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Robot With AI-Based Obstacle Identification And Smart Navigation Using Ultrasonic

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Abstract: Autonomous movement is an essential criterion in contemporary robotic systems employed in intelligent environments and automation in factories. This project shows an AI-based robot that can find obstacles and navigate smartly using an ESP32 and an ultrasonic sensor. It can do this without touching anything. Ultrasonic sensors are used by the system to constantly measure how far away the robot is from other things. The ESP32 microcontroller uses this immediate sensor data together with an intelligent route research algorithm to find the safest and shortest way. The robot uses the analyzed route to automatically control its motors to move onward, turn left, right, or stop. This makes sure that it can move around smoothly and without hitting anything. The proposed system shows that it is smart by changing how it moves based on the conditions in the environment. This cheap and effective solution is good for indoor autonomous robot applications.

I. INTRODUCTION

For the visually impaired, going through daily spaces without sight is a great challenge. White canes are limiting in their tactile feedback and demand direct physical contact with the obstacle, which can be dangerous and inefficient. To solve this, we come up with a smart blind stick with embedded AI-based object detection and proximity measurement. The system utilizes a Node-MCU (ESP8266) microcontroller, three ultrasonic sensors, and a speaker to identify obstacles and estimate proximity. Real-time audible warnings assist users by alerting them to objects around them. For loud environments, where speaker output can be ineffective, the system provides an earphone output for clear and confidential voice feedback. Simple AI reasoning assists in providing safer directions from obstacle data, improving navigation. The device is small, light, energyefficient, and both indoor and outdoor use-friendly. The solution is intended to enhance the mobility and safety of visually impaired users through accessible, real-time assistance.

II. RELATED WORK

“Rich feature hierarchies for accurate object detection and semantic segmentation”

Girshick, R., Donahue, J., Darrell, T., Malik, J.

Object detection performance, as measured on the canonical PASCAL VOC dataset, has plateaued in the last few years. The best-performing methods are complex ensemble systems that typically combine multiple low-level image features with high-level context. In this paper, we propose a simple and scalable detection algorithm that improves mean average precision (mAP) by more than 30% relative to the previous best result on VOC 2012 -- achieving a mAP of 53.3%. Our approach combines two key insights: (1) one can apply high-capacity convolutional neural networks (CNNs) to bottom-up region proposals in order to localize and segment objects and (2) when labeled training data is scarce, supervised pre-training for an auxiliary task, followed by domain-specific fine-tuning, yields a significant performance boost. Since we combine region proposals with CNNs, we call our method R-CNN: Regions with CNN features. We also present experiments that provide insight into what the network learns, revealing a rich hierarchy of image features. Source code for the complete system is available at http://www.cs.berkeley.edu/~rbg/rcnn.

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“Real-time obstacle avoidance for manipulators and mobile robots”

Khatib, O.

This paper presents a unique real-time obstacle avoidance approach for manipulators and mobile robots based on the "artificial potential field" concept. In this approach, collision avoidance, traditionally considered a high level planning problem, can be effectively distributed between different levels of control, allowing real-time robot operations in a complex environment. We have applied this obstacle avoidance scheme to robot arm using a new approach to the general problem of real-time manipulator control. We reformulated the manipulator control problem as direct control of manipulator motion in operational space-the space in which the task is originally described-rather than as control of the task's corresponding joint space motion obtained only after geometric and kinematic transformation. This method has been implemented in the COSMOS system for a PUMA 560 robot. Using visual sensing, real-time collision avoidance demonstrations on moving obstacles have been performed.

“DynaSLAM: Tracking, mapping, and inpainting in dynamic scenes”

Bescos, B., Fácil, J.M., Civera, J., Neira, J.

The assumption of scene rigidity is typical in SLAM algorithms. Such a strong assumption limits the use of most visual SLAM systems in populated real-world environments, which are the target of several relevant applications like service robotics or autonomous vehicles. In this letter we present DynaSLAM, a visual SLAM system that, building on ORB-SLAM2, adds the capabilities of dynamic object detection and background inpainting. DynaSLAM is robust in dynamic scenarios for monocular, stereo, and RGB-D configurations. We are capable of detecting the moving objects either by multiview geometry, deep learning, or both. Having a static map of the scene allows inpainting the frame background that has been occluded by such dynamic objects. We evaluate our system in public monocular, stereo, and RGB-D datasets. We study the impact of several accuracy/speed trade-offs to assess the limits of the proposed methodology. DynaSLAM outperforms the accuracy of standard visual SLAM baselines in highly dynamic scenarios. And it also estimates a map of the static parts of the scene, which is a must for long-term applications in real-world environments.

