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Virtual Reality-Based Disaster Communication System Using Redirected Walking Algorithms

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Virtual Reality (VR), Redirected Walking (RW), Disaster Communication, Rescue Operations, Human-Computer Interaction (HCI)

ABSTRACT

Virtual Reality (VR) represents a significant advancement in human-computer interaction, offering diverse applications across various domains. One of its critical uses is in disaster response and rescue operations. During floods and other natural calamities, traditional communication methods often fail due to network disruptions and physical barriers. This paper proposes a VR-based system to facilitate communication between rescue teams and affected individuals when conventional methods are unavailable.The system incorporates Redirected Walking (RW) algorithms, which predict human motion to guide users within a virtual environment without exceeding physical boundaries. Unlike simple waypoint-based models, our approach provides a realistic representation of user behavior, improving navigation and interaction. The system is designed to work within various virtual and physical environments, allowing for real-time evaluation under dynamic conditions.A key feature of the proposed system is a projection-based communication mechanism, where rescue teams project messages from helicopters to designated ground locations. When individuals step into these specified zones, they receive crucial information, enabling effective communication and coordination during rescue missions. This innovative use of VR enhances disaster management efforts, ensuring better reach and responsiveness in crisis situations

1. INTRODUCTION

Urban flooding has emerged as a major threat to human life and property, causing widespread devastation in various regions. In late July and early August 2019, severe floods impacted over 13 states in India, including Kerala, Gujarat, Karnataka, Maharashtra, Tamil Nadu, Odisha, and Andhra Pradesh, displacing thousands and causing significant economic losses. Similarly, in December 2015, Tamil Nadu witnessed catastrophic flooding, particularly in Chennai, where heavy rainfall led to water levels rising alarmingly inside homes. Citizens mobilized rescue efforts, but the lack of early warnings left many vulnerable, especially individuals with disabilities, who struggled to escape or secure essential resources.

During such disasters, government relief efforts provide food, water, blankets, and medicine, but logistical challenges often result in misallocation of resources. Many affected individuals received supplies they did not need, leaving their primary requirements unmet. Traditional relief distribution methods, such as signaling from helicopters and manually dropping supplies, are inefficient and lack a structured communication system between victims and rescuers.

To address these challenges, we propose a Virtual Reality (VR)-based disaster communication system. This innovative system allows rescue teams to project VR-based messages from helicopters, ensuring clear and effective communication with affected individuals even in areas where conventional communication channels fail. This method enhances disaster response coordination, ensuring victims receive the assistance they need in real-time.

Disasters, both natural and man-made, pose significant risks to built environments. Fires, floods, earthquakes, and terrorist attacks threaten public safety, requiring efficient emergency management strategies. According to the National Fire Protection Association (NFPA), fires alone caused 3,655 deaths, 15,200 injuries, and economic losses of $25.6 billion in the United States in 2018. Effective emergency preparedness, response planning, and hazard prevention are crucial for minimizing casualties and economic impact. By integrating Virtual Reality technology into disaster management, we aim to enhance situational awareness, improve communication, and ensure timely and effective relief distribution.

2. LITERATURE REVIEW

The implementation of Virtual Reality (VR) in disaster management has gained increasing attention due to its potential to enhance situational awareness, improve communication, and facilitate rescue operations. Several studies have explored the role of VR-based systems in disaster response, emergency training, and crisis management. This section reviews key contributions in the field and highlights the significance of VR and redirected walking algorithms in rescue operations.

Virtual Reality in Disaster Management:

VR has been widely explored for simulating disaster scenarios to train first responders and improve emergency preparedness. Zhao et al. (2020) introduced a VR-based disaster response training system that allows emergency personnel to navigate virtual disaster zones and practice rescue strategies in a risk-free environment. Similarly, Liu et al. (2021) developed a VR simulation framework for flood evacuation, which enabled individuals to experience real-time flood scenarios and make informed escape decisions. These studies demonstrate how VR enhances situational awareness and decision-making in emergency situations.

Redirected Walking (RW) Algorithms for Enhanced Navigation:

Redirected Walking (RW) is a key VR technique that helps users navigate a large virtual environment within a limited physical space. Azmandian et al. (2016) explored different RW techniques that subtly manipulate a user's movement, steering them away from physical boundaries while maintaining a natural walking experience. Suma et al. (2012) demonstrated how RW can be integrated into disaster response VR systems, enabling users to navigate virtual environments realistically without needing a large physical space. In the context of disaster communication, RW algorithms can optimize how rescue teams interact with virtual projections, ensuring seamless movement and interaction within the system.

