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## Reliability of IoT Systems for Fire Detection

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### Abstract

In this paper, a smart IoT system including the software and hardware aspects of its design, as well as its operation in the context of a city or a building, along with its advantages, disadvantages, and potential applications, all with a focus on fire safety have been analyzed. Based on the results of the aforementioned research, it is clear that an IoT-based fire system may be tailored to the specific requirements of each individual situation. The major focus of the study is on the planning and evaluation of a WSN that can detect house fires in their earliest stages. The authors address the crucial issue of giving rapid-fire alerts by including a broad range of sensors in the wireless sensor network. In order to provide precise, real-time fire detection, the wireless sensor network (WSN) is constructed from tiny, low-power sensor devices that have sensors able to sense their surroundings. Using the Global System for Mobile Communications (GSM) to reduce the number of false alarms is one strategy the authors propose for coping with sensor malfunctions. The reliability of IoT (Internet of Things) systems for fire detection has been a topic of interest and continuous improvement. IoT-based fire detection systems have the potential to offer numerous benefits, such as real-time monitoring, remote management, and data-driven insights. However, their reliability depends on several factors, including technology, implementation, and maintenance. This research aids in the enhancement of residential community safety by improving the early detection and prevention of house fires.

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## 1. Introduction

The use of Internet of Things (IoT) systems for fire detection has gained significant attention due to their potential to enhance safety and response times [1-3]. This paper examines the reliability of IoT-based fire detection systems and identifies key factors influencing their effectiveness. The study explores sensor quality and accuracy, connectivity and communication, battery life, and power supply, data security, system maintenance and updates, false alarm mitigation, interoperability and standards, response and alert mechanisms, and environmental factors as critical aspects impacting reliability [2-5]. Through a comprehensive review of existing literature, case studies, and industry reports, the paper highlights the importance of high-quality sensors with robust fire detection algorithms to ensure accurate and early fire detection. Reliable communication and data transmission are vital for real-time monitoring and timely response [6-9]. The implementation of redundancy and backup mechanisms can provide additional assurance against system failures. Moreover, data securities emerge as a critical concern, necessitating the adoption of strong encryption and secure communication protocols to safeguard sensitive information [10-12]. Regular system maintenance and software updates are essential to keep the IoT fire detection system optimized and secure. False alarms can undermine reliability, and this study emphasizes the need for continuous improvement in detection algorithms and verification methods [13-16]. Interoperability and adherence to industry standards are crucial in ensuring seamless integration with existing infrastructures and devices. Additionally, the response and alert mechanism play a pivotal role in notifying relevant personnel or authorities promptly [17-18]. The study concludes by urging industry stakeholders to collaborate and invest in research and development to advance the reliability of IoT systems for fire detection continuously [19-21]. As technology evolves, these systems hold immense potential to bolster fire safety measures, provided that they are implemented, monitored, and maintained with due diligence. Fire detection is a critical aspect of modern safety and security systems, aiming to identify and alert occupants about the presence of fire or smoke in a timely manner. Traditional fire detection methods have relied on manual alarms, sprinkler systems, and smoke detectors [22-23]. However, with advancements in technology, the integration of the Internet of Things (IoT) has revolutionized fire detection by offering smarter, more efficient, and proactive solutions. Security and privacy concerns in IoT fire detection are of paramount importance, as these systems involve the collection, transmission, and storage of sensitive data related to fire events and the safety of occupants [24-25]. Addressing these concerns is essential to prevent unauthorized access, data breaches, and potential misuse of the information. The Internet of Things (IoT) refers to the interconnection of everyday objects, devices, and sensors through the internet, enabling them to collect and exchange data without direct human intervention [26-27].

In the context of fire detection, IoT technology allows for the creation of smart and interconnected fire detection systems that go beyond mere detection. Different parameters play a significant role in the reliability of IoT such as sensor quality and accuracy, connectivity and communication, redundancy and backup, battery life and power supply, data security, system maintenance and updates, false alarm mitigation, interoperability and standards, response and alert mechanism, and environmental factors.