"AI Based Obstacle Avoidance Robot"

Sharma, R.

This paper presents an AI-enabled robot designed to detect and avoid obstacles using ultrasonic sensors. The authors highlight the role of microcontrollers in processing sensor data and executing navigation algorithms. The study emphasizes real-time adaptability and collision-free movement, concluding that AI-based robots are cost-effective and suitable for smart environments.

"Ultrasonic Sensor Applications in Autonomous Navigation"

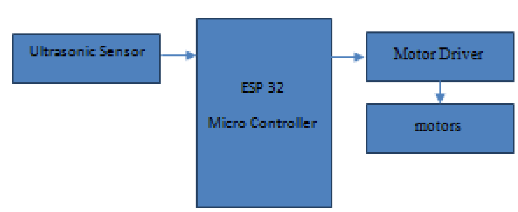
Patel, A.

Patel’s research focuses on the use of ultrasonic sensors for autonomous navigation. The system continuously measures distances to detect obstacles and guides the robot accordingly. The paper discusses sensor accuracy, environmental adaptability, and integration with microcontrollers. The authors conclude that ultrasonic sensors are reliable and affordable for indoor navigation systems.

III. IMPLEMENTATION

The proposed **AI Based Obstacle Detection and Smart Navigation Robot** uses an **ESP32 microcontroller** integrated with **ultrasonic sensors** to achieve autonomous movement. The ultrasonic sensors continuously scan the environment and send distance data to the ESP32. An **auto route analyzer algorithm** evaluates multiple directions and selects the safest path based on obstacle distance. The robot then automatically adjusts its direction and speed to avoid collisions and move efficiently. The system exhibits intelligent behavior by making real-time navigation decisions without human intervention. This approach ensures safe, reliable, and contactless navigat

Block Diagram



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Working

The AI-Based Obstacle Detection and Smart Navigation Robot operates by using ultrasonic sensors and an ESP32 microcontroller to enable autonomous movement while avoiding collisions. The ultrasonic sensors continuously measure distances from surrounding objects, and the ESP32 processes this real-time data to analyze the safest and shortest route. Based on the analysis, the robot intelligently controls its motors to move forward, turn, or stop, ensuring smooth navigation without physical contact. This dynamic adaptation to environmental conditions demonstrates intelligent behavior, making the system a low-cost and efficient solution for autonomous robotic applications in indoor environments.

HARDWARE REQUIREMENT

ESP-32

ESP32 is the SoC (System on Chip) microcontroller which has gained massive popularity recently. Whether the popularity of ESP32 grew because of the growth of IoT or whether IoT grew because of the introduction of ESP32 is debatable. If you know 10 people who have been part of the firmware development for any IoT device, chances are that 7−8 of them would have worked on ESP32 at some point. So what is the hype all about? Why has ESP32 become so popular so quickly? Let's find out.

Before we delve into the actual reasons for the popularity of ESP32, let's take a look at some of its important specifications. The specs listed below belong to the ESP32 WROOM 32 variant.−

- Integrated Crystal− 40 MHz
- Module Interfaces− UART, SPI, I2C, PWM, ADC, DAC, GPIO, pulse counter, capacitive touch sensor
- Integrated SPI flash− 4 MB
- ROM− 448 KB (for booting and core functions)
- SRAM− 520 KB
- Integrated Connectivity Protocols− WiFi, Bluetooth, BLE
- On−chip sensor− Hall sensor
- Operating temperature range− −40 − 85 degrees Celsius
- Operating Voltage− 3.3V
- Operating Current− 80 mA (average)

With the above specifications in front of you, it is very easy to decipher the reasons for ESP32's popularity. Consider the requirements an IoT device would have from its microcontroller (μC). If you've gone through the previous chapter, you'd have realized that the major operational blocks of any IoT device are sensing, processing, storage, and transmitting. Therefore, to begin with, the μC should be able to interface with a variety of sensors. It should support all the common communication protocols required for sensor interface: UART, I2C, SPI. It should have ADC and pulse counting capabilities. ESP32 fulfills all of these requirements. On top of that, it also can interface with capacitive touch sensors. Therefore, most common sensors can interface seamlessly with ESP32.