VR-Based Communication for Emergency Response:

During disasters, conventional communication systems often fail due to infrastructure damage or network congestion. Matsuyama et al. (2019) proposed a VR-based communication system for post-disaster scenarios, where virtual messages and markers were projected onto affected areas, allowing victims to receive critical information even when traditional communication methods were unavailable.

Additionally, Mohanty et al. (2022) explored gesture-based VR communication, which enabled individuals to interact with virtual objects using simple hand gestures, making it easier for survivors to request assistance in crisis situations. These studies reinforce the effectiveness of VR-based messaging and interactivity in disaster response.

UAV and Helicopter-Based Rescue Communication:

Several studies have investigated the use of Unmanned Aerial Vehicles (UAVs) and helicopters for disaster relief and communication. Shah et al. (2020) developed a drone-assisted flood rescue system that deployed autonomous UAVs to detect stranded individuals and relay their locations to rescue teams. Kim et al. (2021) proposed a helicopter-based projection system that used augmented reality (AR) and VR technologies to project rescue messages onto flooded areas, guiding survivors to safe zones. These advancements indicate that integrating VR projections with airborne communication systems can significantly enhance disaster response efficiency.

Integration of VR in Multi-Vehicle Rescue Operations:

The use of Vehicle-to-Vehicle (V2V) communication in disaster scenarios has been a topic of ongoing research. Singh et al. (2018) introduced a V2V emergency alert system that allowed vehicles to exchange real-time data on road conditions and hazards, improving coordinated rescue efforts. In a similar vein, Cheng et al. (2020) explored how RF-based inter-vehicle communication can be combined with VR projections to create a smart disaster response system, where rescue teams and victims can interact through virtual projections and real-time alerts.

The existing literature underscores the growing importance of Virtual Reality (VR), Redirected Walking (RW) algorithms, and aerial communication technologies in disaster management. Studies have demonstrated how VR can be leveraged for training, real-time communication, and enhanced navigation in emergency scenarios. The integration of VR-based projections from helicopters represents a novel approach that builds upon prior research in aerial rescue systems, gesture-based communication, and multi-vehicle coordination. By combining VR, RW algorithms, and UAV/helicopter-assisted messaging, the proposed system aims to bridge the gap between survivors and rescue teams, ensuring faster and more effective disaster response.

3.PROPOSED METHODOLOGY

Community resilience plays a crucial role in mitigating the impacts of disasters, serving as a **metaphor, theory, set of capacities, and strategic approach** to disaster readiness. This study examines **the integration of disaster risk reduction (DRR) principles** outlined in the **Sendai Framework** into **health risk management and disaster governance paradigms**. The key emerging themes in disaster resilience include:

- **Socialization of responsibility for resilience**, emphasizing **community-driven preparedness and response mechanisms**.
- **Public-private partnerships (PPPs)** as enabling mechanisms for **risk reduction and rapid response systems**.
- **Adaptive resilience**, where communities dynamically adjust their response strategies based on evolving risks.

To operationalize these principles, this research proposes a **flood prediction and mitigation system** utilizing **Arduino-based sensors and actuators** to monitor environmental conditions and automate disaster responses effectively

System Architecture:

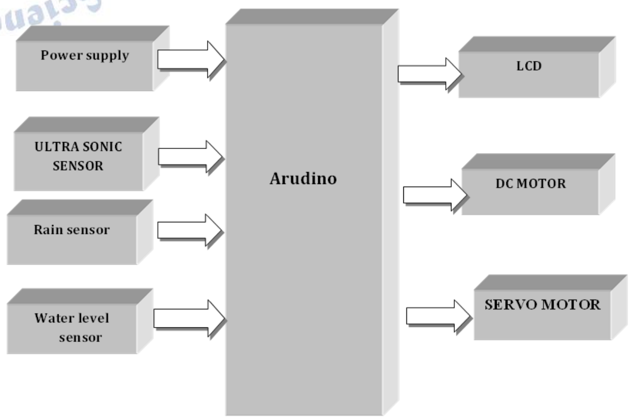

Figure 1: Block Diagram of the proposed system

The proposed system is shown below (Figure 1). The **proposed flood prediction system** integrates **Arduino microcontrollers, sensors, and actuators** to detect and respond to changing environmental conditions. The architecture consists of the following components:

Rain Sensor (Analog Input A0)

- Detects **rainfall intensity** by measuring changes in electrical resistance.
- Sends **real-time data** to the **Arduino microcontroller**.
- Triggers predefined **threshold-based responses** when heavy rainfall is detected.

