

Integrated Tactical Patrolling Stick

Shridhar Pandhare¹, Samarth Mali¹, S.K. Godase^{2,*}

Abstract

The Integrated Tactical Patrolling Stick (ITPS) is a smart, multi-functional device developed to support military personnel and forest officers working in isolated and high-risk areas like border zones and dense jungles. It is equipped with a range of defensive and signaling features that enhance user safety and situational awareness during patrol duties. Among its key components are a flashing LED system combined with a siren for alert signals, a laser pointer to highlight distant targets or objects, and a high-voltage generator designed to deliver electric shocks for self-defense. For nighttime visibility, it includes a high-intensity white light powered by 4 V batteries. To ensure uninterrupted operation, especially in remote settings, the device uses a combination of solar charging, a DC input port, and an advanced Battery Management System (BMS). A built-in controller unit efficiently manages all components and coordinates their functions. Designed for rough terrains, the ITPS combines durability with ease of use, making it ideal for critical field missions. Beyond defense and illumination, the ITPS features GPS tracking for live location monitoring and a GSM/GPRS communication module, allowing real-time alerts and updates to be shared with command units. It also includes a camera module to capture images or live footage during operations, a panic button for emergencies, and a shock feature for protection in hostile encounters. The ITPS is powered by a rechargeable 3.7 V lithium-ion battery supported by solar energy, ensuring reliability in the absence of traditional power sources. Its rugged yet lightweight build makes it suitable for extended field use. By merging defense, communication, and surveillance tools into a single compact unit, the ITPS represents a significant advancement in tactical patrolling gear, offering enhanced security, operational efficiency, and strategic advantage to those on the frontlines.

Keywords: Tactical patrolling stick, forest patrol, LED and siren alert, military equipment, battery management system, solar powered device, laser signaling, high voltage generator, night visibility, real-time control

INTRODUCTION

The Integrated Tactical Patrolling Stick (ITPS) is a scientifically engineered, multifunctional tool designed to support personnel engaged in field operations within remote and high-risk environments, such as border surveillance zones and dense forest terrains. The device integrates advanced technologies into a single compact system, aiming to enhance situational awareness, communication, navigation, and personal safety [1–9]. Conventional patrolling tools often fall short in addressing the complex and dynamic challenges faced by military and forest officers operating under extreme conditions. The ITPS addresses these limitations by incorporating features such as Global Positioning System (GPS) modules, environmental sensors, real-time communication interfaces, illumination systems, and non-lethal defense mechanisms [9–13]. This convergence of functionalities facilitates seamless data acquisition, threat detection, and rapid decision-making in field scenarios. Moreover, the ergonomic and ruggedized design ensures durability

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and ease of use across varied operational contexts. The development of the ITPS reflects a strategic application of interdisciplinary engineering aimed at augmenting field operability and mission efficiency [14–18]. This mini project report outlines the design, development, and potential application of the Integrated Tactical Patrolling Stick (ITPS), an innovative and multi-functional tool tailored to support security personnel in high-risk and remote operational environments. The ITPS is specifically engineered to enhance the safety, situational awareness, and communication capabilities of individuals deployed in sensitive areas such as Naxal-affected zones, dense forest regions, and international borderlines [19–21]. The device features a robust construction, measuring approximately 3 ft in length, crafted from lightweight yet high-strength PVC material, making it both durable and easy to carry during long patrolling missions. A key component of its design is a rectangular compartment embedded within the stick, which houses the essential electronic modules. These may include GPS tracking, communication systems, emergency alert mechanisms, environmental sensors, and defensive tools, all integrated to ensure optimal functionality in the field. The ITPS is built to endure extreme weather and physically demanding terrains, allowing personnel to maintain communication, navigate effectively, and respond swiftly in emergency situations. By consolidating multiple tactical utilities into a single device, the ITPS not only lightens the operational load but also improves coordination and safety, making it a crucial asset for modern security and forest patrolling operations.

