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Joint Air to Ground Unmanned Autonomous Robotic System (Jaguar)

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***Abstract*— Robots are replacing humans in all the possible ways in many fields. It is very important that the robots are deployed instead of humans in dangerous circumstances. Maneuverability is one of the difficulty robots face in many terrains and in many hazardous circumstances. To eliminate the maneuverability problem Joint Air to Ground Unmanned Autonomous Robot (JAGUAR) concept is developed. The JAGUAR is a whole system which includes Multirotor/Unmanned Aerial Vehicle (UAV) and a Rover/Unmanned Ground Vehicle (UGV) working in coordination to perform a specific task.**

The onboard Joint Air to Ground Unmanned Autonomous Robot Control (JAGUARC) system enables the UAV to deploy the UGV at the predefined destination point to perform the assigned task and carry UGV back to the home location autonomously without any human interference. The control module will have different sensors to observe the environment and will autonomously make decisions to coordinate the robots.

Keywords—UAV; UGV; Autopilot Mega board; transmitter; receiver; GPS, Sensors; Control Module.

I. INTRODUCTION

Maneuverability is one of the greatest problems to the ground as well as the aerial robots. To reach few places it is not sufficient for a robot to travel only by air or through ground, the robot needs to travel both by air and on the ground.

In some applications like bomb disposal, the time and avoiding human interference are the primary factors. A robot which can move to the bomb location and pick the bomb and take it to the safe location (unmanned or bomb disposal squad) with very less time and with no human interference at the bomb location would be a great idea. Reconnaissance can be better performed by a small UGV deployed in the enemy area by a multi rotor (UAV) [1] rather than a single UAV. Such applications including many other applications which an aerial or ground robot alone cannot do can be accomplished by Joint Air to Ground Unmanned Autonomous Robot (JAGUAR).

It can fly to the predefined destination point and deploy the ground robot to perform the assigned task and carry it back to the home location autonomously without any human interference. The system on-board JAGUAR which brings the coordination between multi rotor and rover is called the Joint Air-Ground Unmanned Autonomous Robot Control Module which also acts as docking system. It only coordinates UAV in deploying the rover and carrying it back to the home location. Any UAV and UGV coordinated with the control module can be called as a JAGUAR [Fig.2]. On the hardware side the module consist of various sensors and a microcontroller which coordinates the function of UGV and UAV.

Furthermore, due to the quad copter's cyclic design, it is easier to construct and maintain. As the technology becomes more advanced and more accessible to the public, many engineers and researchers have started designing and implementing quad copters for different uses [2].

II. RELATED WORK

An UAV might be a quad copter, tri copter, hexa copter or an octa copter [Fig.1] which can be built through open source documentation [6]. Auto pilot boards (APM, PX4FMU) are programmed to control the flight trajectory. Autonomous navigation of UAV over small range is achieved based on the telemetry command from the ground control system. Autonomous navigation of UAV over longer range can be achieved based on ad hoc network concepts [12]. Mission Planner software [Fig.3] is used to predefine the destination point using the GPS module [4] onboard UAV and program different flight modes like stabilization, failsafe, loiter and many more [7].The information on autonomous docking of a quad copter [5], design consideration of small UAV platform of carrying medium payloads, deals with building a UAV which can carry medium payloads [Fig.4]. To get more thrust KV ratings of the motor must be inversely proportional [3].

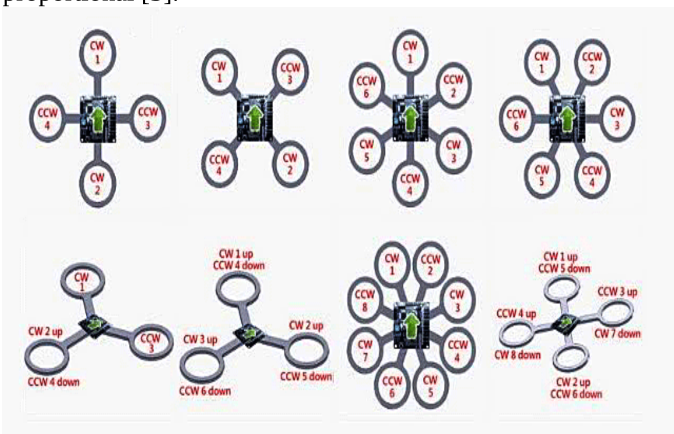

Fig. 1 Different types of multi rotor.