Water Level Sensor (Analog Input A1)

- Monitors **flood levels** by measuring **water conductivity variations**.
- Outputs an **analog signal corresponding to water depth**, allowing real-time flood prediction.
- Alerts the system when **water levels exceed critical thresholds**.

LCD Display (Output Interface)

- Provides a **real-time visual representation** of sensor readings.
- Displays information such as:
  - Rainfall intensity
  - Water level measurements
  - System warnings and responses

Servo Motor (PWM-capable Digital Pin 9)

- Mechanically **adjusts flood barriers or valves** when critical thresholds are reached.
- Automatically **closes water inlets** to prevent excess flooding.

DC Motor with Motor Driver (Digital Pins 10 & 11)

- **Pumps out excess water** when flood levels exceed safety limits.
- Supports additional **mechanical flood mitigation responses**.

System Workflow and Functionality:

The flood prediction and mitigation system operates based on a **sensor-actuator feedback mechanism**:

1. **Data Collection Phase**
   - The **rain sensor** continuously monitors **precipitation levels**.
   - The **water level sensor** tracks **changes in flood conditions**.
   - The **Arduino microcontroller processes real-time sensor data**.
2. **Decision-Making and Alert Generation**
   - When **rainfall intensity** or **flood levels exceed thresholds**, the system triggers **an alert mechanism**.
   - The LCD display shows the **current flood status** and **recommended actions**.
3. **Automated Response Mechanism**
   - The **servo motor** activates, adjusting flood barriers if necessary.
   - The **DC motor initiates water drainage**, mitigating **water accumulation**.
4. **Disaster Risk Reduction Framework Integration**

The proposed system aligns with **disaster risk reduction (DRR) strategies** under the **Sendai Framework**, emphasizing:

- **Early Warning Systems (EWS)**: The **sensor-based monitoring system** enhances **real-time flood prediction and communication**.
- **Infrastructure Resilience**: Automated **barrier adjustments and drainage mechanisms** minimize disaster impact.
- **Community Involvement**: The **public display system and alerts** ensure **timely awareness and decision-making**.
- **Adaptive Response**: The **modular design** allows for **scalability and integration** with **IoT-based disaster response systems**.

This research presents an **automated flood prediction and mitigation system** that integrates **Arduino, sensors, and actuators** to enhance **disaster preparedness and response**. The proposed system effectively **detects, monitors, and mitigates flood risks**, thereby improving community resilience.

5. **Future Enhancements**

To further optimize the system, the following improvements are proposed:

- **Integration with IoT-based Cloud Monitoring**: Enabling **remote flood monitoring** through **wireless communication**.
- **Machine Learning-Based Prediction Models**: Implementing **AI-driven flood forecasting algorithms** for **improved accuracy**.
- **Geolocation and Mobile Alerts**: Notifying **affected communities in real time** via **SMS or mobile applications**.

By integrating **smart disaster response technologies**, the system **enhances emergency preparedness and minimizes flood-related damages**, aligning with **global DRR initiatives**

4. RESULTS& DISCUSSION

Floods are among the most devastating natural disasters, posing significant risks to human lives and property. Early detection and warning systems play a crucial role in mitigating these risks by providing timely alerts and facilitating disaster preparedness. The proposed **Flood Detection and Rescue Management System** integrates **Arduino-based sensors, real-time monitoring, and communication modules** to detect flood levels, classify road conditions, and enhance public safety.

