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A Review of Social Distancing ID Card

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Abstract

The frequency of fire accidents in homes, industries, and public spaces has increased due to electrical faults, human negligence, and flammable materials. Traditional fire-fighting systems often depend on human presence and manual intervention, which delays the response time. To overcome this limitation, this project presents an Automatic Fire Extinguisher System based on Arduino and IoT technology for real-time detection and suppression of fire. Gas, temperature, and flame sensors are used by the system to continually monitor the surroundings. Once a fire or abnormal temperature rise is detected, the Arduino microcontroller automatically activates a DC water pump or CO_2 extinguisher module to control the fire source. Simultaneously, an IoT-based alert is sent to the user's smartphone ↓ through Wi-Fi using the Blynk or ThingSpeak platform. The system ensures immediate action without human intervention, thus reducing property loss and risk to life. It is appropriate for homes, offices, industries, and labs due to its small size and affordable design. Testing results confirm quick response and reliable performance under various conditions. Hence, this project contributes to the development of a smart safety system that enhances modern building security through automation and IoT integration, facilitating improved safety, predictive maintenance, ongoing monitoring, and effective emergency management.

Keywords: Automatic fire extinguisher, Arduino UNO, IoT-based monitoring, flame detection, smart safety system

INTRODUCTION

In today's world, maintaining personal hygiene and a safe distance has become an essential part of everyday life, especially after the outbreak of contagious diseases such as COVID-19. The Social Distancing ID Card is an innovative solution designed to encourage safe interactions by ensuring that individuals maintain a proper physical distance from one another. In crowded areas, such as schools, offices, hospitals, and public places, it becomes difficult to monitor distancing manually [1–3]. This device provides an automated, efficient, and user-friendly approach to prevent the spread of infection through close contact. The system operates using ultrasonic sensors that continuously measure the distance between two individuals wearing an ID card. When the measured distance becomes less than a predefined limit (e.g., one meter), the device instantly alerts the user through a buzzer or LED indicator. The entire setup is controlled by a microcontroller, such as Arduino or ESP32, which processes the sensor data in real time [4–6]. The compact and lightweight design allows the system to be worn comfortably as a regular ID card, ensuring continuous monitoring without inconvenience to the user. The development of this project demonstrates the effective use of sensor technology, microcontrollers, and embedded systems to create a practical and low-cost health and safety device. It not only helps maintain proper social distancing but also raises awareness of preventive safety measures in community settings.

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Overall, the Social Distancing ID Card represents an excellent blend of technology, safety, and innovation, demonstrating how simple electronic systems can contribute to a healthier and more secure environment for all [7–10].

LITERATURE SURVEY

The development of a Social Distancing ID Card is rooted in interdisciplinary advancements in embedded systems, sensor technologies, the Internet of Things (IoT), and real-time proximity detection. This section reviews the relevant literature to establish a technological foundation and identify the research gaps addressed by the proposed system. Table 1 shows the comparative features of the electronic system architecture.

Embedded Systems and Microcontroller Technologies

Embedded systems play a crucial role in the design of compact, real-time monitoring devices. Early foundational work introduced microcontroller-based system designs, emphasizing real-time processing, interfacing, and control applications. Similarly, the fundamental concepts of microprocessor architecture and interfacing are essential for understanding control logic and hardware communication.

Although these studies primarily focused on legacy architectures such as 8051 and 8085, they established the core principles used in modern microcontroller platforms such as Arduino and ESP32. These modern platforms offer enhanced processing capabilities, integrated communication modules, and ease of programming, rendering them suitable for wearable safety applications.

Electronic Circuit Design and Power Considerations

Efficient electronic design is essential for the development of portable and reliable devices. Horowitz and Hill provided a comprehensive guide to electronic circuit design, emphasizing accuracy, flexibility, and practical implementation strategies. Their work supports the design of stable and noise-resistant circuits for embedded systems applications.

Additionally, power electronics and efficient energy handling mechanisms are critical for battery-powered wearable devices. Power optimization ensures a longer operational life and enhances system reliability, which is particularly important for continuous monitoring applications, such as the Social Distancing ID Card.