LITERATURE SURVEY

Development of the Integrated Tactical Patrol Stick (ITPS) is inspired by extensive research into multi-functional, portable security tools tailored for high-risk environments. Various studies and technologies form the foundation for ITPS's features, as outlined below:

1. *Multifunction Patrol Equipment*: Research on field-ready tactical tools emphasizes the integration of illumination, defense, and communication systems into a single device. These studies underline the importance of compact design and ease of use for personnel in forests, border, and insurgency-affected areas [22–25].
2. *Ultrasonic Animal Repellents*: Several studies have demonstrated the use of ultrasonic sound emitters (20–40 kHz) for deterring wild animals. Devices tested in forest zones showed effectiveness up to 10–15 m, validating their use for wildlife protection during night patrols [26–28].
3. *Emergency Alert Systems*: Literature on security communication systems supports the implementation of emergency buttons, buzzers (100 dB), and blinking LEDs for quick distress signaling. These systems have proven vital in reducing response time during ambushes or medical emergencies [29–31].
4. *Solar-Based Power Solutions*: Portable systems powered by solar energy have gained traction in security and defense applications. Studies advocate for dual charging options (solar and DC), enabling device operation in off-grid areas, essential for border and forest personnel [32–38].

PROPOSED METHODOLOGY

The Integrated Tactical Patrol Stick (ITPS) employs a multidisciplinary approach, combining renewable energy technology with tactical field applications to enhance the safety and effectiveness of security personnel operating in high-risk environments. The device is designed as a 3-ft-long stick made of lightweight, high-strength PVC, housing various electronic components within a protective rectangular compartment. Central to the ITPS is its solar energy system, which includes an integrated photovoltaic panel capable of charging a lithium-ion battery [39–41]. This battery powers all onboard features and can also be charged via a standard DC jack for rapid charging in base camps. Light Dependent Resistors (LDRs) are utilized to detect sunlight intensity and guide servo motors to adjust the solar panel's angle, thereby maximizing solar energy capture throughout the day. For field operations, the ITPS incorporates several key tactical features: a high-intensity LED flashlight for night visibility, a laser module for silent long-range signaling, a stun gun delivering up to 1100 V for non-lethal self-defense, and an ultrasonic animal repellent emitting 20–40 kHz frequencies to deter wildlife [42–47]. Additionally, an emergency alert system is embedded into the device, activated via

a button that triggers both a 100 dB buzzer and a blinking red LED to signal distress. All components are efficiently managed by the central power system, ensuring continuous operation with optimized energy distribution. This integrated methodology allows the ITPS to function reliably in remote and hostile environments, providing critical support to personnel with minimal dependency on external power sources.

Hardware Description

- *Solar Panel*: Converts sunlight into electrical energy to charge the battery and power the system.
- *Buck Controller*: Steps down and regulates the solar panel's voltage to safely charge the lithium-ion battery.
- *Battery Management System*: Ensures safe operation of the 3.7 V lithium-ion battery by protecting against overcharge, over-discharge, and short circuits.
- *High Voltage Generator*: Boosts 3.7 V to a high voltage (up to 1100 V) to operate the stun feature for non-lethal self-defense.
- *3×3.7V Li-ion batteries*: Serves as the main power source with a typical capacity of 2200–3000 mAh. It stores solar energy and powers all system components.
- *Laser Diode*: Emits, a narrow laser beam used for signaling and direction marking in low-visibility conditions.
- *LED Module*: Provides illumination (torch) and emergency flashing for visibility and signaling in dark environments.

WORKING

The Integrated Tactical Patrol Stick (ITPS) is a multifunctional, autonomous security tool designed to support personnel in patrol tasks, especially in difficult terrain such as forest areas, border zones and rural environments [48–50]. It is specifically designed to improve the safety, communication and operational efficiency of security forces, forest guards and border guards working in low-resource and high-risk environments. Furthermore, Figure 1 shows the block diagram of the system.