This methodology focuses on:

- **Accurate flood level detection** using sensor-based monitoring.
- **Early warning alerts** for residents and emergency responders.
- **Real-time monitoring** through an integrated camera system.
- **Mapping flooded roads** to assist in safe route navigation.
- **Data transmission to authorities and residents** for quick decision-making

System Architecture and Components:

The **proposed system**(Figure 2) consists of multiple **sensor nodes**, a **communication network**, and an **information dissemination system**. The architecture includes:

1. **Arduino Microcontroller**
   - o Acts as the central processing unit, collecting data from multiple sensors and triggering alerts.
2. **Water Level Sensor**
   - o Measures the **height of floodwater** in various locations.
   - o Helps classify roads as **passable, partially submerged, or impassable**.
3. **Rain Sensor**
   - o Detects **rainfall intensity**, contributing to **flood prediction models**.
   - o Works in tandem with water level sensors for **early flood detection**.
4. **Camera Module (Optional Enhancement)**
   - o Provides **real-time flood visuals** for better assessment.
   - o Enhances decision-making for rescue teams and residents.
5. **GSM or IoT-Based Communication Module**
   - o Sends **real-time flood alerts** to **residents, authorities, and emergency responders**.
   - o Enables **wireless data transmission** for monitoring via mobile apps or web interfaces.
6. **LCD Display and LED Indicators**
   - o Displays **flood levels** and **road safety status** (Safe, Risky, Dangerous).
   - o **LED indicators** visually notify drivers and pedestrians of hazardous roads.
7. **Solar-Powered Battery System (Optional Enhancement)**
   - o Provides an **uninterrupted power supply** in disaster situations

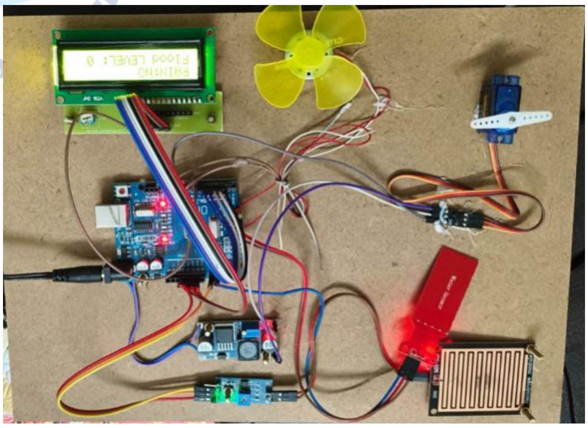

Figure 2: Hardware Implementation of the proposed system

System Workflow and Functionality:

1. **Data Collection and Flood Monitoring**
   - o The water level sensor continuously measures flood depth.
   - o The rain sensor detects heavy rainfall events.
   - o The Arduino microcontroller processes real-time data.

2. **Classification and Alert Mechanism**
   - If water levels exceed predefined thresholds, the system classifies roads:
     - Safe (Green LED): Normal conditions, roads are fully accessible.
     - Risky (Yellow LED): Partial flooding detected; caution advised.
     - Dangerous (Red LED): Roads are impassable; alternative routes suggested.

Table 1: Sequence of events in the proposed system

Test No.	Sensor Readings	Alert Status	Rescue Action Triggered	Response Time (Seconds)	Remarks
1	Water Level: 30 cm (Normal)	No Alert	No Action	0	Normal condition
2	Water Level: 70 cm (Warning)	SMS Alert Sent	No Action	2	Early warning issued
3	Water Level: 120 cm (Critical)	Siren & SMS Alert	Rescue Team Notified	5	Emergency response triggered
4	Water Flow Speed: 1 m/s (Normal)	No Alert	No Action	0	Normal water flow

   - Alerts are displayed on LCD screens at key locations.

3. **Communication and Public Awareness**
   - The GSM/IoT module sends SMS alerts or app notifications to residents and authorities.
   - The camera module captures live footage for authorities to assess the situation remotely.
   - The system shares data with municipal disaster management teams for decision-making.

4. **Flood Rescue and Evacuation Support**
   - Authorities use the flood mapping system to deploy rescue operations.
   - Automated drainage control (optional enhancement) can trigger water pumps to reduce flooding.

Expected Outcomes and Benefits:

The proposed Flood Detection and Rescue Management System aims to:

✓ Improve early flood warnings through sensor-based monitoring.

✓ Enhance road safety by providing real-time flood classification.

✓ Facilitate efficient disaster management through automated alerts and communication.

✓ Reduce property damage and save lives with timely flood prediction and response.