## 2. Benefits and challenges

Using IoT (Internet of Things) for fire detection offers numerous benefits such as real-time monitoring, remote management, data-driven insights, predictive maintenance, energy efficiency, scalability and flexibility, and integration with other systems. Also, IoT comes with lots of challenges such as data security and privacy, connectivity and reliability, interoperability, false alarms, maintenance and updates, power supply and battery life, cost and risk of dependence on technology. Let's explore both the benefits and challenges of using IoT for fire detection:

## 2.1. Benefits

IoT-based fire detection systems provide real-time monitoring of fire-related parameters, such as smoke, heat, gas levels, and temperature. This enables rapid detection and immediate alerting, allowing for swift action to mitigate potential hazards. IoT enables remote access and management of fire detection systems. Facility managers and emergency responders can monitor multiple locations from a centralized platform, facilitating quicker response times and better resource allocation. IoT fire detection systems generate vast amounts of data, which can be analyzed to gain valuable insights into fire patterns, trends, and potential risks. Data analytics can help optimize fire safety measures and preventive strategies. IoT fire detection systems can optimize power consumption through smart sensor management and power-saving algorithms. Implementing IoT-based fire detection systems involves a balance of initial investment against long-term benefits. Initial costs include purchasing sensors, setting up communication infrastructure, and installing software. However, these costs are offset by long-term savings through early fire detection, which can reduce damage, lower insurance premiums, and minimize operational downtime. Scalable systems may require higher initial investments but prove cost-effective over time by accommodating future expansions without significant additional costs. Improved operational efficiency through real-time monitoring and automatic alerts reduces the need for manual inspections and increases response times, further adding to the cost-benefit.

## 2.2. Challenges

IoT fire detection systems involve the collection and transmission of sensitive data. Ensuring data security and privacy is essential to protect against unauthorized access and potential cyber-attacks. IoT devices rely on stable and reliable connectivity to transmit data. Network failures or communication issues can lead to delayed or missed fire detection alerts, compromising system effectiveness. Ensuring interoperability between different IoT devices and platforms can be challenging, especially when integrating multiple vendors' solutions. Standardization efforts are crucial to foster seamless integration. IoT fire detection systems should be designed to minimize false alarms caused by environmental factors, device malfunctions, or other non-fire-related events. Frequent false alarms can lead to complacency and reduce the system's credibility. Regular maintenance and timely software updates are essential to keep IoT fire detection systems functioning optimally. Balancing the benefits against the cost is essential to justify the adoption of such systems. Relying solely on IoT technology for fire detection may introduce risks if the system encounters technical glitches, outages, or if personnel become over-reliant on automation. Wireless sensor connection of IoT devices have been depicted in figure 1.

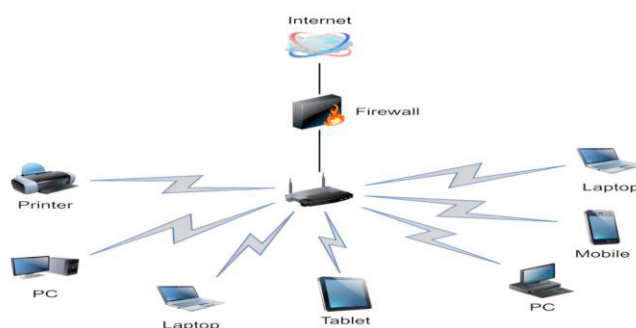


Fig.1. Wireless sensor connection of IoT devices

## 3. Literature review of fire detection

An IoT-enabled big data analytics framework for fire safety management in smart buildings (Zhang and Chen) set out to improve fire safety management in smart buildings via the integration of IoT and big data analytics. A variety of sensors and actuators connected to the Internet of Things (IoT) are proposed as part of a holistic system architecture

