HUMAN TRACKING LUGGAGE CARRYING ROBOT FOR MIGRATING PEOPLE

Suthagar.S
Department of ECE
Kongu Engineering College
Erode, India-638060
susjou@gmail.com

Arun Prasath.G
Department of ECE
Kongu Engineering College
Erode, India-638060
arunprasath9688@gmail.com

Boopesh.M.M
Department of ECE
Kongu Engineering College
Erode, India-638060
boopeshmeganathan79@gmail.com

Dhanya.M.S
Department of ECE
Kongu Engineering College
Erode, India-638060
dhanyamylsamy@gmail.com

***Abstract*—This paper addresses the challenge faced by travelers, particularly those using railways as their mode of transportation, concerning the cumbersome task of carrying luggage. To mitigate this issue, Human Tracking Robot (HTR) has been developed to accompany passengers and transport their belongings between source and destination points, thus eliminating the burden of carrying luggage within railway stations. The problem at hand is the physical strain and inconvenience experienced by passengers while carrying their luggage in railway stations. This issue is particularly aims for elderly individuals, businessmen, and travelers. The objectives of this research are to design a HTR capable of autonomously following passengers, carrying their belongings, and navigating through crowded railway station environments, ultimately enhancing the travel experience. HTR is equipped with ultrasonic sensors to detect obstacles, ensuring safe navigation. For navigation of HTR, FiTrack band is designed which is wore by user and sense the user's direction to follow behind the user. Additionally, a keypad lock system is implemented to secure passenger's belongings. The system is designed to operate efficiently in crowded environments. In the event of an emergency, an emergency stop option is available to prioritize passenger safety. The research demonstrates that the HTR system effectively reduces the physical burden of carrying luggage in railway stations. This innovation is particularly beneficial for elderly individuals those who struggle in carrying their weighted luggage. It ensures the safety and convenience of passengers, contributing to a more pleasant and hassle-free railway station experience.**

***Index Terms*—Human Tracking Robot (HTR), Magnetometer, Travelers, FiTrack Band, keypad lock system.**

I. Introduction

Traveling is an essential part of human life, as people move from one place to another for various reasons. Regardless of age, people often relocate to fulfill their needs. However, carrying heavy backpacks while traveling can be a challenging task. The most common mode of transportation for people is traveling via railways, which is less time-consuming and affordable. However, traveling via railways can have its risks, such as having to carry luggage when boarding the train as shown in the Fig.1. This can be particularly challenging for students, businessmen, physically challenged individuals, and the elderly. Navigating through crowded railway stations can be a struggle, especially for elderly people as they may find it challenging to carry their belongings in the rush. Similarly, businessmen traveling at night may find it challenging to walk to the exit with their backpacks, while physically challenged individuals may find it challenging to carry their luggage. A country like India, which is one of the developing nations with a large population where people frequently travel to improve their standard of living.

Fig. 1. Passenger with heavy luggage

Indian Railways is a national asset that has been in operation for 162 years, making it Asia's second-largest and the world's fourth-largest railway system. With over 19,000 trains and 7,112 stations, it plays a critical role in facilitating economic and social development by enabling geographic connectivity, citizen mobility, and commercial activity, as well as providing

979-8-3503-8343-0/24/$31.00 ©2024 IEEE

world-class logistics and transportation infrastructure [1]. Railways have played a significant role in agricultural development by delivering raw materials and finished goods to production sites. Farmers can now sell their agricultural products to far-flung locations and for a profit on the global market.

Train travel is one of the most popular modes of transportation in India. It allows people to travel across the country while enjoying the natural beauty and creating sweet memories. However, carrying luggage can create hassle on the platform and during boarding time [2]. Various parameters should be taken care of while carrying luggage within a railway station. In trains, people usually keep their luggage by themselves, but if the weight of the luggage is more than 100 kg, it is advisable to reach the station half an hour in advance and pay the surcharge and penalty fee at the counter.

