particularly Convolutional Neural Networks (CNNs), have revolutionized emotion detection by automatically extracting hierarchical features from facial data. Hybrid models, such as Long Short-Term Memory (LSTM)-CNNs, further enhance accuracy by capturing temporal dynamics in video data [14], [17]. These methods outperform traditional models, especially in recognizing complex and nuanced emotions.

3)**Datasets:** Emotion detection models are trained on datasets that provide annotated facial expressions. Prominent datasets include:

FER-2013: A large-scale dataset with diverse samples, suitable for training deep learning models to recognize basic emotions [15], [17].

CK+: The Extended Cohn-Kanade Dataset (CK+) offers high-quality labeled data, focusing on subtle and dynamic emotional expressions [15], [17].

While these datasets are instrumental in advancing emotion detection, they often lack diversity in demographic representation, leading to potential biases in real-world applications.

C. Challenges and Limitations

Despite significant advancements, several challenges im- pede the widespread implementation of emotion detection in healthcare:

a. **Dataset Diversity:** Despite having representation of sev- eral dimensions of diversity, such as age groups, ethnicities and cultural contexts, most existing emotion recog- nition datasets lack and these biases can be reflected in emotion recognition models. [16], [17].

b. **Subtle Emotion Detection:** Even the best models at this point find it difficult to recognize micro expressions and subtle emotions. [14].

c. **Hardware Constraints:** The consumption of computationally intensive deep learning models on the resource constrained IoT devices comes up with serious challenges. [13], [17].

d. **Privacy Concerns:** It is also an ethical issue and faces robust measures to protect the patient privacy when capturing and analyzing facial expression. [7].

e. **Real-Time Processing:** Efficient algorithms and high performance hardware are required for syncing in emo- tion detection with other healthcare data streams. [7], [9].

To make emotion detection in healthcare systems work, these challenges will have to be addressed by the creation of more data, algorithm optimisation and privacy preserving techniques.

IV. INTEGRATION OF IOT AND EMOTION DETECTION

This is a step toward holistic healthcare solution in which IoT and emotion detection are integrated. These systems aid in integrating physiological monitoring with psychological insights to give a full picture of such a patient health, geared toward personalized care they offer, and timely interventions. This section explores the benefits, barriers and opportunities that exist when integrating this.

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A. Benefits

The advantages of merging IoT with emotion in detection systems are numerous and increase care consumptions:

- **Multimodal Monitoring:** How correlation of physiolog- ical data (e.g. heart rate, blood pressure) with emotional states can be applied by health care providers to know more about the health status of patient. Such as, stress related expressions can associate with higher heart rate and permit targeted interventions. [5], [8], [13].
- **Personalized Healthcare:** Real time analysis of phys- iological and emotional data can be combined to the customisation of treatment plan according to that of the individual needs of the patient. [5], [14].
- **Proactive Interventions:** Early detection of the health issues gives the increased chances of successful outcomes while real time monitoring and analysis of emotional and physiological metrics. [8].
- **Enhanced Patient Engagement:** Emotion detection when doing telemedicine consultations fosters bet- ter communication between patients and healthcare providers, which in turn makes telemedicine more em- pathetic and effective. [14].
- **Support for Mental Health:** When combined with emotion recognition, integrating IoT systems with health- care providers becomes more effective to monitor the psychological well-being independently from the physical health, which helps address problems of the patients' stress, anxiety, and depression. [5], [14].

B. Challenges and Opportunities

On the other hand, though integration of IoT and emotion detection appears to bring in a lot of benefits, there are many challenges to be overcome to have something work:

- **Real-Time Processing:** Since the data streams from IoT devices and the emotion detection models need to be synchronized in real time, loading these data streams ef- ficiently in real time with the help of efficient algorithms and hardware is the need of the hour. [7], [9].
- **Data Privacy and Security:** There is also great concern about storing and analyzing sensitive data (face and health metrics) on servers adrift deep in the internet without any government, law enforcement, or even FDA oversight. The need of protecting patient information is absolutely a must: It has to be protected with advanced encryption and anonymization techniques. [4], [7].
- **Hardware Constraints:** A challenge is deployed computationally intensive emotion detection models to IoT devices hardware with limited processing power and memory. [13], [17].
- **Interoperability Issues:** To make this process seamless, the protocols and interfaces need to be standardized to establish a standardisation point between IoT devices and emotion detection systems. [3].
- **Algorithmic Bias:** Often, emotion detection models have bias caused by data, which is not sufficiently diverse enough, causing inaccuracies in determining emotional states for various demographics. [16], [17].