Table 1. Comparative features of electronic system architectures.

System architecture	Cost	Ease of implementation	Performance	User experience	Limitations
8051-based microcontroller architecture and embedded control systems	Medium	Moderate	Reliable performance for controller-based applications	Widely used, well-documented learning resource	Limited to 8051 family and legacy hardware
8085 microprocessor architecture and interfacing concepts	Low	Moderate	Suitable for foundational learning and simple applications	Clear understanding of basic processor concepts	Outdated for modern embedded and IoT systems
Power electronic converter and device-level architecture	High	Difficult	High efficiency and robust power handling	Industrial-grade applicability	Requires advanced design knowledge and hardware resources
General-purpose electronic circuit architecture and design principles	Medium	Moderate	High accuracy and design flexibility	Comprehensive practical guidance for designers	Not application-specific; needs prior electronics background
Biomedical device and instrumentation architectures	High	Difficult	High performance in biomedical applications	Supports medical-grade system design	Complex regulatory and implementation constraints
Ultrasonic distance-sensing module architecture	Low	Easy	Good short-range sensing accuracy	Simple integration with microcontrollers	Affected by environmental noise and surface properties

Ultrasonic Sensor-Based Distance Measurement

Ultrasonic sensors are widely used for proximity detection because of their simplicity, affordability, and reliability. The HC-SR04 ultrasonic sensor operates on the principle of echo timing, where the distance is calculated based on the time taken for sound waves to reflect from an object. This technology provides accurate short-range measurements, making it suitable for personal-safety applications.

Several studies have explored the use of ultrasonic sensing for distance measurements. An ultrasonic object detection system using Arduino, demonstrating real-time detection and response capabilities [11, 12]. A sonar-based distance measurement system, highlighting its accuracy and ease of implementation [13]. Similarly, an ultrasonic-based collision-avoidance system for vehicles was developed to validate the effectiveness of this technology in dynamic environments [14].

These studies confirm that ultrasonic sensors are reliable for proximity detection and can be effectively integrated into the wearable devices.

Arduino-Based Detection and Alert Systems

Arduino-based systems have gained significant popularity because of their low cost, flexibility, and ease of use. A radar simulation system using Arduino and Processing was developed to demonstrate real-time object tracking and visualization [15]. Similarly, an Arduino-controlled radar system was developed for security applications, emphasizing real-time monitoring and alert generation [16].

A Bluetooth-based object detection alert system integrates wireless communication to enhance user interaction [17]. These systems demonstrate the capability of Arduino platforms to handle real-time sensor data and generate alerts.

The simplicity and scalability of Arduino-based systems make them ideal for developing wearable devices, such as the Social Distancing ID Card.

IoT-Based Smart Monitoring Systems

IoT technologies have significantly enhanced the capabilities of monitoring systems by enabling connectivity, remote access, and data analysis. An IoT-based smart obstacle detection system that integrates sensors with cloud platforms for real-time monitoring and analysis [17]. Similarly, an Arduino-controlled security radar system that incorporates IoT features for remote surveillance was developed [18]. A secure Industrial IoT (IIoT) framework using MapReduce and Kalman filtering techniques to improve data reliability and processing efficiency [19, 20]. IoT applications by integrating machine learning for environmental monitoring, enabling predictive analysis, and intelligent decision-making.

Although IoT-based systems provide advanced features, they often increase system complexity, cost, and power consumption. For wearable applications, simpler systems with local alert mechanisms are often required.

Health Monitoring and Safety Systems

The importance of automated safety systems has increased significantly in recent years, particularly during the COVID-19 pandemic. IoT-based health monitoring systems have been widely used to track patient conditions and ensure timely medical interventions [21]. The BIOBOT system assists COVID-19 patients and caregivers, demonstrating the effectiveness of automation in healthcare environments [22].

In addition, deep learning-based face mask detection systems have been proposed to enforce safety measures in public spaces [23]. These systems highlight the growing integration of technology into public health and safety applications.

However, most of these systems focus on monitoring or detection rather than enforcing behavioral changes, such as maintaining social distance. This highlights the need for simple real-time alert systems that directly influence user behavior.