Secondly, the μC should be able to perform basic processing of the incoming sensor data, sometimes at high speeds, and have sufficient memory to store the data. ESP32 has a max operating frequency of 40 MHz, which is sufficiently high. It has two cores, allowing parallel processing, which is a further add-on. Finally, its 520 KB SRAM is sufficiently large for processing a large array of data onboard. Many popular processes and transforms, like FFT, peak detection, RMS calculation, etc. can be performed onboard ESP32. On the storage front, ESP32 goes a step ahead of the conventional microcontrollers and provides a file system within the flash. Out of the 4 MB of onboard flash, by default, 1.5 MB is reserved as SPIFFS (SPI Flash File System). Think of it as a mini−SD Card that lies within the chip itself. You can not only store data, but also text files, images, HTML and CSS files, and a lot more within SPIFFS. People have displayed beautiful Webpages on WiFi servers created using ESP32, by storing HTML files within SPIFFS.

Finally, for transmitting data, ESP32 has integrated WiFi and Bluetooth stacks, which have proven to be a game-changer. No need to connect a separate

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module (like a GSM module or an LTE module) for testing cloud communication. Just have the ESP32 board and a running WiFi, and you can get started. ESP32 allows you to use WiFi in Access Point as well as Station Mode. While it supports TCP/IP, HTTP, MQTT, and other traditional communication protocols, it also supports HTTPS. Yep, you heard that right. It has a crypto‒core or a crypto-accelerator, a dedicated piece of hardware whose job is to accelerate the encryption process. So you cannot only communicate with your web server, you can do so securely. BLE support is also critical for several applications. Of course, you can interface LTE or GSM or LoRa modules with ESP32. Therefore, on the 'transmitting data' front as well, ESP32 exceeds expectations.

With so many features, ESP32 would be costing a fortune, right? That's the best part. ESP32 dev modules cost in the ballpark of ₹ 500. Not only that, the chip dimensions are quite small (25 mm x 18 mm, including the antenna area), allowing its use in devices requiring a very small form factor.

One very big advantage with ESP32, which has aided its quick adoption and massive popularity, is the provision for programming the ESP32 within the Arduino IDE.

ULTRASONIC SENSOR

Ultrasonic sensors are electronic devices that calculate the target's distance by emission of ultrasonic sound waves and convert those waves into electrical signals. The speed of emitted ultrasonic waves traveling speed is faster than the audible sound. There are mainly two essential elements which are the transmitter and receiver. Using the piezoelectric crystals, the transmitter generates sound, and from there it travels to the target and gets back to the receiver component.

To know the distance between the target and the sensor, the sensor calculates the amount of time required for sound emission to travel from transmitter to receiver. The calculation is done as follows:

D = 1/2 T * C

Where 'T' corresponds to time measured in seconds

'C' corresponds to sound speed = 343 measured in mts/sec

Ultrasonic sensor working principle is either similar to sonar or radar which evaluates the target/object attributes by understanding the received echoes from sound/radio waves correspondingly. These sensors produce high-frequency sound waves and analyse the echo which is received from the sensor. The sensors measure the time interval between transmitted and received echoes so that the distance to the target is known.

Ultrasonic Sensor Specifications

Knowing the specifications of an ultrasonic sensor helps in understanding the reliable approximations of distance measurements.

- The sensing range lies between 40 cm to 300 cm.
- The response time is between 50 milliseconds to 200 milliseconds.
- The Beam angle is around $5^{0.}$
- It operates within the voltage range of 20 VDC to 30 VDC
- Preciseness is ±5%
- The frequency of the ultrasound wave is 120 kHz
- Resolution is 1mm
- The voltage of sensor output is between 0 VDC – 10 VDC
- The ultrasonic sensor weight nearly 150 grams
- Ambient temperature is -25^{0}C to $+70^{0}$C
- The target dimensions to measure maximum distance is 5 cm × 5 cm

The ultrasonic sensor pin diagram is:

L298N MOTOR DRIVER IC

There are multiple kinds of motion we face in our daily life some are linear some are rotatory motion. Both motions have their importance in machines and our life. In the 19th century, the scientist started discovering/inventing some ways of producing current and motions when British physicist John Ambrose Fleming invented the right-hand rule.