Considering these challenges, emerging technologies and methodologies provide ways of doing so:

- **Edge Computing:** By going to edge, it allows it to reduce latency to be more real time and it enables local processing of data on these IoT devices. [9], [17].
- **Federated Learning:** However, this approach guarantees decentralized training of emotion detection models on edge devices, facilitates the privacy of patient, with better model accuracy. [9], [17].
- **Improved Hardware:** The increased processing power and efficiencies of the batteries of the IoT devices al- low for complex emotion detection models that would normally require much more power and a hefty external battery pack to run. [13].
- **Comprehensive Datasets:** Expanding datasets to incorporate diverse populations and realworld scenarios may reduce biases and allow for better generalisation on the model. [16], [17].

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Table 2: Comparison Of Emotion Detection Techniques

Paper ID	Dataset Used	Model / Algorithm	Features Extracted	Challenges	Accuracy / Results
[14]	Custom dataset	KNN, Decision Tree	Facial Action Units (FAUs), Lucas-Kanade algorithm	Limited categories (happiness, anger, sadness, etc.)	KNN: 98.03%, DT: 97.21%
[15]	AffectNet, FFHQ	SVM, Random Forest, Decision Tree	Histogram of Oriented Gradients (HOG)	Struggles with subtle emotions like fear and anger	Good for happy/neutral emotions
[16]	LFW, In-house dataset	PCA, LBP, DeepFace	Texture features, hierarchical deep features	Handcrafted methods less effective than DL approaches	DeepFace: FAR 0.01952%, better than PCA/LBP
[17]	CK+, FER-2013	CNN, LSTM-CNN	Spatial (CNN), temporal (LSTM) features	Requires large labeled datasets, high computational cost	CNN: 99.1% accuracy on FER-2013, CK+

V. FUTURE DIRECTIONS

Reflecting on the infusion of IoT and emotion detection system on healthcare, there are new doors of innovation opens for integrating IoT and emotion detection systems in healthcare that can result in more accessible, personalized and effective care in the future. The latter notes emerging trends, research opportunities, and draws a conclusion that these technologies hold a lot of transformative potential.

A. Emerging Trends

With advancements in technology, healthcare and emotion detection systems are undergoing rapid evolution using technology. Key trends include:

- **Wearable AI Systems:** AI, particularly where wear- able devices and sensors are concerned, is increasingly equipped with the capabilities necessary in such a real- time analysis of; physiologically and emotionally based data without requiring cloud connectivity. [16], [17].
- **5G-Enabled IoT Devices:** The adoption of 5G networks facilitates faster and more reliable communication be- tween IoT devices and central systems, enhancing real- time monitoring and reducing latency [16].
- **Edge Computing:** Edge computing is gaining traction as it allows IoT devices to process data locally, reducing dependence on cloud resources and addressing privacy concerns [9], [17].
- **Universal Emotion Models:** The development of univer- sal models that are capable of recognizing a great variety of emotional states in a broad range of populations and contexts driven by the advancing of deep learning. [16], [17].

B. Research Opportunities

Despite significant progress, there are numerous research gaps and challenges that require attention:

- **Expanding Dataset Diversity:** A major limitation of most current emotion detection datasets is that they in- corporate representation of low diversity of demographics and lack of real world conditions. It is crucial to expand these datasets to have models to have a greater accuracy with far less bias. [14], [16].
- **Lightweight Models for IoT:** Hardware constraints pose a challenge to wider deployment of deep learning models and thus it is important to develop such computationally efficient deep learning models that also work well on IoT devices. [13], [17].
- **Enhanced Data Privacy and Security:** To handle sensitive health and emotional data, there needs to be robust encryption and all details of privacy preserving techniques like federated learning should be considered. [7], [17].

- **Ethical Considerations:** It is therefore very important to address ethical concerns of these technologies such as algorithmic bias, transparency and consent, when they are deployed responsibly. [7].
- **Integration with Multimodal Systems:** It is also possi- ble to conduct research on integrating IoT and E emotion detection with other healthcare systems, such as EHRs and AI driven diagnostics, to improve the utility of those systems. [8], [14].

VI. CONCLUSION

That is the revolution, end to end monitoring of physical and mental health by the intersection of IoT and emotion sensing technology. They can transform patient care through increasing its pattern of proactivity, personalization, and accessibility. Although there are several associated challenges such as the hardware constraints, the privacy of the data, and the algorith- mic bias, the novel technologies in edge computing, federated learning and use of AI based solutions are the way out of these hurdles. Defining the IoT-based healthcare and emotion detec- tion future will be a products of encouraging interdisciplinary cooperation between technologists and healthcare experts, and policy makers. Given the limitations that abound and then the technological developments, these systems are going to open up a better future of a smart, holistic and equitable health solutions.

VII. REFERENCES

[1] T. J. Swamy and T. N. Murthy, "eSmart: An IoT based Intelligent Health Monitoring and Management System for Mankind," 2019 Interna- tional Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2019, pp. 1-5, doi: 10.1109/ICCCI.2019.8821845.