Self-powered Power Supply System

At the heart of the ITPS is a self-sufficient power supply mechanism based on a rechargeable 3.7 V lithium-ion battery. This type of battery is often used in compact electronic devices due to its low weight, high energy density and recharge ability. The ITPS system is designed to operate independently without frequent reliance on external power sources, a crucial factor in remote or on-site applications [51–55].

To ensure continuous operation, the ITPS is equipped with a solar power system. A compact solar panel is mounted on the outside of the pole's shaft and strategically positioned to maximize sunlight during daytime patrols. The energy generated from the sunlight is converted into electrical energy and stored in the lithium-ion battery. This solar-based construction not only enhances system sustainability and energy independence but also reduces reliance on external power sources, thereby ensuring uninterrupted functionality even in remote or off-grid locations [56–59].

To manage and stabilize the harvested energy, the system uses a step-down converter, a type of DC/DC converter that reduces the input voltage to the safe charging limits of the battery. This converter ensures that the voltage supplied to the battery remains within the optimum range to prevent damage from overvoltage [60–63].

A battery management system (BMS) is also integrated into the circuit. The BMS performs important functions including:

- Monitoring charge and discharge cycles.
- Preventing overcharging, which can lead to battery swelling or fires.
- Preventing deep discharge, which can permanently damage the battery.

- Regulation of the current flow to protect against short circuits or overheating.
- The BMS significantly increases the safety and service life of the battery and makes the entire power supply system both reliable and robust.

For situations in which charging by solar energy is not possible, such as during night patrols or under cloudy skies, the ITPS has a DC charging connection. This allows the device to be charged quickly in base camps or control rooms using a standard 5 V DC power supply unit or adapter [64–68]. The quick-charging function ensures minimum downtime and longer operational capability under field conditions.

Energy Distribution and Control

The energy stored in the battery is distributed to various modules embedded in the ITPS. Each of these modules is individually controlled by special switches so that the user can only activate the functions required in each case. This design promotes energy efficiency and ensures that the battery is not unnecessarily drained by inactive components. It also simplifies use in critical moments when a quick response is required [69–71].