Related Embedded and Automation Applications

Numerous embedded and IoT-based applications demonstrate the versatility of sensor-based monitoring. Smart school bus tracking systems ensure student safety through real-time location monitoring [24]. IoT-based smart farming systems monitor environmental parameters, such as soil moisture, temperature, and humidity. Home automation systems using voice assistants provide user-friendly control of devices, demonstrating the integration of embedded systems with human interactions. These applications highlight the adaptability of embedded systems for various real-time monitoring and control tasks.

Limitations of Existing Systems

Despite Significant Advancements, Several Limitations Exist in Current Systems

Legacy microcontroller systems lack scalability and integration with modern technologies Ultrasonic sensors are sensitive to environmental conditions such as noise and surface characteristics IoT-based systems increase complexity, cost, and power consumption Limited focus on wearable, user-friendly proximity detection devices These limitations indicate the need for a simple, cost-effective, and portable solution tailored for individual use.

Research Gap and Motivation

From the reviewed literature, it is evident that most existing systems are designed for industrial, vehicular, and large-scale monitoring applications. There is limited research on wearable proximity detection systems that are simple, affordable, and easy to use in the field.

The proposed Social Distancing ID Card addresses this gap by:

- Utilizing ultrasonic sensing for real-time distance measurement
- Providing immediate feedback through buzzer and LED alerts
- Ensuring portability through a compact, wearable design
- Maintaining low cost and ease of implementation

PROPOSED METHODOLOGY

The Social Distancing ID Card helps maintain a safe physical distance in public and crowded places. An ultrasonic sensor was used to measure the distance between two individuals in real time. When the distance falls below a set limit, a buzzer or LED provides an instant alert, reminding users to step back and avoid close contact. This automatic operation reduces the need for manual monitoring and promotes safe behavior in schools, offices, hospitals, and other public areas. The system is built using a microcontroller, such as Arduino or ESP32, which processes the sensor data and controls the alert system. All components of the ultrasonic sensor, buzzer, LED, and power supply were compactly fitted into an ID card-sized unit. Powered by a low-voltage DC source, the device is safe, portable, and energy efficient. This project offers a simple, affordable, and practical solution for maintaining social distancing in daily life [25–27].

The proposed Social Distancing ID Card is designed as a compact, wearable embedded system that monitors interpersonal distance in real time and alerts users when a predefined safe distance is violated (Figure 1). The methodology integrates ultrasonic sensing, microcontroller-based processing, and alert mechanisms to create a low-cost, efficient proximity detection system.

System Overview

The system consists of four main components:

- Ultrasonic sensor
- Microcontroller unit (Arduino/ESP32) Alert system (buzzer and LED)
- Power supply

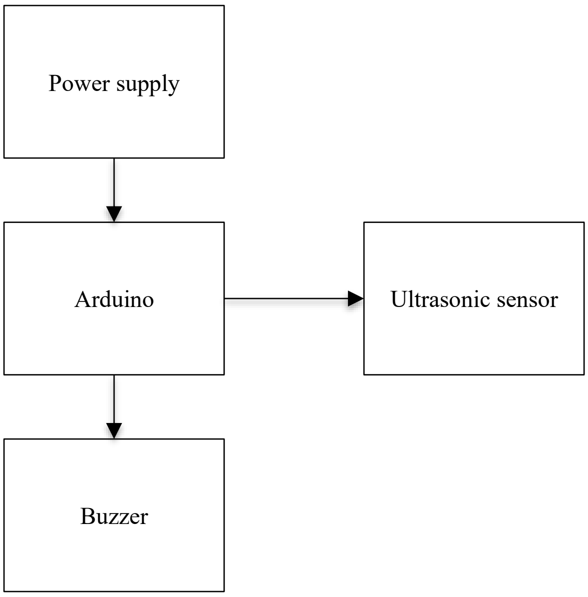

Figure 1. Block diagram of social distancing id card.

The ultrasonic sensor continuously measures the distance between the individuals. The microcontroller processes these data and compares them with a predefined threshold (typically 1 m). If the measured distance falls below the threshold, an alert is triggered using a buzzer or LED indicator.

