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A Review on SWARM Intelligence of Agile Micro Aerial Vehicles

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Abstract—Micro Aerial Vehicles (MAVs), which are smart and able to move quickly, are a class of miniature Unmanned Aerial Vehicles that has a size restriction and may be Autonomous. The size of MAV that are less than 1m in scale and less than 1 kg in mass. Swarm is a number of similar type of vehicles or phenomena close together in space. In this paper we are reviewing a prototype of micro quad rotor with onboard sensors and controls that operate autonomously. The motivation for this paper comes from the observations, speed of the robot increases with a reduction in size, smaller robots are capable of doing the task in tight formations and indoor environments & the swarm robotics.

Keywords-*MAV, swarm, quad rotors, agility.*

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I. INTRODUCTION

The point of making the swarm of robotics comes from the behavioral coordination of social animals such as ants, bees, birds, and fish are examples of how simple individuals can work successful when they collected in groups. The term Swarm Intelligence aims at making robust, scalable, and flexible collective behaviors for the coordination of large numbers of MAVs to perform the work in coordination with each other without disturbing the neighboring vehicles and other physical quantities. Robustness is the ability to perform the given task in the loss of individuals and the absence of a leader. Scalability is the ability to perform well with different group sizes. Flexibility is the ability to survive with a broad spectrum of well-known environments and tasks.

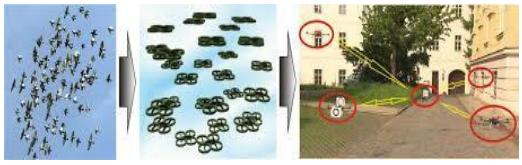

Figure 1: Swarm of micro aerial vehicle

The main characteristics of a swarm Micro Aerial Robotics system are the following:

- MAV Bots are truly agile.
- MAV Bots are fully autonomous.
- Bots co-operate together to complete a given task.
- MAV Bots having high sensing and communication capabilities between them.
- Bots work in the known 3D environment and can act to modify it.

We are presenting this paper as a review on to scaling down the Quadrotors platform to develop a truly small micro UAV. The most important and obvious benefits of scaling down in size is the ability of the quadrotor to operate in constrained environments in tight formations. While the payload capacity of the quadrotor reduces, it is possible to overcome this problem by using multiple quadrotors. Again, the small size benefits us as we know smaller vehicles can operate in closer proximity than large vehicles. Another interesting benefit of scaling down is agility. The MAV is capable of performs a 360◦ flip instantly.

The lots of aerial robotics platforms are available such as, fixed-wing vehicles [1], flapping-wing vehicles [2], vehicles inspired by insect flight. Rotor crafts, including helicopters, quad rotors which having four wings [3] and hex rotors which having six wings etc. Quad rotors being the most commonly used aerial platform in robotics.

II. LITERATURE REVIEWS

Daniel Mellingerresearched [18] on the indeterminate and the coordination of multiple Robots is significantly more complex than in the case when the payload is suspended from Aerial robots. Each robot is capable of controlling propellers to exert wrenches of a fixed pitch, i.e., a thrust and a moment proportional to the thrust, both perpendiculars to the plane of the rotor.

Nathan Michael implemented [19] Micro-uavs which can operate in three-dimensional Environments, explore and map multi-story buildings, manipulate and transport objects, And even perform such tasks as assembly. Just as the incorporation of 2-D mobility reinvigorated Robotics research in the 1990s, the ability to operate in truly three-dimensional environments is bringing the new technologies and applications.

Vijay kumar[17] employed a prototype of 73 gram, 21 cm diameter micro quadrotor with onboard attitude estimation and control that operates autonomously with an external localization system. He argued that the reduction in size leads to agility and the ability to operate in tight formations.