UGV/Rover [Fig.5] can be any custom built robot to perform specific task. UGV can be controlled from a long distance by the long range transmitter and receiver concept [10] deals with the building of the robots for the reconnaissance.

Fig. 2 Multi rotor interface with UGV.

UGVs can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present.

Fig. 3 Mission planner software

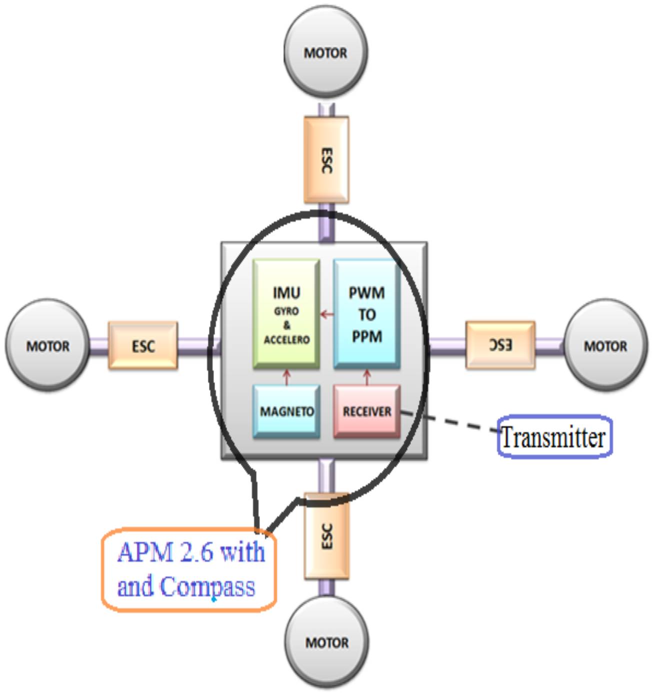

Fig. 4 Open source quad copter

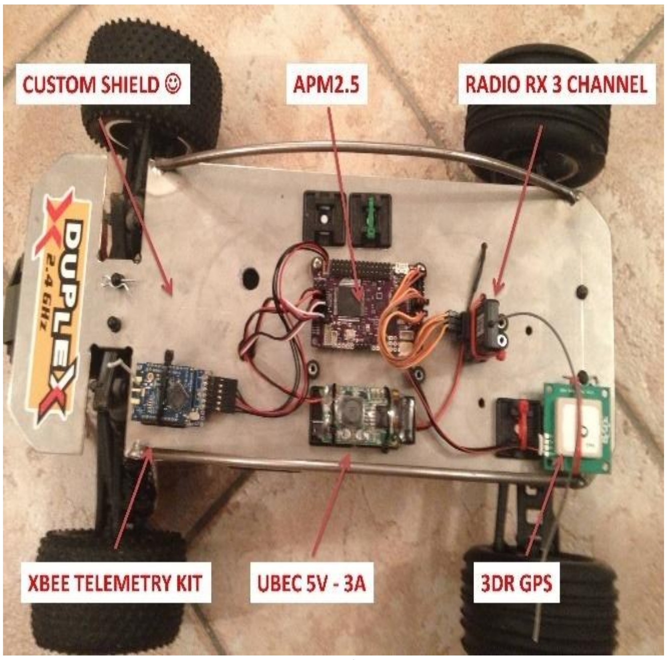

Fig. 5 Example of rover / UGV

III. PRAPROSED JAGUAR METHOD

We can see from the block diagram [Fig.6] that the module is the control system of the JAGUAR. It coordinates the action of the quad and ground vehicle with the help of various sensors and a microcontroller.

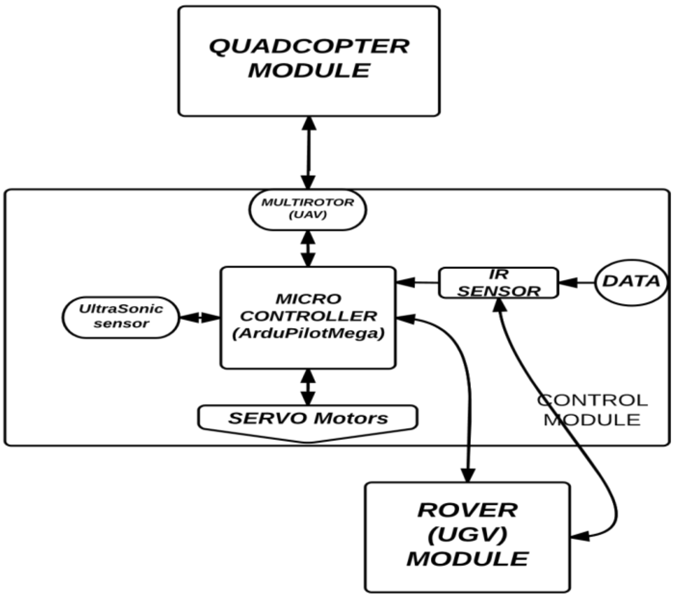

Fig. 6 Block diagram JAGUAR of the system.

