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ARTIFICIAL INTELLIGENT ROBOT FOR ENFORCEMENT SURVEILLANCE (AIRES)

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Abstract This project represents an idea to provide a quick, easy plug and play drone and robot for the military as assistance in the war zone area. Most of the time army has to wait for the drone to collect information from the battlefield or terrorist site, it requires a lot of time and money as the drones fly from an Air Base. These are usually known as UAVs, and they are huge, often detected by the RADAR. The idea is to make a smaller drone which a soldier can carry in his backpack, can fly and use it for quick surveillance before entering a danger zone. As it is difficult to get into the buildings with large drones, this project can help to make surveillances even inside of the building as we will be using smaller drones. Most of the military drones are very expensive and therefore cannot be used every time, and if the drone crashes, the loss is beyond recovery. Hence such drones are operated only in rare cases. To make a drone that can be used for the military purpose, the control system must be more precise, and the drone must sustain windy conditions and cold weather. The challenge is when the drone has to slip through the wind and also to maintain the speed judged by the pilot. Therefore powerful motors which achieve high velocity to function against the wind are used. Also, expertise is required in piloting the drone.

Keywords—Drone, Surveillance, Object Recognition, Sensor fusion

I. INTRODUCTION

In the modern world, threats at the border of the nation are at large. Hence there is a need for continues surveillance. Human errors cannot be tolerated in these areas, else the cost of it is much higher than the human lives which are paid by the security forces. To avoid such catastrophes, this robot (AIRES) provides complete surveillance for the Security forces risking their lives at the border. The main objective of this project is to provide a cost-efficient drone for surveillance. AIRES is more sophisticated than the traditional ones, this comes with well- equipped controller and plug and play drone which and can provide complete monitoring on the ground as well as air. AIRES comes with a drone which has an artificially intelligent camera attached to it with object recognition. The main advantage of the Robot is to provide ground-level information for the Military to get first-hand knowledge of the enemy's and their position. This Robot has multiple uses can be used as surveillance and can be used during the war to gather information about the enemy, the application of this robot is endless and at desperate times this robot could make itself useful in all conditions.

II. RELATED WORK

Many robots have been designed for the applications of the military, but have been failed to deliver the complete usage due to lack of design faults and optimization of sensors. Many of the robots are manual controlled and have limited accessibility. Information gathering the primary task of the military intelligence and is the most important. But there is a necessity of information gathering at the current location. Still, a robot has limited access; it may not cover all the ground; therefore, the troops have to depend on the intel covered by Military intelligence. Most drones fail in military applications because of the control system. Efficient control system requires some connection between the drones, and this is achieved by Bluetooth, Wi-Fi or some medium of communication like 4G LTE etc. In these kinds of drones, the output is very efficient, but the range is compromised. Using radio control will be more expensive with the hardware and the production is not that efficient the size of the drone gets increased as radio connectivity needs a receiver and transmitter antennas also the drone must be made lighter. Response time gets slower and slower as the drone moves. Also, buildings drone which has to achieve speed and has excellent control also getting a live feed from the camera attached to it will cost more. There were some issues with the durability and crash recovery as drones would get severely damaged and beyond redemption. Drone crashes occurred due to response failure or delay in instructions to reach the drone from remote.

III. METHODOLOGY

The purpose of this project is to give complete assistance to the troops, give data about the enemy's positions and perform under extreme conditions. A war zone is a central place where military possibly needs help for collecting information about the enemy's whereabouts, the objective of this robot is to provide this first-hand knowledge and give assistance to the troops for masking an attack plan. Also, provide surveillance to the military during day and night at the ground level. Whenever there is a limitation to land aerial images are captured for information-gathering purpose, the essential goal is not to fulfil complete assistance to the troops. This drone has several advantages, such incredibly powerful motors which means drones are extremely good at fast-flying, having that much power in 5-inch quadcopter it makes it extraordinarily acrobatic and agile with just one flick of the throttle it can launch itself over a 100 ft into the air in a matter of seconds it can also make complicated acrobatic manoeuvres such as roles, flips, dives etc. and it has enough power to catch itself before it hits the ground this drone is not affected by wind that is very important because sometimes the drone may need to go over a cliff. The control system of this drone is what makes it possible to use in war zones however this drone is not meant for any other usage and is very dangerous to fly inside without any precautions, to operate this drone necessary training is required. To do so, the pilot must undergo training by using a simulator.