✓ Provide scalability by integrating with advanced IoT-based flood forecasting systems. Table 1 presents the sequence of events in the proposed system.

5.CONCLUSIONS

Traditional dam monitoring relies heavily on manual inspections, which can be time-consuming and inefficient in emergency situations. To address these challenges, we have developed a flood-based disaster monitoring and management system for dams, utilizing real-time sensor-based monitoring. By integrating various sensors, our system continuously tracks water levels, flow rates, and other critical parameters, enabling automated alerts and proactive decision-making. This advanced approach significantly enhances dam safety, water resource management, and disaster prevention.

Future Scope

Our system is scalable and adaptable, allowing for the integration of newly constructed dams in the future. Additionally, a mobile or web-based application can be developed, enabling people to access flood-prone areas in real time through Google Maps integration. This feature would help communities avoid high-risk zones and plan safer routes. Furthermore, this system can be expanded into a comprehensive disaster management platform, incorporating real-time monitoring of landslides, earthquakes, and other natural disasters, thereby strengthening disaster preparedness and response capabilities.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Anbarasan, M., Muthu, B., Sivaparthipan, C. B., Sundarasekar, R., Kadry, S., Krishnamoorthy, S., & Dasel, A. A. (2020). Detection of flood disaster system based on IoT, big data and convolutional deep neural network. Computer Communications, 150, 150-157.

[2] Babu, V., & Rajan, V. (2019, July). Flood and earthquake detection and rescue using IoT technology. In 2019 International Conference on Communication and Electronics Systems (ICCES) (pp. 1256-1260). IEEE.

[3] Iyekekpolo, U. B., Idachaba, F. E., & Popoola, S. I. (2018). Early flood detection and monitoring system based on Wireless Sensor Network. In Proc. Int. Conf. Ind. Eng. Oper. Manag (Vol. 2018, pp. 1381-1394).

[4] Kumar, N., Agrawal, A., & Khan, R. A. (2019). Cost estimation of cellularly deployed IoT-enabled network for flood detection. Iran Journal of Computer Science, 2(1), 53-64.

[5] Napiah, M. N., Idris, M. Y. I., Ahmedy, I., & Ngadi, M. A. (2017, May). Flood alerts system with android application. In 2017 6th ICT International Student Project Conference (ICT-ISPC) (pp. 1-4). IEEE.

[6] Satria, D., Yana, S., Munadi, R., &Syahreza, S. (2017). Prototype of Google maps-based flood monitoring system using Arduino and GSM module. Int. Res. J. Eng. Technol, 4(10), 1044-1047.

[7] Sharma, A., Chaudhary, A., Rana, A., & Kumar, A. (2021, September). Flood monitoring system using IoT. In 2021 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) (pp. 1-4). IEEE.

[8] Shiravale, S., Sriram, P., & Bhagat, S. M. (2015). Flood alert system by using weather forecasting data and wireless sensor network. International Journal of Computer Applications, 124(10), 14-16.

[9] Ravikiran, D. N., & Dethe, C. G. (2018). Improvements in Routing Algorithms to Enhance Lifetime of Wireless Sensor Networks. International Journal of Computer Networks & Communications (IJCNC), 10(2), 23-32.

[10] Vunabandi, V., Matsunaga, R., Markon, S., & Willy, N. (2015, June). Flood sensing framework by arduino and wireless sensor network in rural-rwanda. In 2015 IEEE/ACIS 16th International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD) (pp. 1-6). IEEE.

[11] Yuliandoko, H., Subono, S., Wardhani, V. A., Pramono, S. H., &Suwindarto, P. (2018). Design of flood warning system based IoT and water characteristics. TELKOMNIKA (Telecommunication Computing Electronics and Control), 16(5), 2101-2110.

[12] Ravikiran, D. N., & Dethe, C. G. (2017). Fuzzy Rule Selection using LEACH Algorithm to Enhance Life Time in Wireless Sensor Networks. Advances in Wireless and Mobile Communications. ISSN, 0973-6972.

[13] RaviKiran, D. N., & Akhil, C. V. A Face Recognition Method for Security Applications in Smart Homes and Cities

[14] Devana, V. K. R., Beno, A., Devadoss, C. P., Sukanya, Y., Ravi Sankar, C. V., Balamuralikrishna, P., ... & Babu, K. V. (2024). A compact self isolated MIMO UWB antenna with band notched characteristics. IETE Journal of Research, 70(8), 6677-6688.