A. Working of JAGUAR

When the UAV lands at the destination after autonomously navigating from the home/base, the control module senses the landing of the quad copter and signals the servomotor to rotate clockwise for pre calculated steps to deploy the UGV (Rover). With the help of the onboard IR sensor, the UGV senses the movement of the servomotor [Fig.7] and signals the home/base of its successful landing.

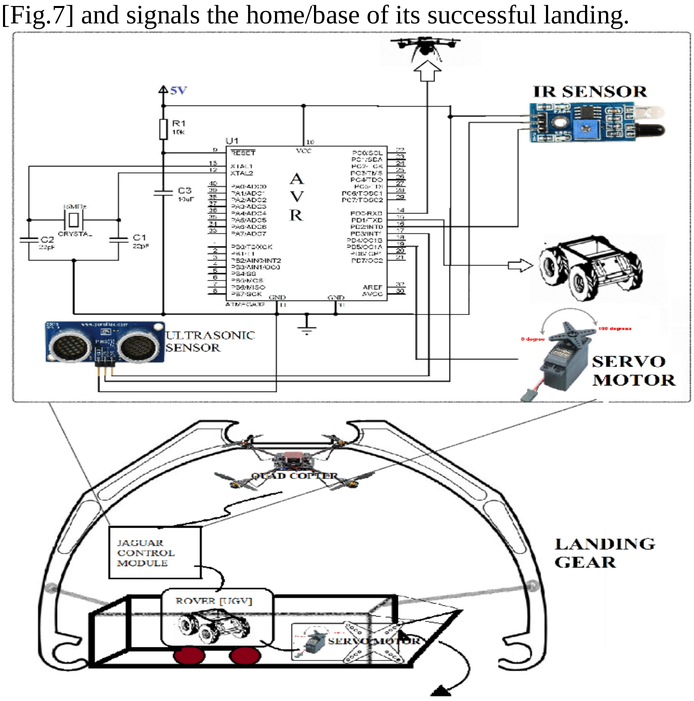

Fig. 7 working diagram of JAGUAR

Then on the UGV is controlled from the base station to accomplish the task. Movement of the UGV out of the docking platform is recorded by the control module as the deployment of the UGV.

When the ground vehicle arrives back to its initial position, the module records it as the successful docking of the vehicle and sends a signal to servomotor to rotate anticlockwise for pre calculated steps and quad copter to return back to the base station. Sensing the movement of the servomotor, the IR sensor on the UGV signals the home of its successful docking and UAV returning back to the home.

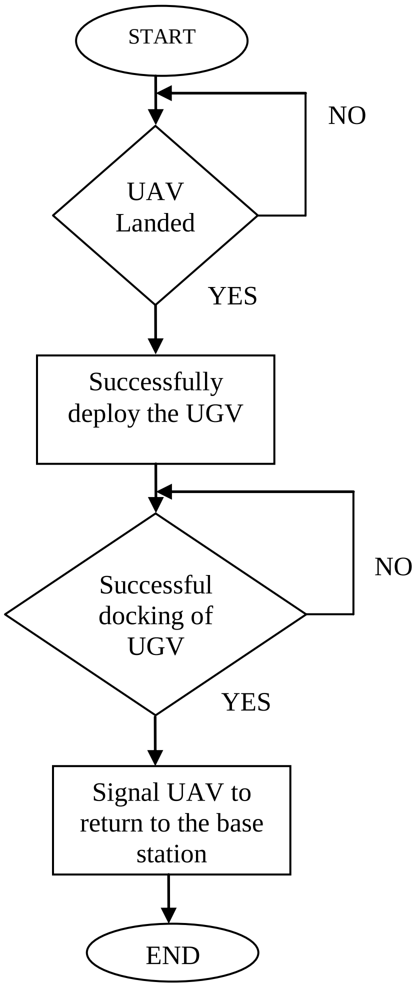

Fig. 8 Flowchart of JAGUAR

IV. JAGUARC SYSTEM IN DETAIL

This module internally contains an IR sensor, an Ultrasound Sensor, a stepper motor (Servo motors), the docking platform and a microcontroller to control all the onboard components [Fig-9].