Passenger density may not seem to have a direct impact on the overall experience, but it is still an important factor. Once a certain limit is reached, passengers are forced to leave the safety zone due to lack of space or discomfort. Crowded platforms often occur before train entrances, but passengers are usually alert and aware during rush hours, which reduces the chance of accidents. Luggage weight is also a crucial factor to consider, as elderly people may have difficulty carrying heavy bags. With a rise in thefts, it is important to have a suitable security system for luggage. People often hurry to catch their train and may walk or run fast towards the compartments, which can lead to slip-related injuries. Therefore, it is essential for everyone to arrive on time, walk cautiously on the platform and have an eye on their luggage.

II. Literature Review

A. Literature Survey

Nguyen et al have created a prototype on the topic of the human-following strategy for mobile robots in mixed environments. Their innovative approach involves using two sets of behaviours to guide the robot's movements in areas that have both mapped and unmapped terrain. However, there are still some limitations that need to be addressed, such as the development of robust obstacle detection algorithms and sensors, in order to ensure smooth, collision-free navigation in complex environments while following humans [1]. Mengxi et al proposed a project titled influencing leading and following in Human-robot teams. The objective of this project is to equip robots with the ability to learn and comprehend group dynamics. This knowledge will then be utilized for guiding the team towards a common objective. The methodology is applied for two variants of group dynamics like leading-following and predator-prey scenarios. Robots utilizing this representation are notably effective in influencing groups to achieve diverse goals when compared to robots lacking access to these graph representations [3]. Ellenrieder et al have developed a paper on shared human–robot path following control of an unmanned ground vehicle a new method for jointly guiding an Unmanned Ground Vehicle (UGV) using both human and robot assistance. It also passively gauges human intent solely based on human input. Moreover, the researchers have utilized a mixed-interaction technique to blend control inputs from both humans and machines, including the implementation of reactive behaviors in the machine control input, communication delays in the control system design, and the need to define metrics to assess the performance of the shared control system [4].Balakrishna and Rajesh have developed a prototype on the topic design of remote monitored solar powered grass cutter robot with obstacle avoidance using IoT. The Grasscutter is an innovative device designed to maintain grass in public spaces. By using IoT, users can remotely control the Grasscutter with the Blynk app via Bluetooth. The device's motion is programmed through the Arduino IDE and can move forward, backward, and turn in any direction [5]. Vadakkan et al presented a paper on the topic as door locking using keypad and Arduino serves as an efficient security system, consider using an Arduino board and keypad to create a door locking mechanism. The Arduino will compare the password entered via the keypad to the default password [6].

B. Summary from Literature

From the literature review, it has been found that while human follower robots do exist, they are not suitable for use in crowded areas due to their lack of security features and the need for extensive data sets for image processing. However, a new prototype has been suggested, which is effective in busy and level environments. This system boasts advanced alert and security features and can even assist individuals in carrying their heavy backpacks when traveling. It operates with precise location tracking to follow and stop once the desired destination is reached.

III. Methodology

The proposed system comprises two separate devices for signal transmission and reception. The transmitter is attached to the smart band worn by the user, while the receiver is placed in the luggage-carrying system. Once the user turns on the smart band and presses the button to start the signal transmission, the signal is transmitted through the NodeMCU, and the magnetometer is used to determine the exact direction of the user.

The receiver receives the signal and the system starts its movement. The system follows the user behind, and the robot moves in eight cardinal directions - north (N), south (S), west (W), and east (E). A single magnetometer worn by the user transmits data through a NodeMCU to control the direction [7]. The robot consistently faces north, which is 0° on the magnetometer. Turning points are established in the northeast (NE), southeast (SE), southwest (SW), and northwest (NW) directions. If the sensor data falls within the range of 315° to 45°, the robot moves forward continuously without any turns. If the data surpasses 45°, the robot turns right, and if it drops below 315°, it turns left. In case of an obstacle obstructing its path, the robot promptly stops and activates an alarm.