for real-time monitoring and recording of environmental parameters, fire-related metrics, and occupancy patterns [28-29]. Data mining and machine learning algorithms are used in the analysis of the gathered information to improve fire detection, risk assessment, and emergency response planning. The purpose of the framework is to facilitate effective resource allocation in fire safety management by increasing the rate of early fire detection and decreasing the number of false alarms [30-31]. Insightful recommendations for improving fire safety management in the context of smart buildings are provided in this research. The researcher provides an architecture for a control system that considers sensors and cameras that are part of the Internet of Things. Cameras give visual input for situational awareness while sensors gather real-time data on fire-related aspects [32-33]. In order to reliably identify fire occurrences and provide timely warnings, the gathered data is processed and analyzed using big data analytics methods. Optimal resource allocation and route planning are only two of the sophisticated algorithms included in the system. In this study, we show how combining IoT, big data analytics, and smart firefighting tactics may greatly enhance fire safety and response capabilities [34]. The authors provide a system that utilizes Internet of Things (IoT) devices and big data analytics strategies to improve industrial fire detection, prevention, and response. In order to monitor environmental factors, equipment health, and fire-related indicators in real-time, the article covers the integration of numerous IoT sensors and devices. Big data analytics methods, including data mining and machine learning algorithms, are used to the gathered data in order to spot irregularities, forecast fire events, and allow preventative steps [35]. The framework uses machine learning techniques for fire detection, fire behavior prediction, and firefighting strategy optimization. According to the study Fire Safety Monitoring and Alert System using IoT and Big Data Analytics by Hossain, Muhammad, and Mohammed (2021), this new method is made possible by combining IoT with big data analytics [6]. This paper proposes a system architecture for monitoring and alerting on fire events that makes sensors connected to the Internet of Things and large-scale data analysis. Sensors connected to the Internet of Things then cameras monitor fire-related variables in real-time, such as heat, smoke, and gas concentrations. These systems play a crucial role in protecting lives and property by swiftly responding to fire incidents and suppressing flames before they escalate. There are several types of automated fire suppression systems, each with its unique features and applications. Gaseous suppression systems use specialized agents for putting out fires, such as the inert gases nitrogen or argon or the cleaner FM-200 or Novec 1230. As soon as smoke is discovered, the system releases the gaseous agent into the protected space, displacing oxygen and extinguishing the fire without leaving any residue.

To put out fires, especially those involving flammable liquids, foam suppression systems employ foam agents. The layer of foam that builds over the fuel surface suffocates the fire by blocking the discharge of combustible vapors. Deluge systems consist of open nozzles attached to a piping network. When a fire is detected, all the nozzles are activated simultaneously, deluging the area with water or a specific extinguishing agent. The thin water droplets produced by water mist systems are very efficient at putting out flames. The mist is effective in putting out fires because it lowers the oxygen level. Their deployment offers several advantages such as rapid response, 24/7 protection, effective fire suppression, minimized human intervention, and scalability. Automated systems react quickly to fire incidents, reducing the time between detection and suppression, thereby minimizing fire spread and damage. Table 1 depicts the comparative methodology and key findings of various researchers.

Table 1. Comparative methodology and key findings.

| Research Paper                       | Methodology   | Key findings  | Year |
|--------------------------------------|---|---|------|
| Zhang, M., & Chen, M.                | Proposed an IoT-enabled big data analytics framework          | Improved fire safety management in smart buildings through real-time data analysis.       | 2019 |
| Hasani et al.                        | IoT-based smart fire detection and firefighting system        | Enhanced fire detection accuracy and quick response using IoT devices and big data.       | 2022 |
| Sharma, R., & Gupta, D.              | Utilized IoT and big data analytics for smart fire management | Proactive fire detection, risk assessment, and optimization of emergency response.        | 2020 |
| Dhir, V., Gupta, A., & Choudhary, S. | Proposed an IoT-based big data analytics framework            | Improved fire management through real-time monitoring, detection, and emergency response. | 2019 |

Hossain, M. S., Muhammad, G., & Mohammed, S. S.

