AI Security Drones For Larger Homes Artificial Intelligence Research Project

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Fig. 1: DJI's Tello Edu AI Drone [15]

***Abstract*—Large Home Security Drones is an artificial intelligence based research project proposed for bigger home's security purposes. This project is an interconnection between Python AI programming and two external WiFi connected hardware such as Tello AI drone and motion detection sensor. For every unusual motion detection, detected by a motion detector sensor in any part of the home, the AI drone will be notified with the signal to take the flight to that area, record the scenario and return back to its base station. Such recordings can be sent to users via various options. Flight navigation and actions performed by the drone are based on artificial intelligence programming via machine learning algorithms. The video camera on the Tello drone is the main feature of this research project. Till now many approaches were made for optimum utilization of drones in various fields such as video production, transportation, agricultural purposes and many more. But very few attempts were made in inculcating advanced features like AI in flying drones. Even GPS was used for navigation purposes to fly from source to desired destination. But now with the help of face detection algorithms via machine learning, drone technology is crossing their limitations. From the similar note, this research project focuses in-depth towards researching advanced drone capabilities in bigger home security purposes along with the discussions made on previous relevant research approaches.**

***Index Terms*—Artificial Intelligence, Machine Learning, Motion Detector, Python, WiFi, Cloud Computing**

I. Introduction

With the launch of DJI company's Tello Edu drone (Figure 1), it is now possible to control and operate drones with AI programming languages like python (also Scratch and Swift). So this research focuses on integrating the idea of advanced home security with such AI based drones. The current topic has more advantages as compared to security cameras which is elaborated further. Motion detector sensors (Figure 2) will be placed inside the house at every possible location as per the security network range. This sensor will send the motion detected signals (true or false format) via WiFi to the drone's python program. The Python program will detect from which area the sensor is sending signals. The drone will be activated to take its flight to that area, start recording the video, and return back to its base station after completion. Motion detected signals and recorded video can be sent to the user via various ways like uploading to cloud storage, mobile notification, or by simply recording in its internal memory card. The flowchart of the project is shown in figure 3. The main part of this project is the AI based flight navigation from base station to the calling sensors and its return journey. Drone will learn its flying path from real time data through object detection, path detection, wall detection, GPS tracking, and related information from its video camera. Base station will be kept mostly hidden or at a higher altitude where no one can reach towards it for safety. Even motion detection sensors can be camouflaged with the house aesthetics. Figure 3 demonstrates the flowchart of the program application. There is a potential scope for fixing limitations of drone technology. As drones can fly outdoors with the help of GPS automated navigation systems. But for indoors, learning paths from real time data is one of the best solutions. For such an approach, machine learning algorithms or related neural network algorithms can solve the problem. To do this, a video camera from a drone is used with the help of face detection algorithms to traverse between source and destination. Some of the main survey topics discussed in this paper are intelligent

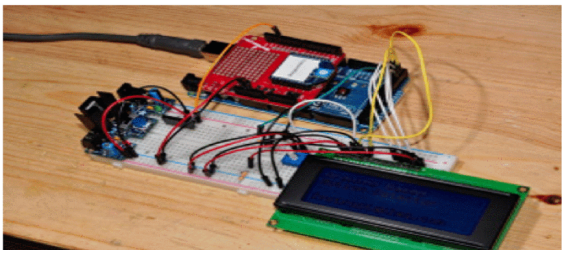

Fig. 2: Motion Detector Sensor with WiFi Arduino Circuit System [14]

navigation systems for drones [10], research algorithms to optimize the drone routes [4] and Face Recognition on Drones: Issues and Limitations[9]. All such topics are very closely related to AI based drone projects for large home security. The intelligent navigation system mentioned describes in brief about how to navigate a drone with AI to do the desired task and return back to its base position. The other topic discusses how to optimise the flight route of a drone to improve the performance within the limitations of drone mechanism. The detailed analysis of the literature survey, review of the existing work, project work and some additional research outcomes are given and discussed below.