A. Design of Human Tracking Robot

The robot is made up of iron material and it is designed in square shape with dimension shown in Table 1. The overall control of robot depends on its back wheels. The front wheels only used for balancing weight. In front a swivel caster, a wheel is fixed to a fork, but the fork can freely revolve around 360° an extra swivel joint above it, allowing the wheel to roll in any direction. In back, the wheels are fixed constant and it maintains left, right and forward direction of robot. For safeguard the luggage, the normal door-lock security method has been implemented. Three sides of robot have fixed with ultrasonic sensors which helps to avoid crash and stops robot and immediately brings alarm. Then it needs a user attention and get back to normal function.

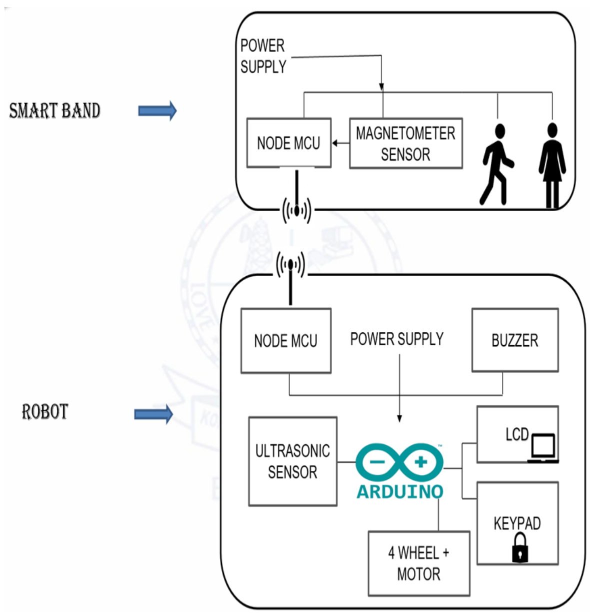

Fig. 2. Architecture of the proposed system

The system is built with various hardware components, including the power supply, NodeMCU, Magnetometer sensor, buzzer, LCD, ultrasonic sensor, keypad, castor wheels, and wiper motor. The software tool – Arduino IDE is also used for programming the various hardware modules as shown in the Fig.2. The system is designed to ensure the safety of the luggage placed over it by using a security system. A keypad is set up to get the 4-digit numerical input from the user. After the system starts, the security lock opens for 15 seconds, allowing the user to place their luggage inside. Once the luggage is placed, the system asks for the 4-digit security pin. The user can choose the number, but it is necessary to remember it since the same pin must be entered at the end to open the lock and retrieve the luggage and it is method of simple door lock system [8]–[10]. An LED display is used to show the system's status, whether it is at rest or in motion, and the direction in which the system is moving. The security system uses a keypad lock and a light-up screen to keep the user's stuff safe and make sure the robot works safely. By using a 4-digit code that only the right person knows, the system makes sure that only that person can open their stuff.

TABLE I
FRAME SPECIFICATIONS

S.No	Specifications	Parameters Maintained
1.	Material	Iron
2.	Frame - Length	400 mm
3.	Frame - Width	322 mm
4.	Frame - Height	300 mm
5.	Thickness of the Material	21 mm

The various components that can be incorporated in proposed system is shown in the Fig.6. It consists of motor, 12V battery, Switch, LCD, Arduino UNO, Relay, Voltage Regulator and NodeMCU. The system has four wheels fitted in the corners, and two wiper motors are installed near the two back wheels to drive it. A 12 V battery is used as a power source, and a voltage regulator circuit is used to regulate the voltage across various components. An ultrasonic sensor detects obstacles, and a buzzer makes a sound if the system is beyond the threshold distance or faces any obstacle [11]. A motor driver starts the motor of the system, and an Arduino UNO controls all the other devices of the system [12].

B. Algorithm

FiTrack Band has transmitter NodeMCU sends data which range from 0° to 360°. If the data falls between the 45° (NW) to 315° (NE) which is cardinal direction degrees, then it moves in forward direction. If it is greater than 315°, then it turns right and after that it normally keep on moving in forward direction. Now the turning points are 45° and 315° which can be get by adding 0° of already given turning points, but the data within 360°. With the help of modulo operator, the desired result can be achieved. The sensor gets and process data for every 2 seconds. This process can be repeated until user reaches their prepared destination. Algorithm makes the robot turns only in exact right and left.