Developed a fire safety monitoring and alert system

Real-time fire monitoring & timely alerts using IoT and big data analytics.

2021

#### 4. Architectural proposal for using IoT in fire detection

In this section of the work, the task is divided into four parts, each of which serves a distinct purpose within the system. The sensor, which is in charge of collecting information about its surroundings, is the primary focus of the work. Through the ZigBee protocol, the collected data is sent to the second unit (the processing unit). The third model is GSM-optimized, guaranteeing that buyers would get prompt notifications in the case of a fire. The fourth section's job is to alert people that a fire has broken out in the building through an alarm. Each component is essential to the overall functioning of our system, which aims to enhance fire safety and prevention in the context of smart homes. In this work, a smart Internet of things system, with an emphasis on fire safety, has been examined, along with the software and hardware components of its design, its functioning within a city or a building, and its benefits, drawbacks, and possible uses. Effective data collection, processing, transmission, and warning systems are examples of these contributions. Existing household fire detection systems are limited in their effectiveness due to their reliance on single-purpose sensors. Because of this, they are not as efficient as they might be. It is difficult for these systems to recognize occurrences when a sensor in a specific place is malfunctioning, making it hard to identify fires in their early stages. False alarms, which may cause unnecessary stress and disruptions, are another issue that has to be addressed. The suggested smart home fire detection system consists of four main parts: a sensor unit, central processing unit, Global System for Mobile Communication (GSM), and security system. This action was taken in response to previous concerns. Figure 2 shows the smart house modeling using IoT

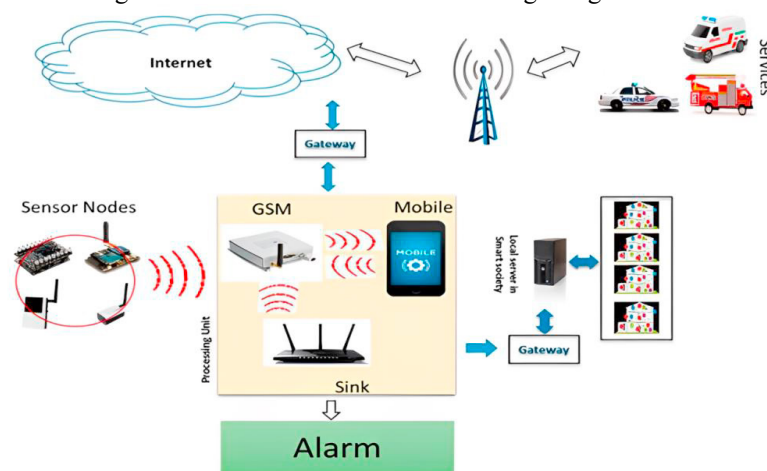


Fig.2 Smart house fire safety modeling using the internet of things

The smart home's sensor network is comprised of smoke, gas, and heat detectors, among others. These sensors all use somewhat different techniques to identify when something significant has happened. The home washbasin is a part of the processing unit that facilitates communication between the sensors and the sensors. The data from the sensors, together with the user's input, determine the sink's fire detection decisions. When even one sensor node triggers a fire alarm, the GSM communication system is activated. The user receives a warning notification as a result of this action. The data from several sensors is analyzed in depth by the washbasin before it sounds an alert, or the user is prompted for approval. Locals about what's going on in their neighborhood. The following sections detail the individual components of each item. Smart house fire safety modeling using the Internet of Things (IoT) involves creating a comprehensive system that integrates various IoT devices and sensors to enhance fire detection, prevention, and response capabilities within a smart home environment. Also, Supervised machine learning models, such as Support Vector Machines (SVM), Random Forests, or Neural Networks, can be trained using labeled data to classify

fire and non-fire events. These models use historical data with known fire occurrences to learn patterns and make accurate predictions.