1. Aerial surveillance

This robot is a perfect match and a guide to the troops in the war zone, a drone attached to it providing 2 kilometres of live video Surveillance. This drone is controlled only by manual with a transmitter and receiver module. The video feed is obtained by the VTX module attached in the drone. Video is broadcast-ed from up to 2 km radius; also, the drone can be controlled within that radius. The main feature of this drone is speed. The motors are so powerful that it may fly up to the average rate of 85 kilometres per hour so that enemy cannot see what is coming to them.

2. Object recognition

Object recognition is a method for the machine vision to recognize objects in pictures or videos. Object recognition is an important output of the algorithms of deep learning and machine learning. As humans look at a photograph or watch a film, characters, events, scenes and visual information can be easily noticed. The goal is to teach a machine to do what naturally happens to humans To get a sense of what an image contains. There are two approaches to use deep learning to achieve object recognition.

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3. The Quadcopter

[12] At this stage, the quadcopter's basic design and how it handles and executes its various manoeuvres must be described. The quadcopter is a type of helicopter which only uses four equal diameter propellers to lift and advance it. Such four props are symmetrically mounted on a cross-shaped base, while the payload lies at the centre of the frame. Those props are rotated every two vice versa so that the total torque applied to the drone is zero.

3.1 Quadcopter Configurations and Frame Design

X configuration, the H configuration, and the + configuration

[12] Each form of arrangement has benefits and drawbacks. The X configuration is the most commonly used motor configuration as it is easy to construct, suitable for a forward-facing camera, and is symmetrical. In Fig, 2.1(a, b, c) quadcopters, using these configuration sort. A downside of this design is the increased complexity of the controls. The + configuration is the easiest to model and monitor mathematically, as opposed to the X configuration. This design is therefore suitable for a forward-facing camera. Therefore very few commercial drones are marketed in this configuration and usually appear only in research or DIY projects

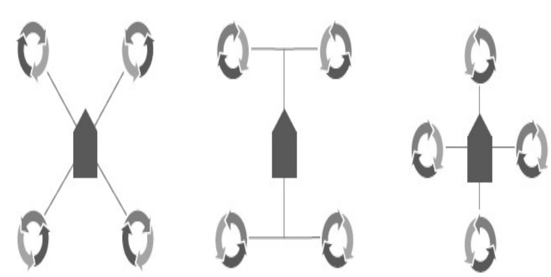

Figure 1. Example of a three configuration

3.2 Control Goals and Orientation Establishment

[12] Unlike other multi-rotor aircraft, the primary objective of the control is to keep the orientation of the quadcopter controlled and its altitude above ground non-zero. For the position, the reference frame uses Cartesian x,y,z coordinate system and uses pitch, roll, and yaw angles from Euler to denote orientation. The root of the axes represents the quadcopter's centre as well as the mass

centre. The axis source represents the quadcopter core as well as the mass core. Operation of orientation is a key operation task for the quadcopter.

.c; c; c represents a user commanded rotation, where **θ;ϕ;ψ** ; represent the rotational velocities of the quadcopter, and where Tc represents the user commanded throttle.