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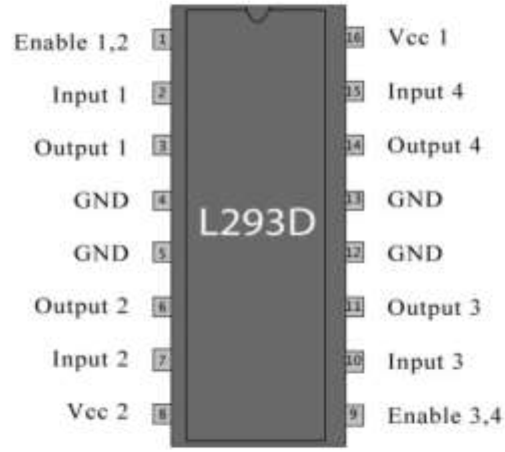
L298N IC is known as a motor driver. It is a low voltage operating device like other ICs. The other ICs could have the same functions like L298N but they cannot provide the high voltage to the motor. L298N provides the continuous bidirectional Direct Current to the Motor. The Polarity of current can change at any time without affecting th e whole IC or any other device in the circuit. L298N has an internal H-bridge installed for two motors.

H-Bridge is an electrical circuit that enables the load in a bidirectional way. L298N Bridge is controlled by external low voltage signals. It may be small in size, but its power output capacity is higher than our expectation. It could control any DC motor speed and direction with a voltage range of 4.5 – 36 Volts. Its diodes also save the controlling device and IC from back EMF. To control the max 600mA amount of current an internal "Darlington transistor sink" installed in it, which could be used to control a large amount of current by providing a small amount of current. It has also internal "pseudo-Darlington source" which amplifies the input signal to control the high voltage DC motor without any interception.

L298N pin out



DC MOTOR

DC Motor is an electrical machine which, when provided with direct current electrical energy, converts it into mechanical energy. It is based on electromagnetic induction, where a conductor carrying current (normally a coil of wire) placed in a magnetic field experiences force to rotate. This rotation is used to perform mechanical work.

There are many applications for DC motors, they can be used in robotics; electric vehicles, and some industrial machinery as well as household devices. DC motor can be used at such places where speed control is required. That is why DC motors are often used in trolleys, electric train production systems, elevators, etc.

Fig: DC motor

IV. RESULT ANALYSIS

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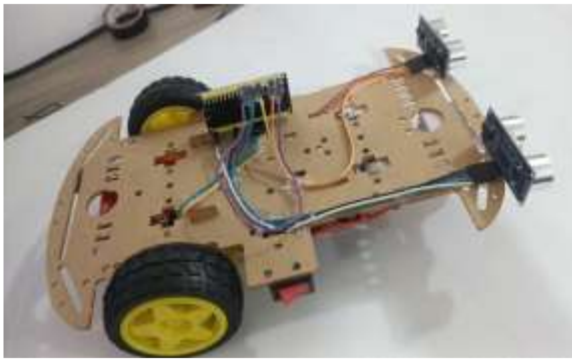

Fig1: autonomous rover

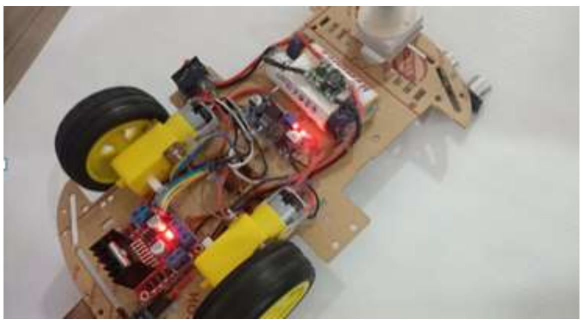

Fig2: components included in the rover

V. CONCLUSION

The AI Based Obstacle Detection and Smart Navigation Robot showcases how ultrasonic sensors and microcontrollers can be integrated with intelligent algorithms to achieve autonomous navigation. By ensuring collision-free movement and dynamic adaptability, the system provides a practical solution for smart environments and industrial automation. Its cost-effectiveness, scalability, and efficiency make it a promising approach for future autonomous robotic applications.

