MULTIAGENT UAV SWARMS

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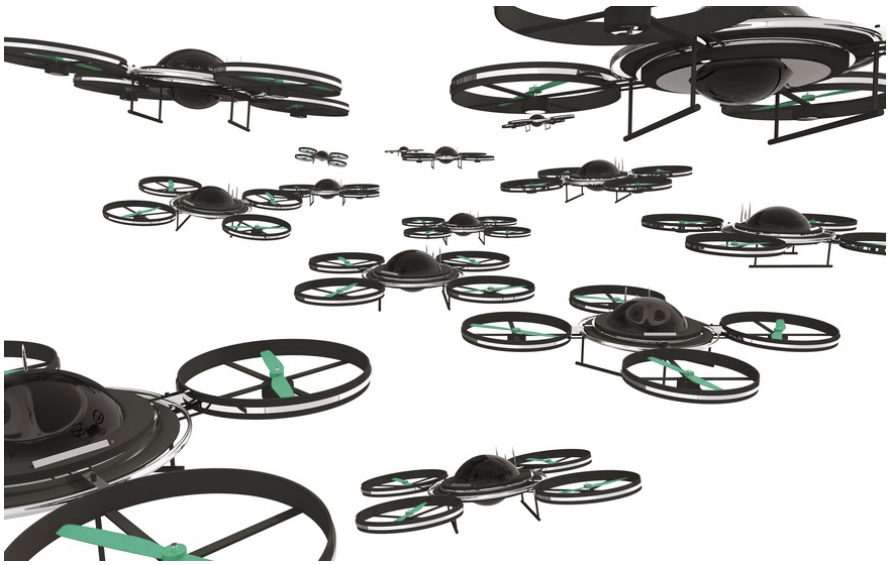

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Abstract

The motivation by which we chose this theme for the work, are a few end-of-grade works that we have read and some articles on these flocks of drones that move with the same fluidity as a flock of birds

(http://www.nature.com/news/autonomous-drones-flock-like-birds-1.14776)

Introduction

Nowadays the drone technology is becoming very important in many sectors: military, surveillance, rescue, meteorological, etc….

This technology is really useful, because the drones can do really dangerous jobs with no human risks, and with some intelligence they can achieve objectives that are complicated for us.

But usually, drones need to cooperate, for achieving goals they can't on their own. In this context we find the drone swarms, big groups of drones that work as one (https://www.youtube.com/watch?v=LQFlimEZA9Q).

If we want to make them work together, we need a brain who is going to coordinate those swarms, usually this brain makes all the calculations, and gives orders to each drone in the group. This is an agent system where one individual takes all the decisions, and it is inefficient for more complex tasks where a lot of decisions must be taken. That's why we need to implement multi agent systems, where each drone in the swarm becomes an agent itself.

Why Swarms?

For some tasks a single drone is not enough, for example, china is now developing a swarm structure that blinds enemy airplanes when they enter on china's air space, this way they don't start a conflict if some plane enters the country accidentally.

In a case of fire, if the area is too much to be controlled by humans a swarm of drones can give information about how big is the fire, in which direction is spreading or what are the safe evacuation routes.

We can see them in shows, dancing and making choreographies just for the joy of the viewers.

Swarm intelligence

SI (Swarm intelligence) is a branch of the artificial intelligence used to study collective behavior of of decentralized, self-organized systems. Those consist in a population of agents interacting locally with each other and their environment.

The agents obey very simple rules, there is not a centralised control structure, but the interactions they have between them leads to the emergence of an intelligent behavior, unknown to the individual agents.

This behaviors are based on examples taken from the nature such as ant colonies, bird flocks, etc…

Models

Boids

Boids (Bird-oid objects) are programs that simulates the flocking behaviors of birds, this was developed by Craig Reynolds in 1986.

Vicsek

Made for studying the swarming behavior of different types of animals, firstly designed to watch the behaviors of the particles.

Aplications

Crowd Simulation

Artists use this technology to simulate complex interactive systems that simulates crowds in movies.

This technology is simple, cheap, and robust, that's why is very attractive.

Human Swarming

In combination with other software, networks of distributed users can be organised as human swarms. This kind of systems are used to make predictions, answer question or evoke opinions.

What is an UAV?

An unmanned aerial vehicle (UAV) is a vehicle without a human pilot onboard. Those are part of an UAS unmanned aerial system, which consist on an UAV, a ground control system, and a system of communication between the two of them.

Usually used for dirty or dangerous jobs, like rescue or military application , nowadays are expanding to more sectors, such as commercial, scientific, recreational,

agricultural, surveillance, product deliveries, aerial photography, or drone racing. Civilian UAV now vastly outnumbers military UAV, with over a million sold in 2015.