C. Wireless Communication Setup

Wi-Fi communication link is established between a transmitter-server and receiver-client using NodeMCU as shown in the Fig.3, both devices must be connected to the same Wi-Fi network. First, upload the appropriate code to each NodeMCU board. The transmitter NodeMCU should collect the data to transmit and utilize the Wi-Fi module to send it to a specified IP address and port on the receiver NodeMCU [13]. The receiver NodeMCU should be programmed to listen for incoming data on the specified IP address and port. When data is received, it can be processed or displayed as needed. Handling exceptions and ensuring the stability of the Wi-Fi network is essential for maintaining a reliable communication link between the transmitter and receiver NodeMCU boards.

The receiver receives the signal, and the system starts moving. The system follows the user behind, and the robot moves in four directions – north (N), south (S), west (W), and east (E). The user wears a single magnetometer that transmits

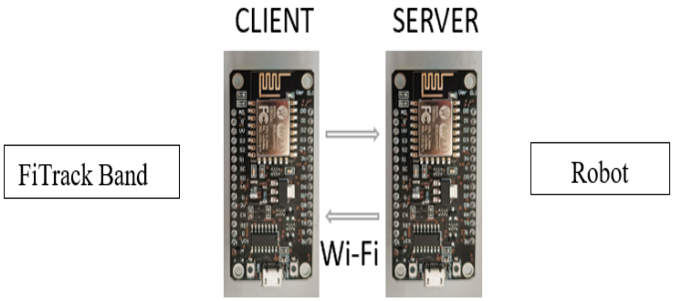

Fig. 3. Client and Server connection through Wi-fi

data through a Node MCU to control the direction. The robot consistently faces north, which is 0 on the magnetometer. Turning points are established in the northeast (NE), southeast (SE), southwest (SW), and northwest (NW) directions. If the sensor data falls within the range of 315° to 45°, the robot moves forward continuously without any turns. If the data surpasses 45°, the robot turns right, and if it drops below 315°, it turns left. In case of an obstacle obstructing its path, the robot promptly stops and activates an alarm.

D. Flow Chart of the Proposed System

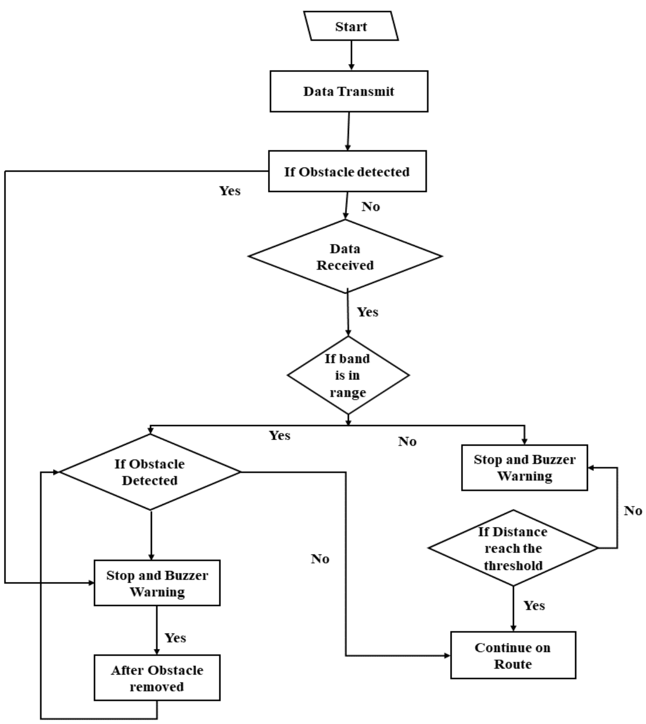

Fig. 4. Flowchart of proposed system

The system initiates and transmits a signal from the transmitter to the receiver. If the receiver receives the signal, the object detection process starts. If the signal is not received, the transmitter resends it until it is received. After the signal is received, the system calculates the distance of the object a shown in Fig.4.