REFERENCES

1. Cadena, C., Carlone, L., Carrillo, H., Latif, Y., Scaramuzza, D., Neira, J., Reid, I., Leonard, J.J. (2016). Past, present, and future of simultaneous localization and mapping: Toward the robust-perception age. IEEE Transactions on Robotics, 32(6): 1309-1332. https://doi.org/10.1109/TRO.2016.2624754
2. Thrun, S., Beetz, M., Bennewitz, M., Burgard, W., Cremers, A.B., Dellaert, F., Fox, D., Hähnel, D., Rosenberg, C., Roy, N., Schulte, J., Schulz, D. (2000). Probabilistic algorithms and the interactive museum tour-guide robot Minerva. The International Journal of Robotics Research, 19(11): 972-999. https://doi.org/10.1177/02783640022067922
3. Thrun, S., Bennewitz, M., Burgard, W., Cremers, A.B., Dellaert, F., Fox, D., Hähnel, D., Rosenberg, C., Roy, N., Schulte, J., Schulz, D. (1999). Minerva: A secondgeneration museum tour-guide robot. In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), Detroit, MI, USA, pp. 1999-2005. https://doi.org/10.1109/ROBOT.1999.770401
4. Dissanayake, M., Newman, P., Clark, S., DurrantWhyte, H.F., Csorba, M. (2001). A solution to the simultaneous localization and map building (SLAM) problem. IEEE Transactions on Robotics and Automation, 17(3): 229-241. https://doi.org/10.1109/70.938381
5. Alvarado Vasquez, B.P.E., Gonzalez, R., Matia, F., De la Puente, P. (2018). Sensor fusion for tour-guide robot localization. IEEE Access, 6: 78947-78964. https://doi.org/10.1109/ACCESS.2018.2885648
6. Redmon, J., Divvala, S., Girshick, R., Farhadi, A. (2016). You Only Look Once: Unified, real-time object detection. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Las Vegas, NV, USA, pp. 779-788. https://doi.org/10.1109/CVPR.2016.91
7. Hart, P.E., Nilsson, N.J., Raphael, B. (1968). A formal basis for the heuristic determination of minimum cost paths. IEEE Transactions on Systems Science and Cybernetics, 4(2): 100-107. https://doi.org/10.1109/TSSC.1968.300136
8. LeCun, Y., Bengio, Y., Hinton, G. (2015). Deep learning. Nature, 521(7553): 436-444. https://doi.org/10.1038/nature14539
9. Bailey, T., Durrant-Whyte, H. (2006). Simultaneous localization and mapping (SLAM): Part II—State of the art. IEEE Robotics & Automation Magazine, 13(3): 108- 117. https://doi.org/10.1109/MRA.2006.1678144
10. [Girshick, R., Donahue, J., Darrell, T., Malik, J. (2014). Rich feature hierarchies for accurate object detection and semantic segmentation. In Proceedings of the IEEE