[12]These control parameters, **θ;ϕ;ψ**; Tc, allow a user to manoeuvre the quadcopter to anywhere in three-dimensional space. Consequently, many commercial systems give users these four degrees of freedom to operate a quadcopter. However, the user must also act as a control system to regulate the quadcopter's height to keep it above the ground. To achieve this, the user must observe the quadcopter's height and continuously adjust the throttle

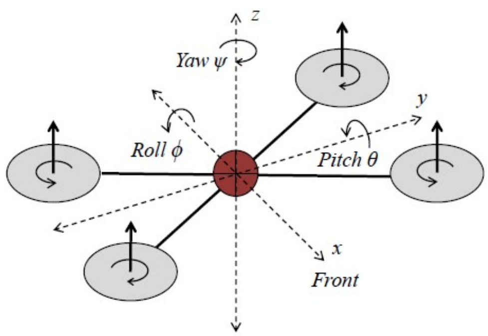

Figure 2. Control Parameters of the drone

Inertial measurement unit: This is made up of 3-axis accelerometer which measures linear acceleration ad axis gyroscope that measures angular rate

Actuator: the quadcopter motor configuration, in general, is the spin direction opposing motor spin in the same direction as each other. The other pair spins in the opposite direction. This is necessary as the thrust, roll, pitch, and yaw can be commanded independently of each other, which means one can control one function without affecting each other. The drone is an under actuated system, and there are only four actuators those are motors. And there are a degree of freedom, three translation directions, and three rotational directions.

		Yaw	Pitch	Roll
Motor (Front Right)	Thrust Command	Increase Speed	Increase Speed	Increase Speed
Motor (Front Left)	Thrust Command	Decrease Speed	Increase Speed	Decrease Speed
Motor (Back Right)	Thrust Command	Decrease Speed	Decrease Speed	Increase Speed
Motor (Back Left)	Thrust Command	Increase Speed	Decrease Speed	Decrease Speed

Algorithm: The algorithm helps to develop a control system that couples rotation and thrust to accomplish the overall goals. Motors produce thrust by spinning the propellers which push the air down causing a reaction force, i.e. up, if the engine is placed in a position that the power is applied to the centre of gravity of an object then that object will move in pure translation. To achieve the thrust, roll, pitch, and yaw, the motor speed must be manipulated in the following way. This motor mixing algorithm is used to produce the movement and manoeuvres for the drone

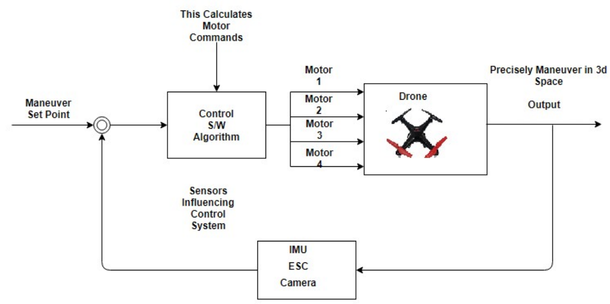

Figure 3. Control Parameters of the drone

3.3 QUADCOPTER SYSTEM ARCHITECTURE

[12] An architecture block diagram which is special to the model quadcopter. This machine contains a flight controller, a modem, and an ESC. The flight controller's core components include a microcontroller (MCU), a modem, and an inertial measuring device (IMU). The flight controller interacts with the ESCs by modulation of the pulse location (PPM). The flight controller also communicates with a lidar sensor through a universal asynchronous receive and transmit (UART) interface, in addition to communicating with ESCs. A USB interface can be used to obtain or program data to communicate with devices external to the quadcopter. Another communication tool is for receiving flight commands and transceiving flight data via a wireless 2.4GHz frequency shift keyed (FSK) interface. The I / O of the system can now be identified after all the components involved have been added. Feedback inputs from the IMU, sonar, and lidar sensors are for the flight controller itself. [12]System outputs are the four individual PPM signals sent to the ESCs. Now that the system's I / O has been briefly added, it will derive a control scheme that uses such I / Os to achieve stable flight.

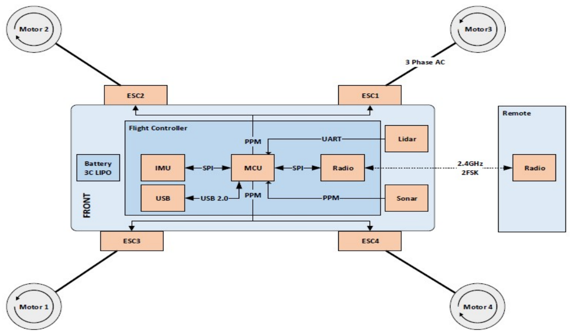

Figure 4. System Architecture

3.4 PID Control

Plant: The system we want to control.