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III. Model Of Micro Agile Quadrotor for Swarm Technique

A. Agile of MAV

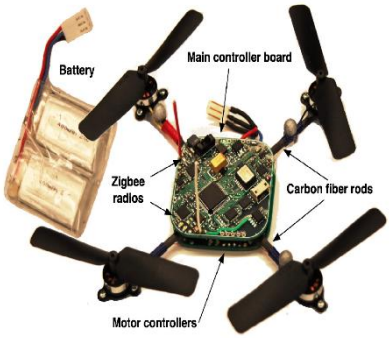
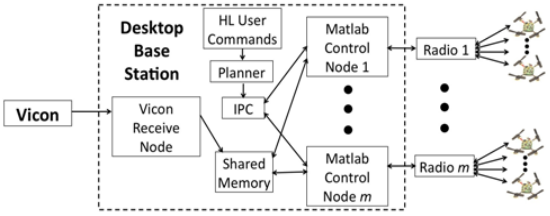


Figure 2: Agile Micro Aerial Vehicle (MAV)

The micro quadrotor is shown in above Figure 2. The MAV consists of lots of onboard sensors to take the information from the environment and send to the main controller board which then process the data and to produce the lift vehicle uses four fixed-pitch propellers. The Motor controllers are also used for controlling the motors to generate the thrust for hovering the vehicle and to drive it autonomously. The flying time of the MAV is approximately 11 minutes with Li-Po battery according to the Vijay kumar's research[17] but it may be variant in other systems. For communication the vehicle contains two transceivers and each quadrotor has two independent radio transceivers.,magnetometer, accelerometer, gyro for the roll and pitch axes,and barometer are also required.

B. Software Infrastructure



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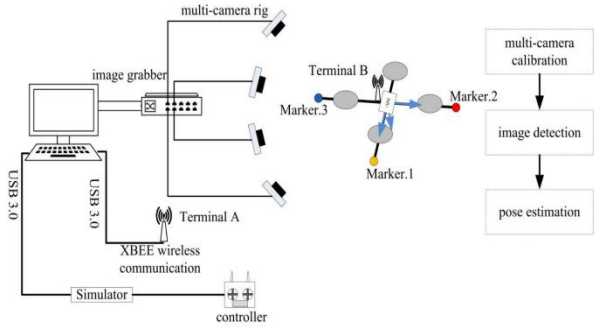

Figure 3: software platform of the different system

To sense the position of each vehicle and provide the data to the Ethernet network to take action on the quadrotor to perform action by the desktop base station.the maximum levels of control and planning is done in matlab on the base station from where the commands are sending to the each Quadrotor.They use VICON software[11]. The onboard controller which is placed on the each micro aerial vehicle send the data taking from the sensors by the transceiver module to software infrastructure and then process it. After taking the data from the micro aerial vehicles the data is first check that it is coming from which group is mentioned in the matlab nodes. The cameras and motion sensors gives the information about the location of each vehicles to the software and then the information is send through the matlab to the each vehicles controller. the base station sends, via custom radio modules, the desired commands, thrust, angular rates and attitude controller gains to the individual quadrotors.

C. Hardware and Sensors required

1] Main processor Board:

There are different types of microprocesses are available and used in the other systems by the users according to its need and application.The ARM Cortex-M family is ARM microprocessor which is designed to use in microcontrollers and it is commonly used as dedicated microcontroller chips, but also used as power management controllers, I/O controllers, system controller, touch screen controllers, smart battery controllers, and sensors controllers[4].

2] Motor Controller:

A motor controller is a device that serves to govern the working of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults[5].

3] Motion capture sensor or camera:

Motion capture is the process of recording the movement of objects or people[6]. In this system the Swarm working is takes place by getting the motion data of the neighboring vehicles and any physical objects which comes in path of vehicles unfortunately or by any reason, so the motion capture

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sensors provides well known path. Bots are able to work in Swarm and Coordinate with each other and form the well-known 3D environment.

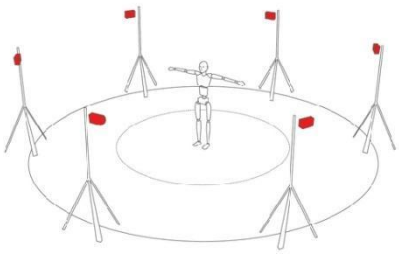

Figure 4: motion capture system

4] Transceivers:

The zigbee transceiver is used to communicate, also there are different protocols used such as bluetooth, wifi and RF but they having the problem of limited range which is eliminated by the zigbee. Zigbee is a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection. Hence, zigbee is a low-power, low data rate, and close proximity. Zigbeetransceivers[8] that can operate at either 900 MHz or 2.4 GHz. Few researchers uses the 900 megahertz bandwidth and few uses 2.4 gigahertz bandwidth of Zigbee transceiver module.