[2] V. Yeri and D. C. Shubhangi, "IoT based Real Time Health Monitoring," 2020 Second International Conference on Inventive Research in Comput- ing Applications (ICIRCA), Coimbatore, India, 2020, pp. 980-984, doi: 10.1109/ICIRCA48905.2020.9183194.

[3] M. R. R. Akash, Yousuf and K. Shikder, "IoT Based Real Time Health Monitoring System," 2020 Research, Innovation, Knowledge Management and Technology Application for Business Sustainability (INBUSH), Greater Noida, India, 2020, pp. 167-171, doi: 10.1109/IN- BUSH46973.2020.9392163.

[4] P. S. Akram, M. Ramesha., S. A. S. Valiveti, S. Sohail and K. T. S.S. Rao, "IoT based Remote Patient Health Monitoring system," 2021 7th International Conference on Advanced Computing and Communica- tion Systems (ICACCS), Coimbatore, India, 2021, pp. 1519-1524, doi: 10.1109/ICACCS51430.2021.9441874.

[5] Z. Jiang, L. Lu, X. Huang and C. Tan, "Design of wearable home health care system with emotion recognition function," 2011 International Conference on Electrical and Control Engineering, Yichang, China, 2011,pp. 2995-2998, doi: 10.1109/ICECENG.2011.6057832

[6] J. -H. Huang, T. -T. Wang, T. -Y. Su and K. -C. Lan, "Design and deployment of a heart rate monitoring system in a senior center," 2013 IEEE International Conference on Sensing, Communications and Networking (SECON), New Orleans, LA, USA, 2013, pp. 71-75, doi: 10.1109/SAHCN.2013.6644963.

[7] M. Elkahlout, M. M. Abu-Saqer, A. F. Aldaour, A. Issa and M. De- beljak, "IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), Gaza, Palestine, 2020, pp. 92-96, doi: 10.1109/iCareTech49914.2020.00025.

[8] H. Wang, J. Huang, G. Wang, H. Lu and W. Wang, "Contactless Patient Care Using Hospital IoT: CCTV-Camera-Based Physiological Monitoring in ICU," in IEEE Internet of Things Journal, vol. 11, no. 4, pp. 5781-5797, 15 Feb.15, 2024, doi: 10.1109/JIOT.2023.3308477.

[9] Rohit, S.L. and Tank, B.V., 2018, April. Iot based health monitoring sys- tem using raspberry PI-review. In 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT) (pp. 997-1002).

[10] G. V. Kumar, A. Bharadwaja and N. N. Sai, "Temperature and heart beat monitoring system using IOT," 2017 International Conference on Trends in Electronics and Informatics (ICEI), Tirunelveli, India, 2017,

pp. 692-695, doi: 10.1109/ICOEI.2017.8300791.

[11] Baballe, Muhammad & Bello, Mukhtar. (2021). A Study on the Impact and Challenges of Temperature Detection System. 1. 22-26.

[12] Arman Kuzubas¸og˘lu, Burcu & Sayar, Ersin & Cochrane, Ce´dric & Koncar, Vladan & Bahadir, Senem. (2021). Wearable temperature sensor for human body temperature detection. Journal of Materials Science: Materials in Electronics. 32. 1-14. 10.1007/ s10854-020-05217-2.

[13] Kakumanu Vamsi Sree Sai Ganesh, S.P. Shibu Jeyanth, Ruhan Bevi, IOT based portable heart rate and SpO2 pulse oximeter, HardwareX, Volume 11, 2022, e00309, ISSN 2468-0672, https://doi.org/10.1016/j.ohx.2022.e00309.
(https://www.sciencedirect.com/science/article/pii/S2468067222000542)

[14] Murugappan, Prof & mutawa, a.m & Sruthi, Sai & Hassouneh, Aya & Abdulsalam, Ali & Selvaraj, Jerritta & R, Ranjana. (2020). Facial Expression Classification using KNN and Decision Tree Classifiers. 1-6. 10.1109/ICCCSP49186.2020.9315234.

[15] Truong Le Vinh, Phuc & Tien, Le & Tri, Duong. (2024). Facial Expression Recognition using Traditional Machine Learning Models.

[16] S. Srisuk, A. Boonkong, D. Arunyagool and S. Ongkittikul, "Hand- craft and Learned Feature Extraction Techniques for Robust Face Recognition : A Review," 2018 International Electrical Engineer- ing Congress (iEECON), Krabi, Thailand, 2018, pp. 1-4, doi: 10.1109/IEECON.2018.8712272.

[17] Khan, Amjad. (2022). Facial Emotion Recognition Using Conven- tional Machine Learning and Deep Learning Methods: Current Achieve- ments, Analysis and Remaining Challenges. Information. 13. 268. 10.3390/info13060268.