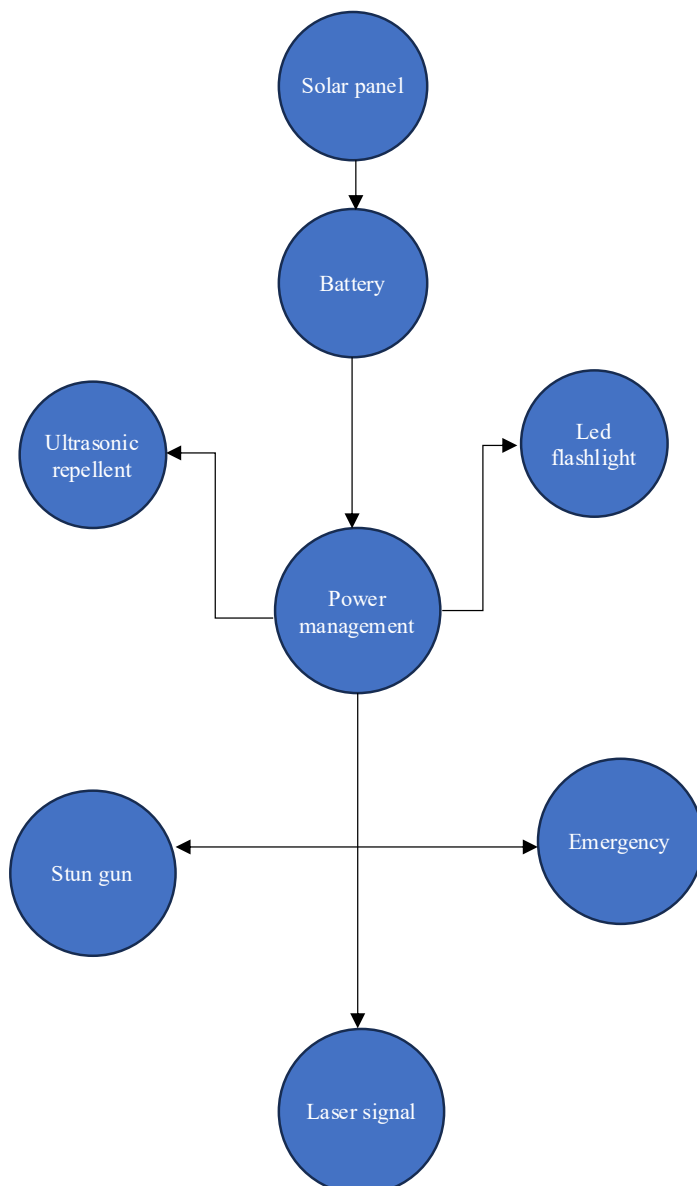


Figure 1. Block diagram of the system.

Night Vision Torch

One of the most important components of the ITPS is the very bright LED torch, which provides light during night patrols or in dark environments. The LED is powered directly from the battery, which ensures a strong and consistent brightness. The torch is particularly useful for navigating rough terrain, inspecting suspicious areas or recognizing potential threats at night. Thanks to its long range and energy efficiency, it is ideal for prolonged outdoor use [72].

Laser Diode for Signaling

To support discreet communication, especially in hostile environments or in situations requiring silence, a laser diode is integrated into the stick. This diode emits a focused beam of light when activated by a push button switch. It allows personnel to send visual signals over long distances without generating noise, making it ideal for tactical operations or group coordination during night patrols. This function can also be used to mark objects from a distance, further enhancing the tactical utility of the stick [73].

Non-lethal Self-defense System

Security personnel working in remote areas are often threatened by both humans and wild animals. To improve their protection, the ITPS has a high-voltage generator that converts the 3.7 V battery voltage into around 1100 V. This voltage is delivered to electrodes at the tip of the rod, which can deliver a non-lethal electric shock when triggered. Although the shock is not intended to cause permanent damage, it is strong enough to deter attackers or create an escape route [42, 45].

This self-defense mechanism acts as a stun device and provides patrol officers with a reliable, hand-held safety tool for emergency confrontations. The system is securely locked and only activates when manually triggered to prevent accidental discharge.

Ultrasonic Animal Repellent

During forest patrols, encounters with wild animals pose a considerable risk. That is why the ITPS is equipped with an ultrasonic buzzer module that emits sounds in the 20–40 kHz range, above the human hearing threshold but within the range that disturbs animals such as dogs, elephants, wild boar and other wildlife. This function acts as a non-violent deterrent and helps patrol officers to avoid close contact or attacks from animals. The sound can be activated via a special switch if required and is particularly useful on dense forest paths or during night shifts [74].

Emergency Alarm System

Emergencies such as injuries, attacks or medical problems can occur during a patrol. The ITPS is therefore equipped with a panic button, an important function that can be used to summon help quickly. When this button is pressed, it is activated simultaneously:

- A high-frequency buzzer that emits a loud warning tone.
- A flashing red LED that serves as a visual distress signal.

RESULTS

After assembling the Integrated Tactical Patrol Stick (ITPS), the complete system was rigorously tested to evaluate its functionality and performance under simulated field conditions. The device successfully demonstrated all integrated features: illumination, signaling, self-defenses, emergency alert, and animal repellent, during controlled lab trials. Each module was activated individually and in combination to assess power consumption, effectiveness, and reliability.

The torch module provided sufficient illumination for visibility up to 20 m in complete darkness. The laser diode proved effective in clear signaling over distances exceeding 50 m, ensuring discreet communication during patrolling. The ultrasonic animal repellent operated within a frequency range of 20–40 kHz and successfully deterred small animals such as dogs and rodents in test scenarios. The high-

voltage stun gun produced a visible and audible spark with an output above 1000 V, confirming its readiness for emergency self-defense situations.