5] Barometer:

A barometer is a scientific instrument used to measure atmospheric pressure. Pressure tendency can forecast the short term changes in the weather. So the vehicle also contains a barometer which can be used to sense a change in the vertical elevation of an object above a surface(altitude). According to that data the Quad rooter of micro aerial vehicle changes the speed of each propeller to balance the robot and the object which is hold by it or placed on it

6] 3-axis magnetometer:

A magnetometer is an instrument that measures magnetism either magnetization of magnetic material like a ferromagnetic, or the direction, strength, or the relative change of a magnetic field at a particular location[9].

7] 3-axis accelerometer:

An accelerometer is a device that measures proper acceleration. By measuring the amount of acceleration due to gravity, an accelerometer can figure out the angle it is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, the accelerometer can find out how fast and in what direction the device is moving[10].

IV. FORMATION OF GROUPS AND TRAJECTORY GENERATION

A.Group formation:

Coordinating a large team of mav is a difficult task in Swarm.For better performance the the swarm must be divided into the groups to manage the complexity the all vehicles.so we can say that a group of vehicle which works simultaneously to complete a single task as a collection of vehicle. Two or more groups act in a team to complete a task which requires completing multiple parallel subtasks [7]. As we know in the swarm of bees there is a queen which is the leader of the team and by following its instruction all link with each other and perform the task efficiently. If the queen is absent then it's not possible to work in coordination. That's why in Swarm MAV created the groups so the problem of absence of leader is removed, system flexibility improved, more secure from hackers and complex to trap the all vehicles. Suppose any vehicle gets trapped then may be the single group gets broken or may be the coordination of the single group gets broken. Most importantly, vehicles within a group are labeled. Global guarantees on shapes, communication topology, and relative positions of individual, agile robots provided by the design controller and planner due to the small group size[13].

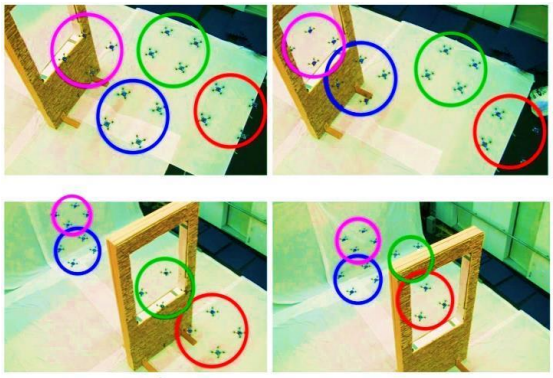

Figure 5:formation of groups and trajectory generation

B.Trajectory generation:

The trajectory function[16] is the path forming with the help of information from the 3D well known environment and the grouping of the MAVs for generating the trajectory to complete the task even in the congested areas. They automatically decides that which group will go first and then who's going next .As the figure 5 shows when the path of travelling becomes small or congested then the MAVs making the group and crossing the path one by one groups.

Instead of planning trajectories for not all MAVs we simply plan trajectories for the groups which is made. Due to this here the flexibility to move independently is not available to the quadrotor.

On the positions of the vehicles the quadrotors have to stay inside their own regions using linear constraints. This approach guarantees collision free trajectories and allows quadrotors the flexibility to move independently.

Integer constraints are used to enforce collision constraints with obstacles and other vehicles and also to optimally assign goal positions[14,15]. In 3D well known area helps to follows the critical trajectories also. This is applicable in the mines of diamonds or metals. Firstly by creating 3D well known environment by taking data from sensors and motion cameras and then the MAVs are capable of doing the task in the underground areas also.

V. CONCLUSION:

Micro UAVs are potentially game changers in robotics. In this paper we reviewed design, modeling and control of a micro quadrotor, the architecture and software for coordinating a team of micro quadrotors. Small size improves the agility and the ability to fly in close proximity, known three-dimensional environments with obstacles. Swarm robotics has several possible applications, including: exploration, surveillance, search and rescue, humanitarian demining, intrusion tracking, cleaning, inspection and transportation of large objects. Another application is construction. Swarms of robots could be used to build complex structures in those cases in which humans would be unable to, such as underwater and in space.

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