The model employs smoke, gas, as well as heat sensors to detect changes that may be related to fire occurrences. Fire byproducts including heat, smoke, gas, infrared, and UV radiations may be detected and identified with the use of these sensors. Changes in gas levels may be detected by the gas sensors, while changes in smoke density can be detected by the smoke sensors, both of which might indicate the presence of a fire. The smoke detectors are designed to pick up on variations in smoke density. We also employ temperature sensors, which can be broken down into two groups based on their intended use: (i) sensors that detect a rapidly increased temperature, and (ii) sensors that detect a steady increase in temperature and sound an alarm when it's reached. Our approach uses a number of these sensors to provide more accurate and timely fire detection in smart home situations. The ZigBee protocol is notable for its low overall power consumption; the majority of the protocol's power is used during data transmission. The protocol employs a wide range of hardware, including coordinators, routers, and end devices. Figure 3 depicts the flow diagram of the node and sink.

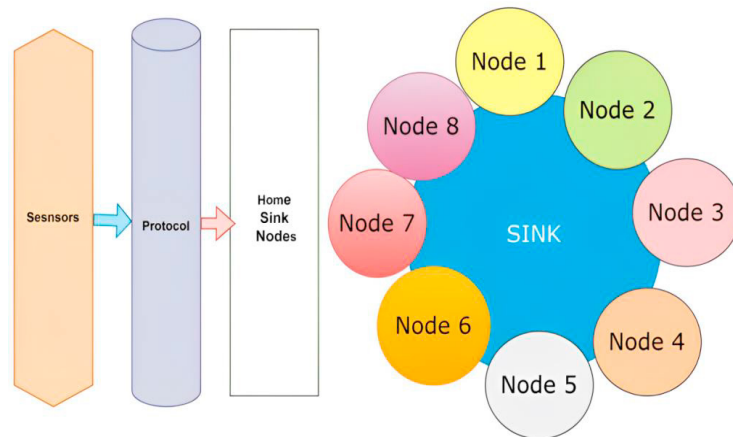


Fig. 3 Flow diagram of the nodes and sink

Direct sequence spread spectrum (DSSS) is the name for ZigBee's encoding technique. It may operate in either the beacon-enabled or beacon-disabled communication modes. The PAN (Personal Area Network) coordinator in a beacon-based communication system will periodically transmit beacon frames or packets. The PAN coordinator will send out beacon packets in a chaotic manner during non-beacon communication. In order to save power, the protocol will turn off the interface anytime the sensors are not actively collecting or transmitting data.

## 5. Discussion

Fire detection in the Internet of Things (IoT) is a topic of significant interest due to the potential of IoT technology to revolutionize fire safety measures. IoT-based fire detection systems offer several advantages and present new opportunities for enhancing fire detection capabilities in various settings, including homes, commercial buildings, industrial facilities, and public spaces. Fire detection in the Internet of Things offers significant potential to enhance fire safety measures by enabling real-time monitoring, accurate detection, and remote management capabilities. However, addressing challenges related to security, interoperability, and user awareness is essential to fully harness the benefits of IoT-based fire detection systems and ensure their widespread adoption and effectiveness in safeguarding lives and property. To ensure the reliability and effectiveness of IoT-based fire detection systems, several key tests must be conducted. These tests cover functional, performance, security, and stress aspects to validate that the system operates correctly under various conditions and scenarios. By conducting these comprehensive tests, organizations can ensure that their IoT-based fire detection systems are reliable, secure, and effective in real-world settings. This rigorous testing regime helps to mitigate risks, improve system performance, and enhance safety outcomes. During the simulation of our smart home fire detection system, we configured the sensors with their