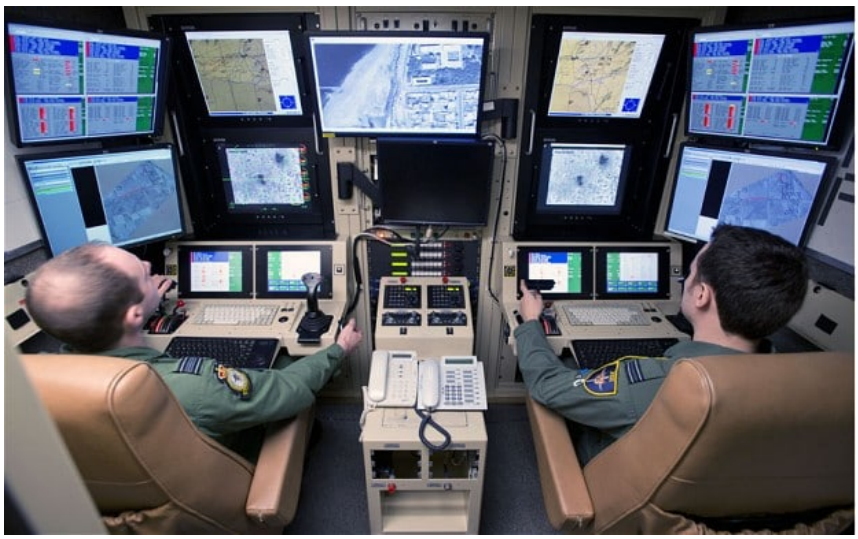
History

The first UAV was developed for military purposes, the first considered UAVs were just a balloons filled with bombs made to attack enemy vehicles. It is not until the first world war when we see the first aerial torpedo, which is an autonomous unmanned vehicle too. After this the development of the UAVs continued being just for military purposes, starting to be more common at the second world war, but still haven't any intelligence, they were just remotely controlled vehicles.

At 1990 it was proved that the UAV were a cheap and efficient weapons.

Working method

In an agent system swarm, a brain who controls all the drones was need, but in a multiagent system each one is an individual who takes decisions. Even so, as we can see in the nature, a swarm needs someone to coordinate their movements, in our case, the same agent that acted as a brain in the agent system, now becomes a coordinator, he is gonna decide what actions the whole swarm has to do, this brain is usually called GCS (Ground Control System).



The GCS is going to decide what is their next mission, and each member of the swarm sends his actual information (position, actual mission, how important is his role in this mission) back to the GCS, and he decides which ones have to move to the next task, and which ones have to stay where they are.

After this, the selected drones become an individual flock, and one of them becomes their coordinator, who is gonna take the important decisions and receive new orders from the GCS.

Technology

Equipment

A typical drone is made of light composite materials to reduce weight and increase maneuverability. This strength composite allows them to fly at extremely high altitudes. Drones are equipped with technology such as infra-red cameras (military UAV), GPS and laser (military UAV). Drones can be controlled by remote control system or a ground cockpit.

The nose of the unmanned aerial vehicle is where all the sensors and navigational systems are present. The engineering materials used to build the drone are highly complex composites which can absorb vibration which decreases the noise produced.

Gyro Stabilization

The gyroscope needs to work almost instantly to the forces moving against the drone.The inertial measurement unit (IMU) works by detecting the current rate of acceleration using one or more accelerometers. The IMU detects changes in rotational attributes like pitch, roll and yaw using one or more gyroscopes. Some IMU include a magnetometer to assist with calibration against orientation drift.

Communications

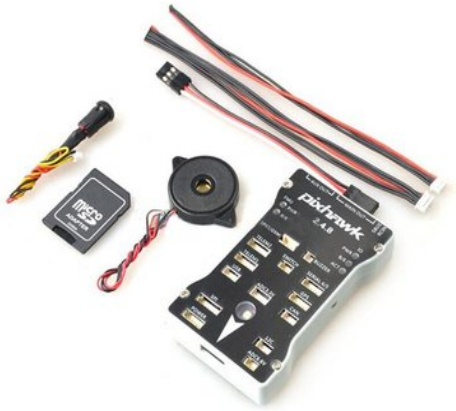
For this kind of architecture, each drone and GCS must have some kind of wireless connection. For this objective we can find various types of software, most of them based MAVLink (Micro air vehicle Link) protocol, one of the most used because it is compatible with most of the commercial Drones.

This softwares also need a proxy that is going to manage the communications between all the entities, a program compatible and usually used with MAVLink is MAVproxy, it is usually installed at the GCS.

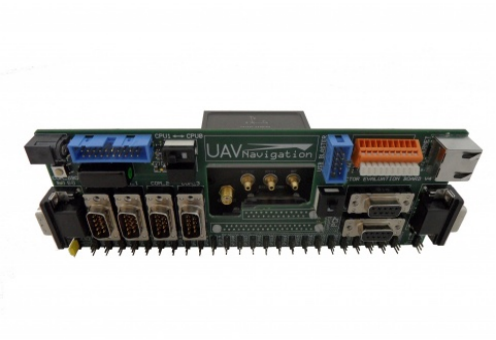
Drivers

One of the most used driver is Pixhawk (for UAV's based on ardupilot), this is compatible with several SDK like DroneKit (manejable with : Android, iOS or Python languages) or ParrotSDK (C++,XCode) this one most commonly used in parrot type UAV

but also compatible with ardupilot. Both drivers are compatible with MAVProxy, letting the programmer make an abstraction and using its functions as a socket.



Other famous or commonly used Drivers are the UAVnavigation, which is used with his own SDK (VectorSDK).



Components of a driver

Flight Controller

The flight controller is the brains of your drone. The flight controller reads all of the sensor data and calculates the best commands to send to your drone in order for it to fly.

Processor

This is the central unit that runs the autopilot firmware and performs all the calculations. Most flight controllers have 32bit processors which are more powerful that than 8bit systems, but there are still a few popular 8 bit autopilot platforms such as ardupilot mega which can be found online very cheaply.

Others

The processor and the FC are the most important elements for our purpose, bot there are other important components in the flight controller:

Accelerometer, Gyroscope, Compass, Barometer, Airspeed sensor,Data Logging, GPS, etc...

Glossary

- **UAV**: unmanned aerial vehicle
- **UAS**: unmanned aerial system
- **GCS**: Ground Control System
- **IMU**: inertial measurement unit
- **MAVLink**: Micro air vehicle Link
- **SDK**: Software Development Kit

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