The input to the plant is the actuating signal, and the output is the controlled variable. The question is how to generate the actuating signal so that our system will create a desirable output. The problem is also how to take the error term and convert it to suitable actuated command so that overtime error is driven to zero.

Altitude controller for a quadcopter drone

The drone has four propellers and all spin up together and produce a force that lifts the drone into the air. The objective here is to get the drone to a specific location.

The following are in terms of PID:-

- The plant is the drone
- The output of the system is altitude
- Input to the system is propeller speed

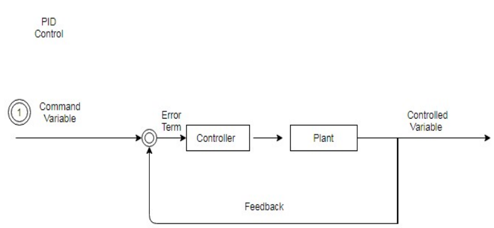

Figure 5. Propagation

Algorithm

- When the drone is on the ground, the error is 50 meters. This must cause it to speed up the propeller and cause it to rise, which reduces the error. Now consider the drone starts to lift off and reaches 50 meters. The error is hence brought down to zero. At this point, the propeller would shut off and fall. When this happens, the propellers' speed will increase again, causing the drone to climb.

- There is a certain propeller speed where the lifting force is precisely equal to the weight of the drone. At that speed, the drone will hover. So the problem is to get the controller to fly the drone. This depends on the controller's gain.

This would raise the drone to 30 meters and stop. The error would be 20 meters. Again increase of 10 would produce 10 meters and 100 would provide 1 meter. Therefore, no matter how high the gain increases the error won't go away. It creates a constant mistake; this is called study rate error. To overcome this study rate error past information could be used to add integrator to the controller which is alongside proportional specifically

An Integrator averages up the input signal over time, maintaining a running total; thus, if the drone enters the steady-state below the target altitude, the error term becomes non-zero, it has the memory of what has kept track in the past. And when a non-zero value is added, the output will increase, and as long as there is a system malfunction, the integral input will continue to adjust and this will increase the performance of the Integral system will increase the speed of the propellers of the drone, the drone will continue to grow. Such two directions, the proportional and the integrative, function together to reduce the error rate to zero

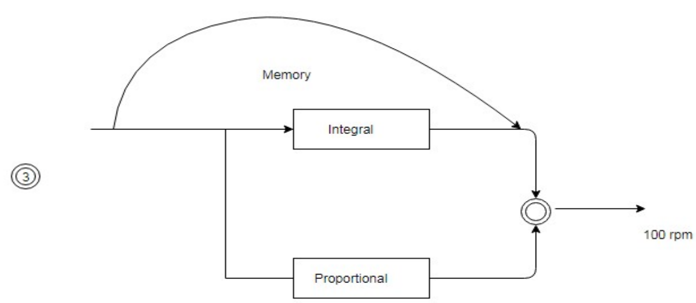

Figure 6. Integrator

In a situation when before reaching the desired output there might be possible to get a minimal error rate, it may so happen that the proportional path is zero since at this point the error is so small. Nevertheless, depending on how this drone reached this height, the integrator may have a value of more than 100rpm, i.e.>100rpm, this will keep the drone rising because it is optimal as it is still below 50 meters. However, the drone would have to go higher than the target to generate a negative error to eliminate the excess propeller speed. This negative error, if amounts lower the integrator performance and slower the speed of the propeller. This overdraft of the intent will not be desired