The emergency buzzer and LED module generated a loud 100 dB sound and a blinking red light, which was clearly noticeable over a 25-m range, thus proving effective for alerting teammates during distress situations.

CONCLUSION

The Integrated Tactical Patrol Stick (ITPS) is a revolutionary tool designed to meet the unique challenges faced by security personnel in high-risk environments such as Naxal-affected areas, forests, and border zones. By combining essential functions such as illumination, signaling, self-defense, wildlife deterrence, emergency alert, and dual-mode charging, into a single compact and portable device, the ITPS enhances situational awareness, operational safety, and responsiveness. Its use of solar energy ensures sustainability in remote areas, and its rugged construction guarantees reliability in harsh conditions. With a focus on non-lethal defense and resource efficiency, ITPS offers a modern, eco-friendly solution for frontline security operations.

REFERENCES

1. Godase MV, Mulani AO, Ghodak MR, Birajadar MG, Takale MS, Kolte MA. MapReduce and Kalman filter based secure IIoT environment in Hadoop. *Sanshodhak*. 2024;19:38–47.
2. Gadade B, Mulani AO, Harale AD. IoT based smart school bus and student tracking system. *Sanshodhak*. 2024;19:48–53.
3. Dhanawadel A, Mulani AO, Pise AC. IoT based smart farming using Agri BOT. *Sanshodhak*. 2024;20:117–25.
4. Poonam SM, Arora SM. A DWT-SVD based robust digital watermarking for digital images. *Procedia Comput Sci*. 2018;132:1441–8. doi:10.1016/j.procs.2018.05.076.
5. Anucha M, Eziakolamnwa V, Abuo P. Part design and implementation of an Arduino-based quadcopter drone for surveillance applications. *Int J Trop Eng Comput*. 2025;1(1):1–9.
6. Ahmmed F, Rahman A, Islam A, Alaly A, Mehnaj S, Saha P, Hossain T. Arduino-Controlled Multi-Function Robot with Bluetooth and nRF24L01+ Communication. *International Journal of Robotics & Control Systems*. 2024 Jul 1;4(3).
7. Swami SS, Mulani AO. An efficient FPGA implementation of discrete wavelet transform for image compression. In: 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS). 2017 Aug; 3385–9.
8. Mane PB, Mulani AO. High speed area efficient FPGA implementation of AES algorithm. *Int J Reconfigurable Embedded Syst*. 2018; 7(3): 157–65.
9. Mulani AO, Mane PB. Area efficient high speed FPGA based invisible watermarking for image authentication. *Indian J Sci Technol*. 2016; 9(39): 1–6.
10. Kashid MM, Karande KJ, Mulani AO. IoT-based environmental parameter monitoring using machine learning approach. In: *Proc Int Conf Cognit Intell Comput (ICCIC)*; 2021 Nov. Singapore: Springer Nature; 2022; 43–51.
11. Nagane UP, Mulani AO. Moving object detection and tracking using Matlab. *J Sci Technol*. 2021; 6(1): 2456–60.
12. Kulkarni PR, Mulani AO, Mane PB. Robust invisible watermarking for image authentication. In: *Emerging Trends in Electrical, Communications and Information Technologies: Proc ICECIT-2015*. Singapore: Springer; 2016; 193–200.
13. Ghodake MRG, Mulani MA. Sensor based automatic drip irrigation system. *J Res*. 2016; 2(2): 53–56.
14. Mandwale AJ, Mulani AO. Different approaches for implementation of Viterbi decoder on reconfigurable platform. In: 2015 Int Conf on Pervasive Computing (ICPC). 2015 Jan; 1–4.
15. Jadhav MM, Chavan GH, Mulani AO. Machine learning based autonomous fire combat turret. *Turk J Comput Math Educ*. 2021; 12(2): 2372–81.