[15] Kumar, M. S., Vellela, S. S., Rao, G. R., Srinivas, B. R., Javvadi, S., SyamsundaraRao, T., & Kumar, K. K. (2024, September). An Interactive Healthcare Recommendation System Using Big Data Analytics. In 2024 3rd International Conference for Advancement in Technology (ICONAT) (pp. 1-6). IEEE.

[16] Addepalli, T., Babu, K. J., Beno, A., Potti, B. M. K., Sundari, D. T., & Devana, V. K. R. (2022). Characteristic mode analysis of two port semi-circular arc-shaped multiple-input-multiple-output antenna with high isolation for 5G sub-6 GHz and wireless local area network applications. International Journal of Communication Systems, 35(14), e5257

[17] Thommandru, R., & Saravanakumar, R. (2024, December). Performance Analysis of Circularly Polarised MIMO Antenna for Wireless Applications. In 2024 International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS) (pp. 513-518). IEEE.

[18] Vellela, S. S., &Balamanigandan, R. (2022, December). Design of Hybrid Authentication Protocol for High Secure Applications in Cloud Environments. In 2022 International Conference on Automation, Computing and Renewable Systems (ICACRS) (pp. 408-414). IEEE.

[19] Krishna, P. B. M., Satish, A., Rao, R. Y., Illiyas, M., & Narayana, I. S. (2022). Design of Complementary Metal–-Oxide Semiconductor Ring Modulator by Built-In Thermal Tuning. Cognitive Computing Models in Communication Systems, 145.

[20] Vellela, S. S., & Balamanigandan, R. (2024). Optimized clustering routing framework to maintain the optimal energy status in the wsn mobile cloud environment. Multimedia Tools and Applications, 83(3), 7919-7938.

[21] Saravanakumar, R., Raja, A., Narayan, P., Rajesh, G., Vinoth, M., & Thommandru, R. (2024, September). Dual-Band Performance Enhancement of Square Wheel Antennas with FR4 Substrate for Sub 7GHz Applications. In 2024 International Conference on Advances in Computing Research on Science Engineering and Technology (ACROSET) (pp. 1-7). IEEE.

[22] RaviKiran, D. N., Reddy, O. B., Mahalakshmi, R. S., Chaitanya, T. L., & Kumar, S. P. S. K. Secure Visual Data Processing: Image Encryption and Decryption through Reversible Logic Gates in VLSI Design.

[23] Vellela, S. S., & Balamanigandan, R. (2024). An efficient attack detection and prevention approach for secure WSN mobile cloud environment. Soft Computing, 1-15.

[24] Srija, V., & Krishna, P. B. M. (2015). Implementation of agricultural automation system using web & gsm technologies. International Journal of Research in Engineering and Technology, 4(09), 385-389.

[25] Kumar, K. K., Rao, T. S., Vullam, N., Vellela, S. S., Jyosthna, B., Farjana, S., &Javvadi, S. (2024, March). An Exploration of Federated Learning for Privacy-Preserving Machine Learning. In 2024 5th International Conference on Innovative Trends in Information Technology (ICITIIT) (pp. 1-6). IEEE.

[26] Dalavai, L., Purimetla, N. M., Vellela, S. S., SyamsundaraRao, T., Vuyyuru, L. R., & Kumar, K. K. (2024, December). Improving Deep Learning-Based Image Classification Through Noise Reduction and Feature Enhancement. In 2024 International Conference on Artificial Intelligence and Quantum Computation-Based Sensor Application (ICAIQSA) (pp. 1-7). IEEE.

[27] Potti, B., Subramanyam, M. V., & Prasad, K. S. (2013). A packet priority approach to mitigate starvation in wireless mesh network with multimedia traffic. International Journal of Computer Applications, 62(14).

[28] RaviKiran, D. N., Swetha, G., Annapurna, D. L., Teja, C. V., & Karthik, A. IoT Based Advanced Automatic Toll Collection and Vehicle Detection System.

[29] Potti, B., Subramanyam, M. V., & Satya Prasad, K. (2016). Adopting Multi-radio Channel Approach in TCP Congestion Control Mechanisms to Mitigate Starvation in Wireless Mesh Networks. In Information Science and Applications (ICISA) 2016 (pp. 85-95). Springer Singapore.