This approach ensures real-time monitoring without requiring human intervention, making it suitable for crowded environments, such as schools, offices, hospitals, and public places.

Ultrasonic Distance Measurement Mechanism

The system uses an ultrasonic sensor (HC-SR04) to measure the distance based on the time-of-flight principle, where sound waves are transmitted and reflected from nearby objects. The distance was calculated using the equation Distance=Speed of Sound×Time/2

Ultrasonic sensing is widely used because of its accuracy, low cost, and ease of integration with microcontrollers. Prior studies have demonstrated their effectiveness in object detection and proximity monitoring systems. In addition, ultrasonic sensors have been successfully applied in collision avoidance systems, validating their reliability in dynamic environments.

Microcontroller-Based Processing

The microcontroller (Arduino or ESP32) acts as the central processing unit of this system. It performs the following functions Generates trigger pulses for the ultrasonic sensor Measures echo pulse duration Computes distance in real time Compares measured distance with threshold Activates alert system when required Microcontroller-based embedded systems are widely used for real-time control applications due to their reliability and ease of programming. Arduino-based implementations provide flexibility and rapid prototyping capabilities, as demonstrated in radar and object-detection systems.

Alert and Feedback Mechanism

The system includes a buzzer and LED to provide immediate feedback to users. When the distance between two individuals becomes less than the predefined limit, the microcontroller activates

Buzzer: Generates an Audible Warning LED

Provides visual indication This dual-alert mechanism ensures that users are notified even in noisy or visually obstructed environments. Similar alert-based systems have been implemented for object detection and safety applications, proving their effectiveness in real-time response scenarios.

System Integration and Operation

All components were integrated into a compact, ID card-sized unit, ensuring portability and ease of use. The operational flow of the system is as follows.

- The ultrasonic sensor continuously emits sound waves, and the reflected waves are received and converted into distance values. The microcontroller processes the data in real time.
- If distance < threshold → alert is triggered
- If distance ≥ threshold → system remains idle

This continuous monitoring mechanism eliminates the need for manual supervision and promotes automatic adherence to the social distancing norms.

Power Supply and Energy Efficiency

The system was powered using a low-voltage DC source (battery), ensuring safety and portability. Efficient power utilization is critical for wearable devices, and an optimized embedded design helps reduce energy consumption.

Compared with IoT-based systems that require continuous connectivity and higher power, the proposed system operates locally, resulting in lower energy consumption and improved battery life.

Design Considerations

Several design factors were considered to ensure system effectiveness:

- *Compactness*: All components are miniaturized to fit within an ID card form factor
- Cost-effectiveness: Use of low-cost components, such as Arduino and HC-SR04
- *Ease of implementatio*n: Simple circuit design and programming
- *User comfort*: Lightweight and wearable design
- *Reliability*: Real-time response with minimal delay

These considerations align with the existing embedded system design practices for portable and user-friendly devices.

Comparison with Existing Systems

Unlike IoT-based monitoring systems that rely on cloud connectivity and data processing, the proposed system focuses on local real-time alerts, thereby reducing complexity and cost.

Although advanced systems incorporate machine learning and remote monitoring, they are not always suitable for wearable applications because of their higher computational requirements. The proposed system provides a simple and effective alternative for immediate behavioral correction.

Advantages of the Proposed Methodology Real-Time Proximity Detection

Low cost and easy implementation Portable and wearable design No dependency on Internet connectivity Immediate user feedback

Limitations and Future Scope

Despite its advantages, the system has certain limitations:

- Ultrasonic sensors may be affected by environmental noise and surface properties
- Limited detection range compared to advanced radar systems
- No data logging or remote monitoring capability

Future Enhancements May Include:

Integration with IoT for data tracking and analytics, use of advanced sensors (IR, radar, or LiDAR), and mobile application connectivity for monitoring

Figure 2. Prototype of the proposed smart bag system.

RESULT

The proposed Social Distancing ID Card system (Figure 2) was implemented and tested under various real-world conditions to evaluate its performance in terms of proximity detection, response time, reliability, and usability. The results demonstrate the effectiveness of the proposed system as a low-cost, real-time safety solution.