16. Shinde G, Mulani A. A robust digital image watermarking using DWT-PCA. *Int J Innov Eng Res Technol.* 2019; 6(4): 1–7.
17. Suresh M, Nataraj KR. Area optimized and pipelined FPGA implementation of AES encryption and decryption. *Int J Comput Eng Res.* 2012;2(7):133–9.
18. Mulani AO, Mane DP. An efficient implementation of DWT for image compression on reconfigurable platform. *Int J Control Theory Appl.* 2017; 10(15): 1–7.
19. Deshpande HS, Karande KJ, Mulani AO. Area optimized implementation of AES algorithm on FPGA. In: 2015 Int Conf Commun Signal Process (ICCSPP). 2015 Apr; 10–14.
20. Kulkarni P, Mulani AO. Robust invisible digital image watermarking using discrete wavelet transform. *Int J Eng Res Technol.* 2015; 4(1): 139–41.
21. Mulani AO, Jadhav MM, Seth M. Painless non-invasive blood glucose concentration level estimation using PCA and machine learning. In: *Artificial Intelligence, Internet of Things (IoT) and Smart Materials for Energy Applications.* CRC Press; United States. 2022.
22. Shinde G, Mulani A. A robust digital image watermarking using DWT-PCA. *Int J Innov Eng Res Technol.* 2019;6(4):1–7.
23. Mulani AO, Mane PB. Area optimization of cryptographic algorithm on less dense reconfigurable platform. In: 2014 Int Conf Smart Structures Syst (ICSSS); 2014 Oct; 86–9.
24. Jadhav HM, Mulani A, Jadhav MM. Design and development of chatbot based on reinforcement learning. In: *IEEE Machine Learning Algorithms for Signal and Image Processing.* 2022; 219–29.
25. Mulani AO, Mane P. Secure and area efficient implementation of digital image watermarking on reconfigurable platform. *Int J Innovative Technol Exploring Eng.* 2018; 8(2): 56–61.
26. Kalyankar PA, Mulani AO, Thigale SP, Chavhan PG, Jadhav MM. Scalable face image retrieval using AESC technique. *J Algebraic Stat.* 2022; 13(3): 173–6.
27. Takale S, Mulani A. DWT-PCA based video watermarking. *J Electron Comput Netw Appl Math (JECNAM).* 2022; 2(6): 1–7. ISSN 2799-1156.
28. Kamble A, Mulani AO. Google assistant based device control. *Int J Aquat Sci.* 2022; 13(1): 550–5.
29. Kondekar RP, Mulani AO. Raspberry Pi based voice operated Robot. *Int J Recent Eng Res Dev.* 2017; 2(12): 69–76.
30. Ghodake RG, Mulani AO. Microcontroller based automatic drip irrigation system. In: *Techno-Societal 2016: Proc Int Conf Adv Technol Soc Appl.* Springer; 2018; 109–15.
31. Mulani AO, Birajadar G, Ivković N, Salah B, Darlis AR. Deep learning based detection of dermatological diseases using convolutional neural networks and decision trees. *Trait Signal.* 2023; 40(6): 2819.
32. Boxey A, Jadhav A, Gade P, Ghanti P, Mulani AO. Face recognition using Raspberry Pi. *J Image Process Intell Remote Sens.* 2022; 2(4): 15–23. ISSN 2815–0953.
33. Patale JP, Jagadale AB, Mulani AO, Pise A. A systematic survey on estimation of electrical vehicle. *J Electron Comput Netw Appl Math.* 2023; 3(1): 1–6. ISSN 2799–1156.
34. Gadade B, Mulani A. Automatic system for car health monitoring. *Int J Innov Eng Res Technol.* 2022;57–62.
35. Shinde MRS, Mulani AO. Analysis of biomedical image using wavelet transform. *Int J Innov Eng Res Technol.* 2015; 2(7): 1–7.
36. Mandwale A, Mulani AO. Implementation of convolutional encoder & different approaches for Viterbi decoder. In: *IEEE Int Conf Commun Signal Process Comput Inf Technol.* 2014 Dec.
37. Mulani AO, Jadhav MM, Seth M. Painless machine learning approach to estimate blood glucose level with non-invasive devices. In: *Artificial Intelligence, Internet of Things (IoT) and Smart Materials for Energy Applications.* CRC Press; US. 2022; 83–100.
38. Poojary S. Role of bioinformatics, computational biology and Computer Technologies in combating COVID-19 virus-a review. *Int J Biotech Trends Technol.* 2020;10:26-30. doi:10.14445/22490183/IJBTT-V10I2P605.
39. Utpat VB, Karande DK, Mulani DA. Grading of pomegranate using quality analysis. *Int J Res Appl Sci Eng Technol.* 2022 Feb; 10(2): 875–881.