II. Intelligent Navigation System Survey

As per the research done on intelligence navigation system in the paper[10], the subject covers the overall idea of navigating an AI based drone. Basically it mentions the program and programming team which are responsible for implementation, automatic navigation, maintenance, updating, up-gradation, collecting real data with the help of video camera and handling the real world hurdles. With the help of GPS [6] from google maps or predefined flight route, drone can perform its flight and return back. The basic data needed for navigation is the real data collected during flight and predefined flight patterns. The survey also highlights about a dedicated team of programmers needed for maintaining the AI drone workflow. Even though the cost of drones are less, the cost to maintain is higher for initial period of time. Once the drone navigates completely and independently with the AI algorithms, the project will be cost efficient for mass production. The idea behind this topic is discussed in a very generic way having less real time practicality from the point of view of implementation and success. Because none of the ground level approach or strategy discussed. Nor even the right algorithm for optimal distance for drone's flight is focused. Which shows that main strategy to navigate the drone is needed with the help of the accurate algorithm. As drone has its own limitations of battery life and flight under difficult climatic conditions. Accept

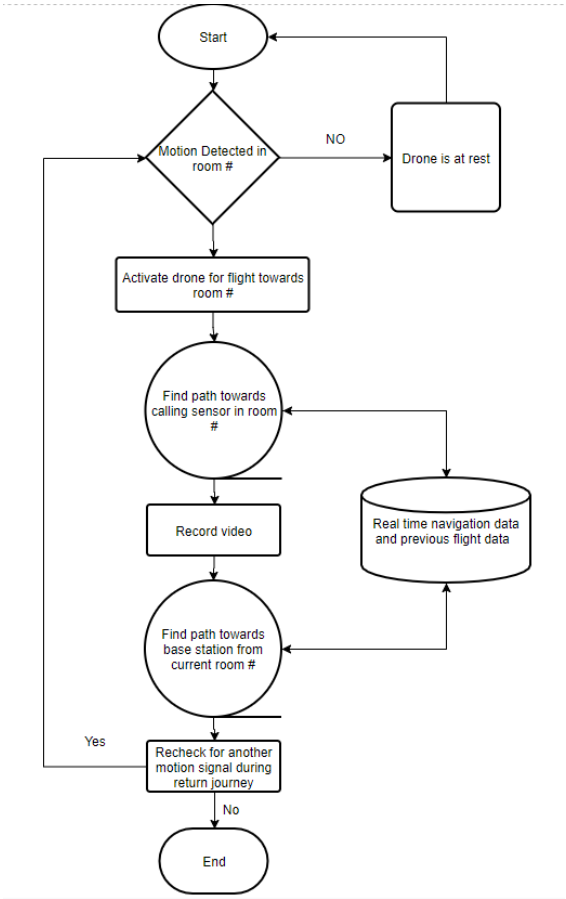

Fig. 3: Flowchart

climatic condition limitations, home security AI drone project mostly focuses on improving performance with limited battery life until it gets charged. In order to overcome this issue, next literature survey on optimising flight route of drone using some efficient algorithms is done.

III. Research algorithms to optimize the drone route survey

Due to the limitations of drone in flight timings, the route from source to destination and return back to base station needs to be optimised. To improve the efficiency of drones battery, optimal flight path algorithms are implemented. The survey on such topic[4] is made precisely and broadly. The paper mainly focuses on Ellipsoidal and Cartesian (x, y, z) coordinates for route optimization (figure 4). In this survey, two most popular algorithms discussed are Dijkstra algorithm and the shortest path between two vertices by number of peaks algorithms (Breadth-first search algorithm).

Dijkstra algorithm is the most effective way to find minimal paths from a given vertex to all other vertices. Some of the major Dijkstra algorithm advantages from