corresponding threshold values and added the GSM module in order to avoid false alarms from being triggered. When the readings of two or more sensors surpass their threshold values, the system will sound an alert. If the user also certifies that there was a fire, the system will also sound an alarm. In order to guarantee the dependability of the system, we carried out a series of tests, and the findings showed that there was an almost nonexistent incidence of false alarms. We compared the results of the simulation we ran with the results we got from using methods that are already in use in order to determine how effective our suggested strategy is. Because of this comparison, we were able to discover that our technology is very effective in terms of detecting and preventing fires. In the sections that follow, we will show and discuss the specific outcomes of our simulated trials. Temperature sensor readings ( $^{\circ}\text{C}$ ) for single and multiple sensor scenario data include various factors such as living room, kitchen, bedroom, and garage with range of readings [22-70], [20-63],[18-60],[15-64] respectively. The multi-sensor environment outperformed the single-sensor scenario by providing a more robust and accurate fire detection system. The integration of various sensor types minimized false alarms and ensured reliable fire detection. This approach enhances the safety and security of smart homes, demonstrating the effectiveness of combining multiple sensors for comprehensive monitoring and alerting systems.

## 6. Conclusion

In this work, we explain an issue, and to solve it, we performed simulations of two alternative situations. This allowed us to compare the behavior of sensors and address the problem. To begin, we ran a simulation of a scenario with a single sensor. In this scenario, a temperature sensor was installed in every section of the smart house. Second, we put into action the multi-sensor environment that was suggested in our previous study. Two different kinds of datasets were produced as a result of these simulations: (i) data from the single-sensor scenario, and (ii) data from the multi-sensor scenario. Using these datasets, we conducted an analysis on the behavior of the sensors. In the scenario with a single sensor, we speculated that the fire started in the kitchen, so we deactivated the sensor that was located in the kitchen so that we could study how the other sensors responded.

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## References

- [1] Babar M, Jan MA, He X, Tariq MU, Mastorakis S, Alturki R. An optimized IoT-enabled big data analytics architecture for edge–cloud computing. *IEEE internet of things journal*. 2022 Mar 14; **10**(5):3995-4005. <https://doi.org/10.1109/IJOT.2022.3157552>
- [2] Al Hasani IM, Kazmi SI, Shah RA, Hasan R, Hussain S. IoT based Fire Alerting Smart System. *Sir Syed University Research Journal of Engineering & Technology*. 2022 Dec 25; **12**(2):46-50.
- [3] Vijayalakshmi SR, Muruganand S. A survey of Internet of Things in fire detection and fire industries. In 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC) 2017 Feb 10 (pp. 703-707). IEEE.
- [4] Kamel S, Jamal A, Omri K, Khayyat M. An IoT-based Fire Safety Management System for Educational Buildings: A Case Study. *International Journal of Advanced Computer Science and Applications*. 2022; **13**(7). DOI:10.14569/IJACSA.2022.0130789
- [5] Bhoi SK, Panda SK, Padhi BN, Swain MK, Hembram B, Mishra D, Mallick C, Singh M, Khilar PM. Fires-iot: A fire detection system for smart home based on iot data analytics. In 2018 International Conference on Information Technology (ICIT) 2018 Dec 19 (pp. 161-165). IEEE.
- [6] Hossain, M. S., Muhammad, G., & Mohammed, S. S. (2021). Fire Safety Monitoring and Alert System using IoT and Big Data Analytics. In 2021 IEEE Region 10 Symposium (TENSYP), 1199-1204.
- [7] Afshari SS, Enayatollahi F, Xu X, Liang X. Machine learning-based methods in structural reliability analysis: A review. *Reliability Engineering & System Safety*. 2022 Mar 1; **219**:108223.
- [8] Lyu Y, Yin P. Internet of Things transmission and network reliability in complex environment. *Computer Communications*. 2020 Jan 15;150:757-63. <https://doi.org/10.1016/j.comcom.2019.11.054>
- [9] Singh K, Singh Y, Barak D, Yadav M. Evaluation of Designing Techniques for Reliability of Internet of Things (IoT). *International Journal of Engineering Trends and Technology*. 2023; **71**(8):102-18. <https://doi.org/10.14445/22315381/IJETT-V71I8P209>
- [10] Catelani M, Ciani L, Bartolini A, Del Rio C, Guidi G, Patrizi G. Reliability analysis of wireless sensor network for smart farming applications. *Sensors*. 2021 Nov 18 **21**(22):7683. <https://doi.org/10.3390/s21227683>