If the distance between the system and the user is less than the threshold, the system continues to follow the user [13]. However, if the distance is greater than the threshold, the robot stops and turns on the buzzer to warn the user. If the system stops due to the distance being greater than the threshold, the user must manually turn on the system to continue following them. After turning on the system, the object distance is checked again. If the distance is within range, the system functions properly. Once the destination is reached, the user can stop the system as per their need. These steps are repeated to ensure effective system utilization.

The three ultrasonic sensors, one is on front side and remaining two on left and right side of the robot. If there are any disturbances in robot path, it senses the object and stops [14]. After it bring alarm for getting the user's attention. The main conditions are robot always facing north direction for path planning of robot [9]. Other condition is, user needs to move from source to destination always in front of robot except turnings. With all these initial conditions, when start a robot by turning switch-on, it shows stop in initial stage on LCD. If both the NodeMCU get connected, it will receive the data of user direction. According to that direction, the robot will keep on moving. If the user needs to turn right, based on our algorithm, the robot left wheel rotates forward and right wheel rotates backward. Once it changes the direction to right, then it starts to keep move in forward direction. Likewise, if the user needs to turn left, based on our algorithm, the robot left wheel rotates forward and right wheel rotates backward. Once it changes the direction to left, then it starts to keep move in forward direction on planned path [15]. This process will keep on repeating until user reached their desired destination.

IV. Result and Discussion

A. Designed HTR and FiTrack band

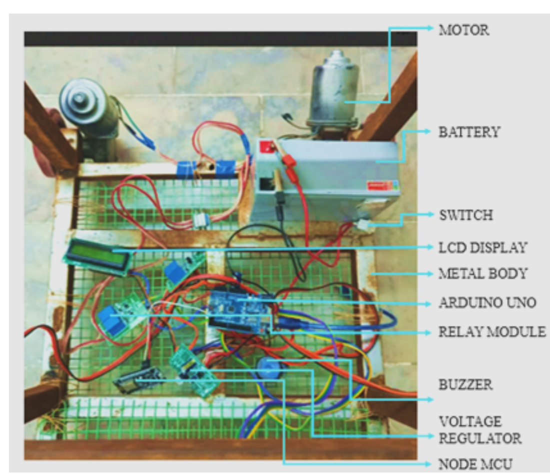

Fig. 5. Top View of Human Tracking Robot (HTR)

HTR was designed to carrying the luggage for the migrating people. By the magnetometer sensor the data will be transmitted and received by the robot and follow the user accordingly.Fig.5 show the top view of the Human Tracking Robot. It represents the components used to build the robot and marks with components specifications.

Fig. 6. Front View of HTR with Luggage

Fig.6 shows the robot loaded with luggage of 5kg. With the load of 5 kg, it gives smooth performance and the wheel rotate with maximum rotation 30 rpm which is measured through rpm meter. Until it reaches the user's destination, it provides constant speed and does not change its speed according to user's speed. This is because to prevent hitting on any of obstacles and also means for user safety.

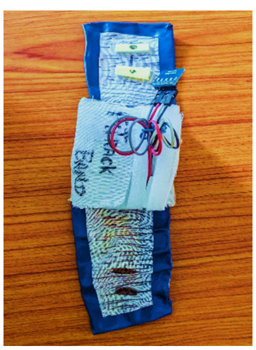

Fig. 7. FiTrack Transmitter band

The FiTrack band is shown in the Fig.7 which consist of power supply, NodeMCU and magnetometer sensor. While using the robot, user need to wear it and don't try to shake band, because the entire robot data depend on it. The demo band is made up of sponge and cotton cloth. To keep magnetometer in stable condition, it was fixed into sponge which increases accuracy in sensing user direction data for sensor. Fig.8 represents the entire prototype of FiTrack band which is wore by user.

Fig. 8. FiTrack Band

The complete finished data receiving HTR model is shown in Fig.9 where HTR is incorporated with luggage carrier and keypad security lock system.