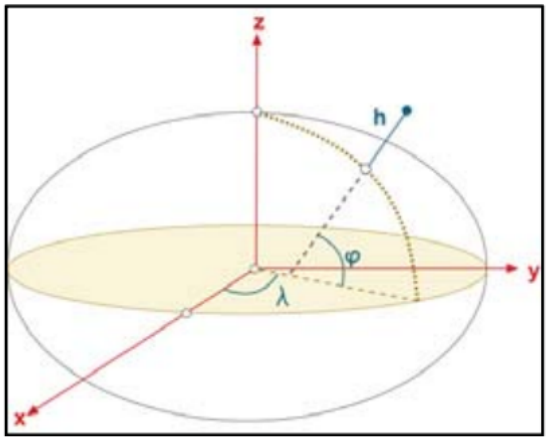

Fig. 4: Ellipsoidal and Cartesian (x, y, z) coordinates [4]

the survey are: It is the most effective way to find a path in a graph, realization by finding all paths to the other vertexes, it enables the storage and processing of the received information, it is extremely suitable for use with drones as the minimum path is actually the minimum distance between two points, which is very important for the conception.And the major disadvantages from the survey are: it is slower method in comparison with others and if there are too many modifications in the graph (unattainable vertex, changing the route configuration, adding a new vertexes etc.) the algorithm‘s performance drops.

The shortest path between two vertices by number of peaks algorithms advantages are that it is the fastest algorithm and is suitable for a dynamically changing graphs. Some of its disadvantages are that it gives information about the path only between two vertexes and in general, may result in the same path as the Dijkstra algorithm.

IV. Face Recognition on Drones: Issues and Limitations Survey

The empirical study of this paper[9] evaluates several factors that may influence the performance of face detection and recognition techniques on drones. The findings also shows that the current face recognition technologies are capable of recognizing faces on drones with some limits in distance and angle, especially when drones take pictures in high altitudes and the face image is taken from a long distance and with a large angle of depression (figure 5). Some of the analysis and findings from this paper are: The small-sized facial images taken by drones from long distances do cause trouble to both face detection and recognition, the pose variances introduced by large angles of depression dramatically weaken the capability of both face detection and recognition, and a

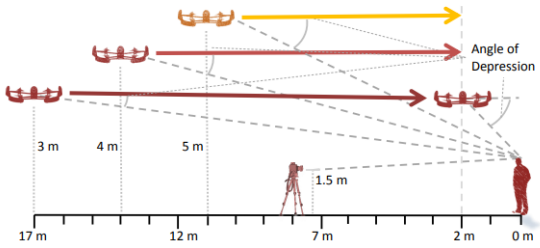

Fig. 5: Face detecting distance and angle of depression by drone [9]

recognition model augmented with 3D modelling techniques might increase the performance of face recognition in the case with large angles of depression. However, this augmentation may also decrease the distinguishability of faces in common cases, and thus requires further investigation.

V. Advantages against smart cameras

Installation of smart security cameras in every desired larger area will add up the cost and there are also some potential disadvantages in using it[3]. Also many chances of CCTV cameras getting destroyed by the burglars. In order to avoid that, AI drones are used for greater safety and better budget management. Base station of the drone will be kept at a higher altitude inside the house or at some hidden places where unauthorized people cannot reach it. This project is best for large homes, bigger warehouses and offices.

VI. Ducking Action

In case if the thief or burglar tries to hit back the drone from capturing video, drone can recognize the obstacles coming towards it via face/object detection algorithm and will try to duck from it. Such feature is the limitation of stable CCTV cameras.

VII. Existing Work

Various attempts were made to utilize drones for various purposes apart from videography such as food delivery drones, courier drones, agricultural drones and may more. The maturity of such approaches are showing great progress but still not achieved the milestone. Home security drones with AI as a backbone is still not explored yet and was the main reason to choose this topic as research. It still has to face challenges against CCTV cameras. As drones have more advantages such has mobility, ducking from object coming against them. None of the research paper directly related to this topic is done so far or if its done then still yet to publish. Few of the related literature survey is discussed above. In order to make this project successful, obtaining data and

implementing actions upon it is needed first, just like Roomba[8] Vacuum cleaner learns data and performs actions from it.

VIII. Project Work

A. Introduction

The project work is based upon setting up a AI based drone with the help of motion detection sensor to capture the unusual detection in absence of user in larger homes. A python based project will be implemented which does the execution of drones when it receives the signal from motion detector. Machine learning algorithms will be used to learn the inner navigation paths from real time data which will be obtained from face detection algorithms. The real time will be stored in server or project directory to fetch the data for learning. Drone will take its flight and record the destination scenario which will fetched to user. After completion of task, drone will return towards it base station. The program can be located on any server online or local server which is connected to the WiFi network.