40. Takale S, Mulani DA. Video watermarking system. *Int J Res Appl Sci Eng Technol.* 2022; 10(3): 105–107.
41. Mandwale A, Mulani AO. Different approaches for implementation of Viterbi decoder. In: *IEEE Int Conf Pervasive Comput (ICPC).* 2015 Jan; 1–4.
42. Maske Y, Jagadale MAB, Mulani DAO, Pise MAC. Implementation of BIOBOT system for COVID patient and caretakers assistant using IoT. *Int J Inf Technol Comput Eng.* 2021;2(1):30-43. doi:10.55529/ijitc.21.30.43.
43. Mulani AO, Mane DP. Fast and efficient VLSI implementation of DWT for image compression. *Int J Res Appl Sci Eng Technol.* 2016; 5: 1397–402.
44. Kambale A. Home automation using Google Assistant. *UGC Care Approved J.* 2023; 32(1): 1071–7.
45. Pathan AN, Shejal SA, Salgar SA, Harale AD, Mulani AO. Hand gesture controlled robotic system. *Int J Aquat Sci.* 2022; 13(1): 487–93.
46. Korake DM, Mulani AO. Design of computer/laptop independent data transfer system from one USB flash drive to another using ARM11 processor. *Int J Sci Eng Technol Res.* 2016.
47. Mandwale A, Mulani AO. Implementation of high-speed Viterbi decoder using FPGA. *Int J Eng Res Technol.* 2016; 5(2): 73–76.
48. Kolekar SD, Walekar VB, Patil PS, Mulani AO, Harale AD. Password based door lock system. *Int J Aquat Sci.* 2022; 13(1): 494–501.
49. Shinde R, Mulani AO. Analysis of biomedical image. *Int J Recent Innovative Trend Technol.* 2015; 1(3): 83–86.
50. Sawant RA, Mulani AO. Automatic PCB track design machine. *Int J Innovative Sci Res Technol.* 2022; 7(9): 600–604.
51. Abhangrao MR, Jadhav MS, Ghodke MP, Mulani A. Design and implementation of 8-bit Vedic multiplier. *Int J Res Publ Eng Technol.* 2017; 24–26. ISSN:2454–7875.
52. Gadade B, Mulani AO, Harale AD. IoT based smart school bus and student monitoring system. *Naturalista Campano.* 2024; 28(1): 730–7.
53. Mulani DAO. A comprehensive survey on semi-automatic solar-powered pesticide sprayers for farming. *J Energy Eng Thermodyn.* 2024; 4(42): 21–28. ISSN 2815–0945.
54. Salunkhe DSS, Mulani DAO. Solar mount design using high-density polyethylene. *Naturalista Campano.* 2024; 28(1): 1483–1493.
55. Seth M. Painless machine learning approach to estimate blood glucose level of non-invasive device. In: *Artificial Intelligence, Internet of Things (IoT) and Smart Materials for Energy Applications.* CRS Press; United States. 2022.
56. Kolhe VA, Pawar SY, Gohery S, Mulani AO, Sundari MS, Kiradoo G, et al. Computational and experimental analyses of pressure drop in curved tube structural sections of Coriolis mass flow metre for laminar flow region. *Ships Offshore Struct.* 2024; 19(11): 1974–83.
57. Birajadar GB, Mulani AO, Khalaf I, Farhah N, Gawande PG, Kinage K, et al. Epilepsy identification using hybrid CoPro-DCNN classifier. *Int J Comput Digit Syst.* 2024; 16(1): 783–96.
58. Kedar MS, Mulani A. IoT based soil, water and air quality monitoring system for pomegranate farming. *J Electron Comput Netw Appl Math.* 2021; 1(2): 33–43. ISSN 2799–1156.
59. Godse AP, Mulani AO. *Embedded Systems.* India: Technical Publications; 2009.
60. Pol RS, Bhalerao MV, Mulani AO. A real time IoT based system prediction and monitoring of landslides. *Int J Food Nutr Sci.* 2022; 11(7): 5204–5223.
61. Mulani AO, Sardey MP, Kinage K, Salunkhe SS, Fegade T, Fegade PG. ML-powered Internet of Medical Things (MLIOMT) structure for heart disease prediction. *J Pharmacol Pharmacother.* 2025; 16(1): 38–45.
62. Aiwale S, Kolte MT, Harpale V, Bendre V, Khurge D, Bhandari S, et al. Non-invasive anemia detection and prediagnosis. *J Pharmacol Pharmacother.* 2024; 15(4): 408–16.
63. Mulani AO, Bang AV, Birajadar GB, Deshmukh AB, Jadhav HM, Liyakat KKS. IoT based air, water, and soil monitoring system for pomegranate farming. *Ann Agri-Bio Res.* 2024; 29(2): 71–86.