Experimental Setup

The prototype was developed using an ultrasonic sensor (HC-SR04), Arduino microcontroller, buzzer, light-emitting diode (LED), and battery-powered supply. The system was tested in indoor environments, such as classrooms and corridors, as well as semi-open spaces, to evaluate its performance under different conditions.

Distance measurements were recorded by placing objects and individuals at varying distances from the sensor, typically ranging from 20 to 200 cm. The threshold distance was set to 1 m, in accordance with standard social-distancing guidelines [28, 29].

Distance Measurement Accuracy

The ultrasonic sensor demonstrated reliable performance for short-range distance measurements. The measured values were consistent with the actual distances, with minor deviations owing to environmental factors such as surface reflectivity and ambient noise.

These results are consistent with those of previous studies, in which ultrasonic sensors have shown good accuracy for object detection and distance measurement applications [1, 8]. Similarly, their effectiveness in collision-avoidance systems further supports their reliability in proximity-based applications [4].

However, slight variations were observed when detecting soft or irregular surfaces, which is a known limitation of ultrasonic sensing.

Response Time Analysis

The system exhibited fast response times, with alerts triggered almost instantaneously (within milliseconds) when the measured distance fell below the threshold value. This real-time performance is attributed to the efficient processing capability of the microcontroller used.

Similar real-time responsiveness has been observed in Arduino-based detection systems, such as radar and object-tracking applications [2, 6]. A quick response ensures that users receive immediate feedback, enabling prompt corrective action.

Alert System Performance

The buzzer and LED alert mechanisms functioned effectively under different conditions:

- The buzzer provided a clear audible warning in proximity
- The LED indicator ensured visibility even in moderately noisy environments
- This dual-alert approach enhances usability and ensures that users are notified, regardless of environmental conditions.
- Comparable alert-based systems have demonstrated similar effectiveness in safety and detection applications [7].

System Reliability and Stability

The system operated continuously without any significant performance degradation. The microcontroller maintained a stable operation, and no major hardware failures were observed during testing. Embedded systems based on Arduino platforms are known for their reliability and robustness in real-time applications. The simplicity of the design further contributes to the system stability, as fewer components reduce the likelihood of failure.

Power Consumption and Portability

The system consumed minimal power owing to the use of low-voltage components and the absence of continuous wireless communication. This makes it suitable for battery-powered operation and enhances its portability.

Compared with IoT-based systems that require continuous connectivity and higher energy consumption [3, 19], the proposed system offers a more energy-efficient solution. This is particularly important for wearable devices that require long operational periods.

Usability and Practical Implementation

The compact ID card design allows the system to be worn comfortably without hindering user movement. The automatic operation eliminates the need for manual monitoring, making it highly user friendly.

The system proved effective in crowded environments, such as classrooms and public areas, where maintaining a social distance manually is difficult. Similar IoT-based health and safety systems have emphasized the importance of automation in reducing human effort.

Comparative Analysis of Existing Systems

Compared to existing systems, the proposed solution offers several advantages:

- It has a simpler architecture than IoT-based monitoring systems, lower cost owing to minimal hardware requirements, and faster response owing to local processing.
- Higher portability due to compact design
- Although advanced systems provide features such as remote monitoring and data analytics [9], they often introduce complexity and higher costs. The proposed system focuses on immediate, real-time alerts, which are more practical for individual use than periodic alerts.

Limitations Observed

Despite its effectiveness, the system has certain limitations:

- Sensitivity to environmental conditions (e.g., noise, surface properties) Limited detection range compared with radar-based systems
- Lack of connectivity for data logging and analysis
- These limitations are consistent with those reported in ultrasonic-based systems.

DISCUSSION

The results indicate that the proposed Social Distancing ID Card successfully meets the objective of providing real-time proximity alerts. The system achieves a balance between performance, cost, and simplicity, making it suitable for widespread application.

Unlike complex IoT-based solutions, the proposed system emphasizes immediate behavioral feedback, which is critical for maintaining social distancing in dynamic environments such as restaurants. Ultrasonic sensing ensures adequate accuracy for short-range detection, whereas the microcontroller enables rapid decision-making.