Conference on Computer Vision and Pattern Recognition (CVPR), USA, pp. 580-587. https://doi.org/10.1109/CVPR.2014.81
11. [11] Kazerouni, I.A., Fitzgerald, L., Dooly, G., Toal, D. (2022). A survey of state-of-the-art on visual SLAM. Expert Systems with Applications, 205: 117734. https://doi.org/10.1016/j.eswa.2022.117734
12. [12] Khatib, O. (1986). Real-time obstacle avoidance for manipulators and mobile robots. The International Journal of Robotics Research, 5(1): 90-98. https://doi.org/10.1177/027836498600500106
13. [13] Bescos, B., Fácil, J.M., Civera, J., Neira, J. (2018). DynaSLAM: Tracking, mapping, and inpainting in dynamic scenes. IEEE Robotics and Automation Letters, 3(4): 4076-4083. https://doi.org/10.1109/LRA.2018.2860039
14. [14] Yu, C., Liu, Z., Liu, X. J., Xie, F., Yang, Y., Wei, Q., Fei, Q. (2018). DS-SLAM: A semantic visual SLAM towards dynamic environments. In 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Madrid, Spain, pp. 1168-1174. https://doi.org/10.1109/IROS.2018.8593691
15. [15] Zhu, F., Zhao, Y., Chen, Z., Jiang, C., Hui, Z., Hu, X. (2025). DYGS-SLAM: Realistic map reconstruction in dynamic scenes based on double-constrained visual SLAM. Remote Sensing, 17(4): 625. https://doi.org/10.3390/rs17040625
16. [16] Zhu, Y., Wan Hasan, W.Z., Harun Ramli, H.R., Norsahperi, N.M.H., Mohd Kassim, M.S., Yao, Y. (2025). Deep reinforcement learning of mobile robot navigation in dynamic environment: A review. Sensors, 25(11): 3394. https://doi.org/10.3390/s25113394
17. [17] Mur-Artal, R., Tardós, J.D. (2017). ORB-SLAM2: An open-source SLAM system for monocular, stereo, and RGB-D cameras. IEEE Transactions on Robotics, 33(5): 1255-1262. https://doi.org/10.1109/TRO.2017.2705103
18. [18] Xiao, L., Wang, J., Qiu, X., Rong, Z., Zou, X. (2019). Dynamic-SLAM: Semantic monocular visual localization and mapping based on deep learning in dynamic environment. Robotics and Autonomous Systems, 117: 1-16. https://doi.org/10.1016/j.robot.2019.03.012
19. [19] Fox, D., Burgard, W., Thrun, S. (1997). The dynamic window approach to collision avoidance. IEEE Robotics & Automation Magazine, 4(1): 23-33. https://doi.org/10.1109/100.580977
20. Bhagwat, V. B. (2024). A simplified transition from EBS Payroll to Cloud Payroll: Benefits and Drawbacks. Journal of Computational Analysis and Applications, 33(6).
21. Gajula, S. (2024). Cybersecurity risk prediction using graph neural networks. Journal of Information Systems Engineering and Management, 9(4), 3301–3315. https://doi.org/10.52783/JISEM.V9I4S.13885
22. Venkata Ramana, P. (2024). AI-driven predictive analytics in ERP systems for proactive supply chain optimization. International Journal of Research in Information Technology and Computing, 8(4).
23. Shashank, A. (2025). AI-Enhanced ETL Processes: Leveraging Artificial Intelligence for Optimized Data Integration Systems. Journal Of Multidisciplinary, 5(8), 219-225.
24. Poojari, R. INTELLIGENT SYSTEMS+B108 AND APPLICATIONS IN ENGINEERING.
25. Maturi, S. Y. (2021). Blockbond hardening: Securing pooled-hash protocols against traffic tampering, MITM hash-rate hijacking, and template coercion. International Journal of Communication Networks and Information Security, 13(3), 718–728.
26. Maturi, S. Y. (2023). Crowdsourced frontier: Unveiling autonomous adversarial cybercapabilities via open AI competition. International Journal of Intelligent Systems and Applications in Engineering, 11(1s), 275–284.
27. Kumar Adabala, P. (2021). Optimizing ERP Modernization: A Smart Data Migration Framework Approach. International Journal of Enhanced Research in Science, Technology &Amp; Engineering, 10(07), 61–72. https://doi.org/10.55948/ijerste.2021.0708
28. Gummadi, V. P. K. (2023). MuleSoft batch processing: High-volume streaming architecture. Computer Fraud & Security, 50-57. https://doi.org/10.52710/cfs.886
29. Shashank, A. (2025). Self-Healing Data Pipelines for Enhanced Reliability: A Paradigm Shift in Enterprise Data Management. Journal of Computer Science and Technology Studies, 7(8), 1097-1104.

30. Ghali Krishna Harshitha. A Study on the Impact of Ethical Attitude of Managers on Organizational Climate. World Journal of Management and Economics, pp. 1–5.
31. Boyapati, P. K., Susarla, R. S., & Kandula, S. T. R. (2025, April). Revolutionizing Fraud Detection in Real-Time Financial Transactions Using AI-Based Boundary-Integrated Neural Networks with Starfish Optimization Algorithm. In International Conference on Computer Vision and Robotics (pp. 75-87). Cham: Springer Nature Switzerland.
32. Boyapati, P. K. Building a centralized data operations hub for healthcare enterprise integration. IJSAT-Int. J. Sci. Technol. 16 (2). https://doi.org/10.71097/IJSAT.v16.i2.3219