The Ultrasound sensors sense the landing of the UAV by measuring the altitude of the module from the ground [11].Gives the equation for measuring the distance of an object by using ultrasonic transmitter and receiver.

Distance (cm) = (Travel Time*10-6 * 34300)/ 2 (1)

When the altitude of the system decreases below a pre-defined or threshold altitude, an interrupt is called to signal the landing of the UAV.

Height (H) <= Threshold height (H_t) (2)

Upon the arrival of the interrupt, the microcontroller signals the servomotor to rotate clockwise for the pre calculated steps to deploy the UGV.

For a half stepping motor one step is equal to 0.9 degrees of rotation and for a full stepping motor one step is equal to 1.8 degree of rotation.

If a half stepping motor needs to rotate *Y* degree's then the number of steps (*X*) is given by

$$X = Y/0.9 \quad (3)$$

If a full stepping motor needs to rotate *Y* degrees then the number of steps (*X*) is given by

$$X = Y/1.8 \quad (4)$$

After the UGV is deployed or moved out of the docking platform, the IR sensors on the JAGUARC signal the microcontroller of the successful deployment of the UGV. The IR sensor [13] detects the UGV as it arrivals on to the docking platform and signals the microcontroller. Knowing the successful docking of the UGV, the microcontroller signals the servomotor to rotate back to its initial position and UAV to return back to the base station.

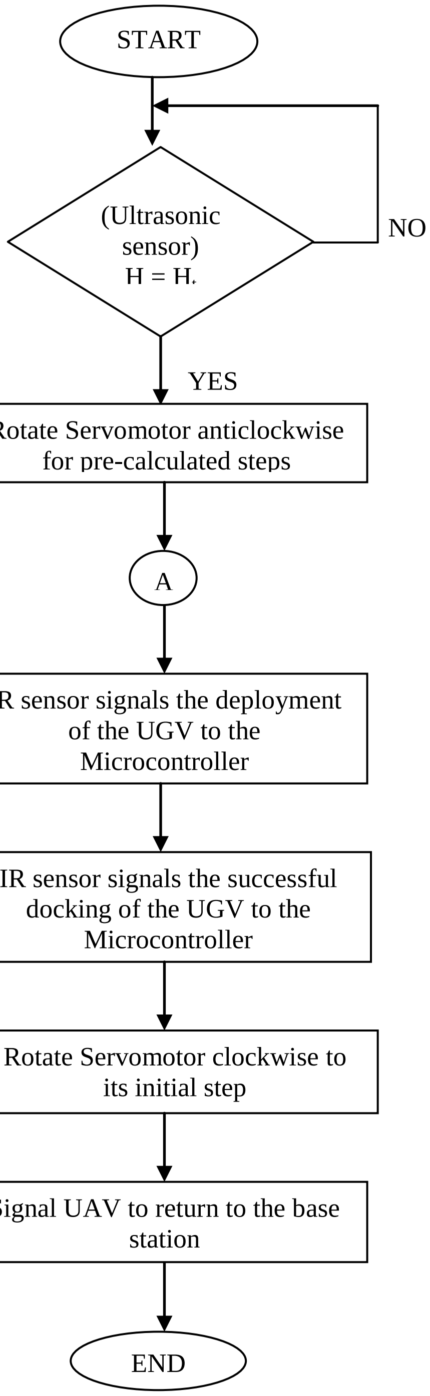

Fig. 10 Flowchart of JAGUARC

V. Conclusion

Nowadays there are many Unmanned Aerial Vehicles (UAV's) and Unmanned Ground Vehicles (UGV's) which can perform many different tasks. In this paper an approach is made to solve the maneuverability problems of the robots and enable UAV's and UGV's to work in coordination to perform a given task more efficiently by designing a control module called Joint Air to Ground Unmanned Autonomous Robot Control module.

An UAV and UGV being coordinated by this module can be together called as Joint Air to Ground Unmanned Autonomous Robot (JAGUAR). Various sensors and a microcontroller in the control module enable it to deploy the UGV at the destination point and UAV to fly back to the base station in a well-coordinated manner to accomplish a task more efficiently.

With the use of the appropriate UAV and UGV with this new module, JAGUAR can be used as a bomb disposal robot without human interference, reconnaissance robot, Nuclear waste disposal robots, Autonomous garbage collection robot and many more.

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