Overall, the system demonstrates that simple embedded solutions can effectively address real-world public health issues.

CONCLUSION

The proposed Social Distancing ID Card presents a simple, effective, and low-cost solution for maintaining a safe interpersonal distance in public and crowded environments. By integrating ultrasonic sensing technology with a microcontroller-based processing unit, the system enables real-time distance monitoring and provides immediate feedback through audible and visual alerts to the workers. The results demonstrate that the system achieves reliable short-range detection, a fast response time, and stable operation under typical usage conditions.

The use of ultrasonic sensors for proximity detection has been validated in previous studies, confirming their suitability for real-time distance measurement applications. Furthermore, Arduino-based embedded systems have proven to be efficient and flexible platforms for implementing real-time monitoring solutions. Compared with IoT-based systems, which often involve higher complexity, cost, and power consumption, the proposed system offers a more practical and energy-efficient alternative for wearable applications.

One of the key contributions of this study is the development of a compact, wearable, and user-friendly device that promotes behavioral compliance through immediate alerts rather than relying on remote monitoring or post-analysis. This makes the system particularly suitable for environments where manual supervision is difficult, such as educational institutions, offices, hospitals, and public spaces.

However, the system has certain limitations, including sensitivity to environmental conditions and a lack of connectivity for data logging and remote monitoring. These limitations are inherent to the ultrasonic sensing technology and basic embedded implementations. Future work should focus on integrating advanced sensors, IoT connectivity, and mobile applications to enhance system functionality and scalability.

In conclusion, the Social Distancing ID Card demonstrates how simple embedded technologies can be effectively utilized to address real-world public health challenges in the future. The proposed system bridges the gap between complex smart monitoring systems and practical, low-cost wearable solutions, making it a viable approach for enhancing safety and awareness in daily life.

REFERENCES

1. Rajendran MP, Ramaswamy K, Varadharajan V, Rajendran J, Thangavel M, Kumar V, et al. Bluetooth controlled robot with ultrasonic object detection using Arduino and L293D driver. In: AIP Conference Proceedings; 2025 Jun 5. Vol. 3306, No. 1. p. 060038. AIP Publishing.
2. Pahuriray AV, Cerna PD. IoT-enabled flood monitoring and early warning systems: a systematic review. Int J Comput Sci Mob Comput. 2025;14(4):50-67.
3. Swami S, Singh R, Gehlot A, Iqbal MI, Sharma SD, Kumar D, et al. Vision-based approach for human motion detection and smart appliance control. IAES Int J Robot Autom. 2024;13(4):445.
4. Ahmed Amin A, Mubarak A, Manzoor HU. Design of intelligent vehicular and sensor