- [11] Xu Z, Saleh JH. Machine learning for reliability engineering and safety applications: Review of current status and future opportunities. *Reliability Engineering & System Safety* 2021 Jul 1; 211:107530.
- [12] Xing L, Tannous M, Vokkarane VM, Wang H, Guo J. Reliability modeling of mesh storage area networks for Internet of Things. *IEEE Internet of Things Journal*. 2017 Sep 6; **4(6)**:2047-57. <https://doi.org/10.1109/JIOT.2017.2749375>
- [13] Sharma P, Gupta PK. Optimization of IoT-Fog Network Path and fault Tolerance in Fog Computing based Environment. *Procedia Computer Science*. 2023 Jan 1; **218**:2494-503. <https://doi.org/10.1016/j.procs.2023.01.224>
- [14] Sandelic M, Peyghami S, Sangwongwanich A, Blaabjerg F. Reliability aspects in microgrid design and planning: Status and power electronics-induced challenges. *Renewable and Sustainable Energy Reviews*. 2022 May 1; **159**:112127. <https://doi.org/10.1016/j.rser.2022.112127>
- [15] Li XQ, Song LK, Bai GC. Recent advances in reliability analysis of aeroengine rotor system: a review. *International Journal of Structural Integrity*. 2022 Jan 12; **13(1)**:1-29. DOI 10.1108/IJSI-10-2021-0111
- [16] Singh K, Singh Y, Khang A, Barak D, Yadav M. Internet of Things (IoT)-Based Technologies for Reliability Evaluation with Artificial Intelligence (AI). In *AI and IoT Technology and Applications for Smart Healthcare Systems 2024* May 15 (pp. 387-395). Auerbach Publications.
- [17] Chen J, Zhang L, Liang YC, Kang X, Zhang R. Resource allocation for wireless-powered IoT networks with short packet communication. *IEEE Transactions on Wireless Communications*. 2019 Jan 23; **18(2)**:1447-61. <https://doi.org/10.1109/TWC.2019.2893335>
- [18] Singh K, Singh Y, Barak D, Yadav M, Özen E. Parametric evaluation techniques for reliability of Internet of Things (IoT). *International Journal of Computational Methods and Experimental Measurements*. 2023; **11(2)**. <https://doi.org/10.18280/ijcem.110207>
- [19] Bhatia S, Goel N, Ahlawat V, Naib BB, Singh K. A Comprehensive Review of IoT Reliability and Its Measures: Perspective Analysis. *Handbook of Research on Machine Learning-Enabled IoT for Smart Applications Across Industries*. 2023:365-84.
- [20] Singh K, Singh Y, Barak D, Yadav M. Detection of Lung Cancers From CT Images Using a Deep CNN Architecture in Layers Through ML. In *AI and IoT-Based Technologies for Precision Medicine 2023* (pp. 97-107). IGI Global.
- [21] Singh K, Barak D, Singh Y. IoT Chatbot in Insurance. *International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)*. 2021; **33(1)**:12-6.
- [22] Dhir, V., Gupta, A., & Choudhary, S. (2019). An IoT-based Big Data Analytics Framework for Smart Fire Management System. *International Journal of Computer Applications*, 181 (9), 1-5
- [23] Singh K, Barak D. Healthcare Performance in Predicting Type 2 Diabetes Using Machine Learning Algorithms. In *Driving Smart Medical Diagnosis Through AI-Powered Technologies and Applications 2024* (pp. 130-141). IGI Global.
- [24] Sood K, Dev M, Singh K, Singh Y, Barak D. Identification of Asymmetric DDoS Attacks at Layer 7 with Idle Hyperlink. *ECS Transactions*. 2022 Apr 24; **107(1)** :2171. DOI 10.1149/10701.2171ecst