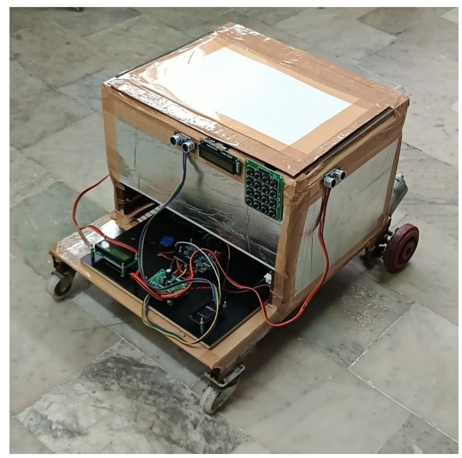

Fig. 9. Side View of HTR which receives data from FiTrack band

B. Discussion

The three ultrasonic sensors, one is on front side and remaining two on left and right side of the robot. If there are any disturbances in robot path, it senses the object and stops. After it bring alarm for getting the user's attention. The main conditions are robot always facing north direction for initialization of robot. Other condition is, user needs to move from source to destination always in front of robot except turnings. With all these initial conditions, when start a robot by turning switch-on, it shows stop in initial stage on LCD. If both the NodeMCU get connected, it will receive the data of user direction. According to that direction, the robot will keep on moving. If the user needs to turn right, based on our algorithm, the robot left wheel rotates forward and right wheel rotates backward [16]. Once it changes the direction to right, then it starts to keep move in forward direction. Likewise, if the user needs to turn left, based on our algorithm, the robot left wheel rotates forward and right wheel rotates backward. Once it changes the direction to left, then it starts to keep move in forward direction. This process will keep on repeating until user reached their desired destination.

TABLE II
PERFORMANCE ANALYSIS OF ROBOT

Payload (Kg)	Revolution Per Minute	Performance
1 - 5	30	Smooth
6 - 10	28	Satisfactory
10 - 15	25	Optimized
15 - 20	15	Less
Above 20	2	Under performed

Table 2 shows, if the luggage with 5 to 10 kg, then it provides maximum speed and good performance without any interruption. It gives maximum RPM of 30, if the load weight is less. When the weight within the range of 6 to 10 kg, it's RPM gets reduced from its maximum. If the weight within range of 10 to 15 kg, it results in optimized level of speed and took some time to reach the destination. While it is in between 15 to 20 kg, the entire performance of robot was less and its RPM reduced to 15. So, it brings a major delay to reach the user destination. If the weight of luggage is above 20 kg, the robot remains in stop state due to overload condition.

V. CONCLUSION

In conclusion, the proposed HTR system offers an innovative solution to a common challenge faced by travelers, particularly those using railway stations. HTR capable of following passengers and carrying their luggage, this system significantly reduces the burden of carrying heavy bags in crowded environments. The methodology outlined in this solution ensures user safety through a security system while enabling precise tracking of the system's location. The use of smart bands, transmitter-receiver devices, magnetometers, and a data transmission system enables seamless and efficient tracking and movement of the robot. Moreover, the robot's ability to navigate in eight cardinal directions and respond to obstacles adds an extra layer of safety and convenience for passengers. The security system, featuring a keypad lock and LED status display, ensures the user's luggage is protected, and the robot operates securely. With the user's unique 4-digit security pin, the system guarantees that only the authorized person can access their belongings. With its ability to follow users, ensure security, and navigate through crowded environments, this innovation represents a significant step towards enhancing the travel experience and reducing the physical strain of handling luggage in railway stations.

The future scope for this innovative HTR is promising, with opportunities for further advancements such as incorporating advanced AI and machine learning algorithms for even more intelligent obstacle avoidance, enhancing the robot's adaptability to different environments, and expanding its usage to airports, bus stations, and other transportation hubs. Additionally, the integration of remote control and real-time tracking through smartphone applications can further improve user convenience, making it a valuable asset for a broader range of travelers. Furthermore, research and development efforts could focus on optimizing energy efficiency, durability, and the potential for eco-friendly power sources, ensuring sustainable and environmentally responsible solutions for luggage transportation in the future.