communication network: a comprehensive survey. Syst Sci Control Eng. 2025;13(1):2529187.
5. Oruganti SK, Bhalerao MV, Naranje VG, Magdi DA, Gore S, editors. Recent Advances in Technology & Management. CRC Press; 2026 May 26.
6. Shitole M, Thokale S, Patil N, Shingare S, Godase SK. Review on ultrasonic sensor-based RADAR systems for object detection and distance measurement. Int J Adv Res Sci Commun Technol. 2025;5:392-408.
7. Shelke D, Pawar P, Tate P, Shinde P, Mali AS. Obstacle avoiding robot car. Int J Adv Res Sci Commun Technol. 2025.
8. Kumar KP, Al-Rubaie YB, Alassedi Z, Bavireddi V, Srikar D, Reddy R. IoT based advanced security system in military for identification of trespassers using ultrasonic radar. In: 2024 International Conference on Augmented Reality, Intelligent Systems, and Industrial Automation (ARIIA); 2024 Dec 20. p. 1-4.
9. Godase MV, Mulani A, Ghodak MR, Birajadar MG, Takale MS, Kolte M. A MapReduce and Kalman filter based secure IIoT environment in Hadoop. Sanshodhak. 2024;25:38-47.
10. Mulani AO, Mane PB. Watermarking and cryptography based image authentication on reconfigurable platform. Bull Electr Eng Inform. 2017;6(2):181-7.
11. Karande KJ, Talbar SN. Independent component analysis of edge information for face recognition. New Delhi: Springer India; 2014.
12. Karande KJ, Talbar SN. Face recognition under variation of pose and illumination using independent component analysis. ICGST-GVIP. 2008 Dec.
13. Gaikwad DS, Karande KJ. Image processing approach for grading and identification of diseases on pomegranate fruit: an overview. Int J Comput Sci Inf Technol. 2016;7(2):519-22.
14. Kawathekar PP, Karande KJ. Severity analysis of osteoarthritis of knee joint from X-ray images: a literature review. In: 2014 International Conference on Signal Propagation and Computer Technology (ICSPCT); 2014 Jul 12. p. 648-52.
15. Daithankar MV, Karande KJ, Harale AD. Analysis of skin color models for face detection. In: 2014 International Conference on Communication and Signal Processing; 2014 Apr 3. p. 533-7.
16. Karande JK, Talbar NS, Inamdar SS. Face recognition using oriented Laplacian of Gaussian (OLOG) and independent component analysis (ICA). In: 2012 Second International Conference on Digital Information and Communication Technology and Its Applications (DICTAP); 2012 May 16. p. 99-103.
17. Bankar AS, Harale AD, Karande KJ. Gestures controlled home automation using deep learning: a review. Int J Curr Eng Technol. 2021;11(6):617-21.
18. Pang Z, Tian J, Chen Q. Intelligent packaging and intelligent medicine box for medication management towards the Internet-of-Things. In: 16th International Conference on Advanced Communication Technology; 2014 Feb 16. p. 352-60.
19. Monica M, Yeshika B, Abhishek GS, Sanjay HA, Dasiga S. IoT based control and automation of smart irrigation system: an automated irrigation system using sensors, GSM, Bluetooth and cloud technology. In: 2017 International Conference on Recent Innovations in Signal Processing and Embedded Systems (RISE); 2017 Oct 27. p. 601-7.
20. Modi S, Misal V, Kulkarni S, Mali AS. Hydroponic farming monitoring system—automated system to monitor and control nutrient and pH levels. J Microcontroller Eng Appl. 2025;12(3):11-6.
21. Gangonda SS, Patavardhan PP, Karande KJ. VGHN: variations aware geometric moments and histogram features normalization for robust uncontrolled face recognition. Int J Inf Technol. 2022;14(4):1823-34.
22. Gangonda S, Mukherji P. Speech processing for Marathi numeral recognition using MFCC & DTW features. Int J Eng Res Appl. 2012 Mar:118-22.
23. Gangonda SS, Patavardhan PP, Karande KJ. Recognition of Marathi numerals using MFCC and DTW features. In: International Conference on Recent Trends in Image Processing and Pattern Recognition; 2018 Dec 21. Singapore: Springer Singapore; 2018. p. 183-93.
24. Pise AC, Karande KJ. Investigating energy-efficient optimal routing protocols for VANETs: a comprehensive study. In: International Conference on Information and Communication Technology

for Intelligent Systems; 2024 Apr 4. Singapore: Springer Nature Singapore; 2024. p. 407-17.
25. Salunkhe A, Pawar V, Pise P, Mule S, Survase A, Godase V, et al. A review on real-time RFID-based smart attendance systems for efficient record management. Adv Res Analog Digit Commun. 2025;2(2):32-46.
26. Vaibhav VG. A neuromorphic-inspired, low-power VLSI architecture for edge AI in IoT sensor nodes. J Microelectron Solid State Devices. 2025;12(2):41-7.
27. Dhope V, Chavan A, Hadmode N, Godase V. Smart plant monitoring system. Int J Creat Res Thoughts. 2024. Available from: https://www.ijcrt.org
28. Khan MS, Patil R, Haider SA. Application of convolutional neural networks for wildfire detection. In: 2020 SoutheastCon; 2020 Mar 28. Vol. 2. p. 1-5.
29. Pawar V, Phule A, Metkari A, Takale SR. Review of smart energy meter implementations using ESP32 microcontroller and IoT platforms. Int J Adv Res Sci Commun Technol. 2025;5(4).