- [25] Singh K, Singh Y, Barak D, Yadav M. Comparative Performance Analysis and Evaluation of Novel Techniques in Reliability for Internet of Things with RSM. *International Journal of Intelligent Systems and Applications in Engineering*. 2023 Jul 11; **11(9s)**:330-41. <https://ijisae.org/index.php/IJISAE/article/view/3123>
- [26] Yadav M, Kumar S, Kaushik A, Chhabra D. Piezo-beam structure in a pipe with turbulent flow as energy harvester: Mathematical modeling and simulation. *Journal of The Institution of Engineers (India): Series D*. 2023 Dec; **104(2)**:739-52.
- [27] Bhatia S, Goel AK, Naib BB, Singh K, Yadav M, Saini A. Diabetes Prediction using Machine Learning. In *2023 World Conference on Communication & Computing (WCONF) 2023* Jul 14 (pp. 1-6). IEEE. <https://doi.org/10.1109/WCONF58270.2023.10235187>
- [28] Yadav M, Kaushik A, Garg RK, Yadav M, Chhabra D, Rohilla S, Sharma H. Enhancing dimensional accuracy of small parts through modelling and parametric optimization of the FDM 3D printing process using GA-ANN. In *2022 International Conference on Computational Modelling, Simulation and Optimization (ICCMO) 2022* Dec 23 (pp. 89-94). IEEE. <https://doi.org/10.1109/ICCMO58359.2022.00030>
- [29] Kaushik A, Gahletia S, Garg RK, Sharma P, Chhabra D, Yadav M. Advanced 3D body scanning techniques and its clinical applications. In *2022 International Conference on Computational Modelling, Simulation and Optimization (ICCMO) 2022* Dec 23 (pp. 352-358). IEEE
- [30] Sicari S, Cappiello C, De Pellegrini F, Miorandi D, Coen-Portisini A. A security-and quality-aware system architecture for Internet of Things. *Information Systems Frontiers*. 2016 Aug; **18**:665-77. DOI 10.1007/s10796-014-9538-x
- [31] Singh K, Yadav M, Singh Y, Barak D. Reliability Techniques in IoT Environments for the Healthcare Industry. In *AI and IoT-Based Technologies for Precision Medicine 2023* (pp. 394-412). IGI Global. DOI: 10.4018/979-8-3693-0876-9.ch023
- [32] Kumar, S., Kumar, A., Parashar, N., Moolchandani, J., Saini, A., Kumar, R., Yadav, M., Singh, K., & Mena, Y. (2024). An Optimal Filter Selection on Grey Scale Image for De-Noising by using Fuzzy Technique. *International Journal of Intelligent Systems and Applications in Engineering*, **12(20s)**, 322–330. Retrieved from <https://ijisae.org/index.php/IJISAE/article/view/5143>
- [33] Yadav M, Kumar H. Profit analysis of repairable juice plant. *Reliability: Theory & Applications*. 2024; **19(1(77))**:688-95. <https://doi.org/10.24412/1932-2321-2024-177-688-695>
- [34] Singh, K., Yadav, M., Singh, Y., Barak, D., Saini, A., & Moreira, F. Reliability on the Internet of Things with designing approach for exploratory analysis. *Frontiers in Computer Science*, 2024, **6**:1382347. <https://doi.org/10.3389/fcomp.2024.1382347>
- [35] Branco F, Moreira F, Martins J, Au-Yong-Oliveira M, Gonçalves R. Conceptual approach for an extension to a mushroom farm distributed process control system: IoT and blockchain. In *New Knowledge in Information Systems and Technologies: 1 (2019)* (pp. 738-747). Springer International Publishing. [https://link.springer.com/chapter/10.1007/978-3-030-16181-1\\_69](https://link.springer.com/chapter/10.1007/978-3-030-16181-1_69).