REFERENCES

[1] N. G. Rezk, E. E.-D. Hemdan, A.-F. Attia, A. El-Sayed, and M. A. El-Rashidy, "An efficient iot based smart farming system using machine learning algorithms," *Multimedia Tools and Applications*, vol. 80, pp. 773–797, 2021.

[2] T. A. Shaikh, W. A. Mir, T. Rasool, and S. Sofi, "Machine learning for smart agriculture and precision farming: towards making the fields talk," *Archives of Computational Methods in Engineering*, vol. 29, no. 7, pp. 4557–4597, 2022.

[3] R. Priya, D. Ramesh, and E. Khosla, "Crop prediction on the region belts of india: a naïve bayes mapreduce precision agricultural model," in *2018 international conference on advances in computing, communications and informatics (ICACCI)*. IEEE, 2018, pp. 99–104.

[4] K. D. von Ellenrieder, S. C. Licht, R. Belotti, and H. C. Henninger, "Shared human–robot path following control of an unmanned ground vehicle," *Mechatronics*, vol. 83, p. 102750, 2022.

[5] Y. Tace, M. Tabaa, S. Elfilali, C. Leghris, H. Bensag, and E. Renault, "Smart irrigation system based on iot and machine learning," *Energy Reports*, vol. 8, pp. 1025–1036, 2022.

[6] A. Vadakkan, A. Babu, C. Pappachan, and A. Sunny, "Door locking using keypad and arduino," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 3, no. 11, pp. 780–787, 2021.

[7] K. Spanaki, E. Karafili, and S. Despoudi, "Ai applications of data sharing in agriculture 4.0: A framework for role-based data access control," *International Journal of Information Management*, vol. 59, p. 102350, 2021.

[8] E. K. Raptis, K. Englezos, O. Kypris, M. Krestenitis, A. C. Kapoutsis, K. Ioannidis, S. Vrochidis, and E. B. Kosmatopoulos, "Cofly: An automated, ai-based open-source platform for uav precision agriculture applications," *SoftwareX*, vol. 23, p. 101414, 2023.

[9] M. Wakchaure, B. Patle, and A. Mahindrakar, "Application of ai techniques and robotics in agriculture: A review," *Artificial Intelligence in the Life Sciences*, p. 100057, 2023.

[10] S. Chen, H. Lin, and G. Yang, "Efficient agricultural disaster financing using satellite data and artificial intelligence," *Computers and Electrical Engineering*, vol. 103, p. 108394, 2022.

[11] F. Alrowais, M. M. Asiri, R. Alabdan, R. Marzouk, A. M. Hilal, D. Gupta *et al.*, "Hybrid leader based optimization with deep learning driven weed detection on internet of things enabled smart agriculture environment," *Computers and Electrical Engineering*, vol. 104, p. 108411, 2022.

[12] V. Dhanya, A. Subeesh, N. Kushwaha, D. K. Vishwakarma, T. N. Kumar, G. Ritika, and A. Singh, "Deep learning based computer vision approaches for smart agricultural applications," *Artificial Intelligence in Agriculture*, 2022.

[13] A. A. Kumbi and M. N. Birje, "Deep cnn based sunflower atom optimization method for optimal water control in iot," *Wireless Personal Communications*, pp. 1–26, 2022.

[14] G. G. Devarajan, S. M. Nagarajan, T. Ramana, T. Vignesh, U. Ghosh, and W. Alnumay, "Ddnsas: Deep reinforcement learning based deep q-learning network for smart agriculture system," *Sustainable Computing: Informatics and Systems*, vol. 39, p. 100890, 2023.

[15] J. Padmapriya and T. Sasilatha, "Deep learning based multi-labelled soil classification and empirical estimation toward sustainable agriculture," *Engineering Applications of Artificial Intelligence*, vol. 119, p. 105690, 2023.

[16] A. Din, M. Y. Ismail, B. Shah, M. Babar, F. Ali, and S. U. Baig, "A deep reinforcement learning-based multi-agent area coverage control for smart agriculture," *Computers and Electrical Engineering*, vol. 101, p. 108089, 2022.