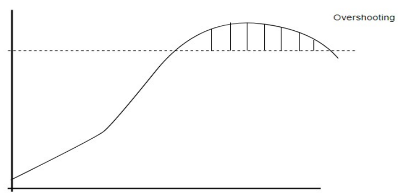

Figure 7. Overshooting

There is a simple way around this problem that is by adding a path to our controller that can predict a future and respond to how fast the drone is closing to the goal. This is done by derivative
A derivative provides a calculation of the rate of error shift, i.e., how quickly the error increases or shrinks. When the target is approaching quickly and steadily on the drone, this means the error is increasingly decreasing. Because the error has a negative rate of change that will generate a negative value for our derivative path that will add negative value to our controller output, thereby reducing the speed of the propeller.
The controller is using the change in error to determine that the drone is closing in on the goal way fast and then prematurely slow down the propellers preventing the drone from overshooting

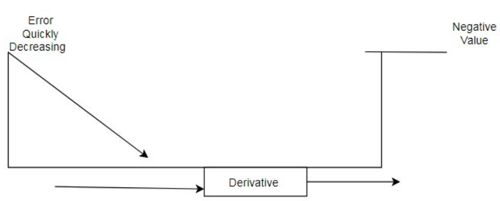

Figure 8. Derivative

3.5 Radio control

Radio is a device that transmits radiofrequency. Radio is transmitting the movement of control the motors, especially the amount of throttle going into the engines.

Binding radio to the receiver

The frequency at which radio transmits and receives is 2.4 GHz, and it uses digital communication to make sure that the signals received by the receiver are right and are error checked. This information is sent in frames or packets the process of making the transmitter and receiver is called binding. It is not about binding a receiver to a specific radio there must be linking between the radio transmitter model memory and receiver this is called fail-safe as if any other radio operating at 2.4GHz the receiver will not be manipulated.

3.6 Sensor fusion

Sensor fusion is an integral part of the autonomous system combining two or more data source in a way that generates a better understanding of the system
Sensors are collecting information from the external world where the system needs to interpret data something that could be understandable. The system plant must figure out how to get the task done, and the best action needed to get it done by. This step is modulated by the control system using sensor fusion to estimate orientation it is also called attitude and heading reference system (AHRS) s
When talking about direction, it describes how far an object is oriented from some known reference, in a drone the horizon is kept as a reference and verified how far the longitude axis is rotated of the local horizon, therefore, to define an orientation a reference frame is chosen and then the rotation is specified from the frame

IV. RESULTS AND DISCUSSION

This paper describes the design and structure of a drone which could be used for military purpose and is a simple plug and play drone. The main objective of doing this project is providing a cost-efficient drone for quick and immediate surveillance where large UAV's fail to fly, like inside of a building or in a forest etc. However, UAV's are and could be detected by the enemy's RADAR, that would create a significant problem and cost of flying those UAV's is very high.
Classical drones are not suitable in military zones as they can be quickly brought down by the enemy because of their low speed and capability. This proposed drone does not get affected by the wind as its motors are mighty which will make the drone fly against the wind which is very useful if there is need to fly over a cliff or if the weather is windy

Methods	**Classical**	**Proposed**
Communication Range	500 meters	1 kilometres to 3kilometers (increasable)
Communication Range Increment	Not Allowed	Modifiable depending on the usage
Communication Type	Wi-Fi, RF	Radio Frequency on 2.5 GHz
Flight Time	10 minutes	10 minutes to 1 hour depending on the battery
Flight Weather	Normal	Normal, Windy

Conditions		
Speed	Up to 45 kilometres per hour	45 to 100 kilometres per hour (Programmable)
Cost	Starts from 40k to 70k	Starts from 20k to 30k (price may vary depending upon the hardware)
Pilot	Anyone	Must be trained
Movements	Front, back, up, down, roll	Front, back, up, down, roll, pitch, yaw and other acrobatic manures

Table 2: Comparison

However, both the drones fail to work in the rainy conditions, but during cold the proposed drone may work fine as the motors are running fast enough heat is generated, but it is still in the testing phase and hasn't been tested yet. Classical drones are not suitable for cold weathers even if the day is windy as their propellers are designed only to work on normal weather conditions. Applications of drones for Indian military purpose are limited; therefore, this project inspires to take the initiative to develop cost-efficient drones which would assist troops in quick surveillance.

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