64. Kulkarni TM, Mulani AO. Face mask detection on real time images and videos using deep learning. *Int J Electr Mach Anal Des.* 2024; 2(1): 22–30.
65. Thigale SP, Jadhav HM, Mulani AO, Birajadar GB, Nagrale M, Sardey MP. Internet of things and robotics in transforming healthcare services. *Afr J Biol Sci (S Afr).* 2024; 6(6): 1567–75.
66. Pol DRS. Cloud based memory efficient biometric attendance system using face recognition. *Stoch Model Appl.* 2021; 25(2): 403–416.
67. Nagtilak MAG, Ulegaddi MSN, Adat MAS, Mulani AO. Breast cancer prediction using machine learning. *International Journal of Research in Science & Engineering (IJRISE).* 2021; 1(2): 55–61.
68. Rahul GG, Mulani AO. Microcontroller based drip irrigation system. In: *Techno-Societal 2016; ICATSA.* Cham: Springer; 2016; 109–115.
69. Kulkarni TM, Mulani AO. Deep learning based face-mask detection: An approach to reduce pandemic spreads in human healthcare. *Afr J Biol Sci.* 2024; 6(6): 783–795.
70. Hernandez-Guzman V, Cruz-Ramos C, Nakano-Miyatake M, Perez-Meana H. Watermarking algorithm based on the DWT. *IEEE Lat Am Trans.* 2006;4(4):257-67. doi:10.1109/TLA.2006.4472122.
71. Jadhav VS, Salunkhe SS, Salunkhe G, Yawle PR, Pol RS, Mulani AO, Rana M. IoT based health monitoring system for human. *Afr J Biomed Res.* 2024 Sep; 27: 1309–1315.
72. Jadhav VS, Salunke GD, Chaudhari KR, Mulani AO, Thigale SP, Pol RS, Rana M. Deep learning-based face mask recognition in real-time photos and videos. *Afr J Biomed Res.* 2024 Sep; 27: 142–149.
73. Mulani AO. Electric vehicle parameters estimation using web portal. *Recent Trends Electron Commun Syst.* 2023; 10(3): 1–6.
74. Nagtilak AG, Ulegaddi SN, Mane M, Mulani AO. Automatic solar powered pesticide sprayer for farming. *Int J Microw Eng Technol.* 2023;9(2):7–18.