[30] Thommandru, R. (2004). Innovative Meta Ring Array Antenna Design for Ka-Band: Utilization of Arlon Substrate for Enhanced Performance.

[31] Polasi, P. K., Vellela, S. S., Narayana, J. L., Simon, J., Kapileswar, N., Prabu, R. T., & Rashed, A. N. Z. (2024). Data rates transmission, operation performance speed and figure of merit signature for various quadurature light sources under spectral and thermal effects. Journal of Optics, 1-11.

[32] Thommandru, R. (2024). Cost-effective circularly polarized MIMO antenna for Wi-Fi applications. Cost-effective circularly polarized MIMO antenna for Wi-Fi applications (November 02, 2024).

[33] Haritha, K., Vellela, S. S., Vuyyuru, L. R., Malathi, N., & Dalavai, L. (2024, December). Distributed Blockchain-SDN Models for Robust Data Security in Cloud-Integrated IoT Networks. In 2024 3rd International Conference on Automation, Computing and Renewable Systems (ICACRS) (pp. 623-629). IEEE.

[34] Potti, D. B., MV, D. S., & Kodati, D. S. P. (2015). Hybrid genetic optimization to mitigate starvation in wireless mesh networks. Hybrid Genetic Optimization to Mitigate Starvation in Wireless Mesh Networks, Indian Journal of Science and Technology, 8(23).

[35] Thommandru, R. (2022). Survey on MIMO Antenna for 5G Applications.

[36] Sreechandra Swarna and Venkata Ratnam Kolluru (2024), Active Channel Selection by Sensors using Artificial Neural Networks. IJEER 12(4), 1466-1473. DOI: 10.37391/ijeer.120441.

[37] S Sree Chandra, Devarapalli Dharmika, Guntupalli Vijayadurgarao, Maila Sandeep, Nalliboina Ganesh,Fruit Classification based on Shape, Color and Texture using Image Processing Techniques, International Journal for Modern Trends in Science and Technology, 2024, 10(03), pages. 100-107.https://doi.org/10.46501/IJMTST1003017

[38] S Sree Chandra, Chamakura Pavani, Tammineni Thirumalarao, Perla Srilekha, Tripuraneni Sireesha, Verilog-Based Solution for Multi-Vehicle Parking, International Journal for Modern Trends in Science and Technology, 2024, 10(02), pages. 394-400. DOI: https://doi.org/10.46501/IJMTST1002052

[39] Ramesh Babu K, Dr. Naga Ravikiran, Sreechandra Swarna, Raju T, Prabhakar D and Aswini Lalitha, A New Encrypted Secret Message Embedding in Audio by using LSB Based Stenography with AES, International Journal for Modern Trends in Science and Technology, 2024, 10(12), pages. 17-23. https://doi.org/10.46501/ijmtst.v10.i12.pp17-23

[40] Sreechandra Swarna and Venkata Ratnam Kolluru (2024), Active Channel Selection by Sensors using Artificial Neural Networks. IJEER 12(4), 1466-1473. DOI: 10.37391/ijeer.120441.

[41] S Sree Chandra, Devarapalli Dharmika, Guntupalli Vijayadurgarao, Maila Sandeep, Nalliboina Ganesh,Fruit Classification based on Shape, Color and Texture using Image Processing Techniques, International Journal for Modern Trends in Science and Technology, 2024, 10(03), pages. 100-107.https://doi.org/10.46501/IJMTST1003017

[42] S Sree Chandra, Chamakura Pavani, Tammineni Thirumalarao, Perla Srilekha, Tripuraneni Sireesha, Verilog-Based Solution for Multi-Vehicle Parking, International Journal for Modern Trends in Science and Technology, 2024, 10(02), pages. 394-400. DOI: https://doi.org/10.46501/IJMTST1002052

[43] Ramesh Babu K, Dr. Naga Ravikiran, Sreechandra Swarna, Raju T, Prabhakar D and Aswini Lalitha, A New Encrypted Secret Message Embedding in Audio by using LSB Based Stenography with AES, International Journal for Modern Trends in Science and Technology, 2024, 10(12), pages. 17-23. https://doi.org/10.46501/ijmtst.v10.i12.pp17-23