B. Connections

Drone and motion detector sensors are connected to home WiFi network[1]. Python project is also connected to the same network from server. Path navigation sign boards will help drone to detect the image to make decisions. Connection will be crypto-protected to protect its integrity[7]. Tello drone and motion detection sensor python libraries will connect the respective devices to python project. TCP/IP network protocols will build up the connection[2].

C. Machine Learning

The Tello Drone will learn the navigation path via video camera through face/object detection algorithms. It will detect the sign boards or symbols needed for navigation and will store the sequence to navigate. The neural networks[5] like fully connected or convolution will play a vital role in learning real time data for drone. The learning's from such network will be used to trigger the flight controls of drone like turn left, right, up, down, start, stop, takeoff, land, and many such related controls. Python libraries like tensor and pytorch [12] will be used for performing such learning.

IX. Discussions

After analysing the previous work, it is sure that drone's future indoor navigation system can be definitely achieved by face/object detection algorithm through indoor travel sign boards. With such symbols, drone can detect the image and take desired flight options to finish the security assigned task. For this use of GPS is not required. One of the previous work of optimising drone flight path can be beneficial for increasing battery efficiency. Till now the code in python is made by Tello company on GitHub for human pose detection from tello Edu drone. So in this program, addition of machine learning algorithm for indoor navigation can be achieved by face detection algorithm. The learning for navigation will be from real time and such data will be stored for more accuracy. The actual machine learning algorithm for this project is still not decided as it depends on performance of drone, WiFi speed and quality of video camera of drone to detect video during flight. With the help of this paper, an initiative for AI droned based security projects will get a strong foundation for development.

X. Cross-validation

Estimating the performance of the drone detection and identification system[13] is conducted using stratified K-fold cross-validation; an iterative process that repeats for K times to produce performance estimates with low bias and low variance regardless of the size difference between classes. First, the drone database is randomly segmented into K disjoint folds with balanced number of instances of each class in each fold. After that, at an arbitrary iteration K, fold K is used as testing data for the neural networks while the rest of the database is used for training. This process is repeated K times such that the neural networks are tested using the entire database. Finally, performance of the system is estimated by the average performance of all iterations resulting from the K-fold cross-validation procedure.

XI. Performance evaluation

Average performance of the drone detection and identification system is presented using accuracy, precision, recall, error, false discovery rate (FDR), false negative rate (FNR) and F1 scores via confusion matrices[13]. These performance metrics are defined and is shown in figure 6.

XII. Conclusion

With the advancement of AI in drone technology, bigger home security objectives can be upgraded to a next level. Such AI driven drones will learn its navigation paths and predefined actions from its real time and previous time data. Drones are evolving rapidly every day and are being used for various applications. This project will give the feeling of drones performing security watch from birds eye view where chances of getting it dismantle or damaged are very less.

The intelligence navigation system required for drone flight needs real data and predefined data to make drone to take decision. It may require Breadth-first search algorithm or any other specific one which is yet to be

$$\text{accuracy} = \frac{TP+TN}{TP+TN+FP+FN},$$

$$\text{precision} = \frac{TP}{TP+FP},$$

$$\text{recall} = \frac{TP}{TP+FN},$$

$$\text{error} = 1 - \text{accuracy},$$

$$\text{FDR} = 1 - \text{precision},$$

$$\text{FNR} = 1 - \text{recall},$$

$$\text{F1 score} = 2\left(\frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}}\right),$$

Fig. 6: Performance Evaluation where TP, TN, FP, and FN are true positives, true negatives, false positives, and false negatives, respectively. [13]

calculated. After implementing the right algorithm, flight path will be made optimal to reduce extra flight time.

In order to detect objects by drone's video camera, face detection algorithm needs to be implemented where distance and angle of depression is taken into consideration.

The repository of Tello-Edu drone on GitHub[11] is a very helpful tool for building up the structure of the project. So with the help such research done on enhancing abilities of drones can improvise the security actions needed for larger home areas.

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