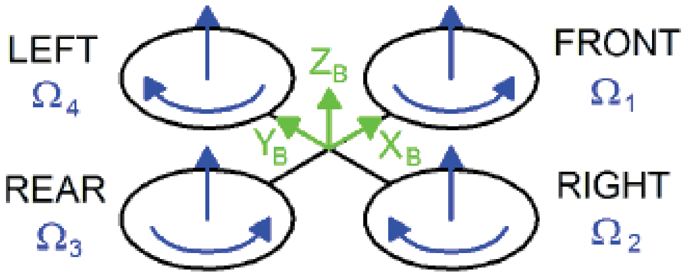
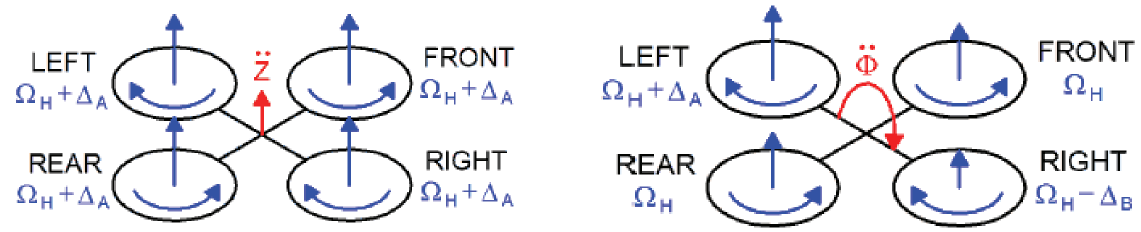
# 2 AR.Drone Overview

## 2.1 Introduction to quadrotor UAV

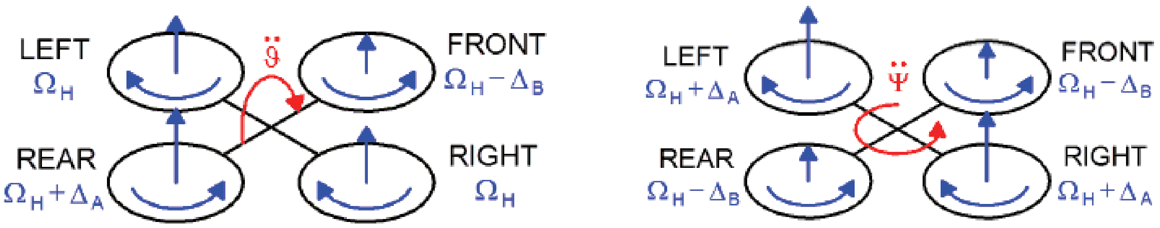
AR.Drone is a quadrotor. The mechanical structure comprises four rotors attached to the four ends of a crossing to which the battery and the RF hardware are attached.

Each pair of opposite rotors is turning the same way. One pair is turning clockwise and the other anti-clockwise.





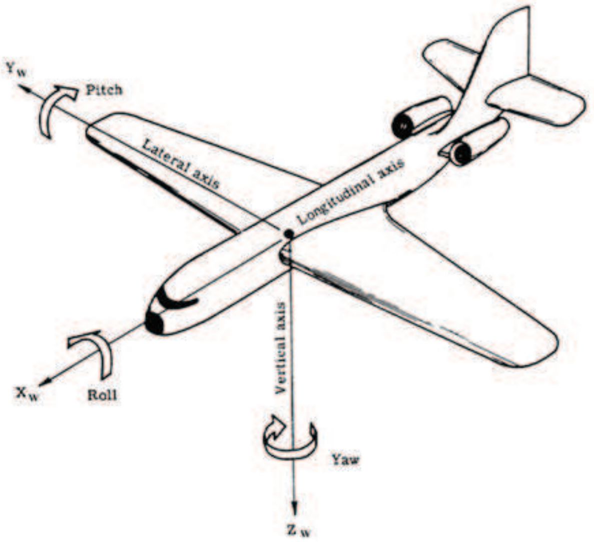
(a) Throttle (b) Roll



(c) Pitch (d) Yaw

Figure 2.1: Drone movements

Manoeuvres are obtained by changing pitch, roll and yaw angles of the AR.Drone .



Varying left and right rotors speeds the opposite way yields roll movement. This allows to go forth and back.
Varying front and rear rotors speeds the opposite way yields pitch movement.
Varying each rotor pair speed the opposite way yields yaw movement. This allows turning left and right.

(a) Indoor (b) Outdoor

Figure 2.2: Drone hulls

## 2.2 Indoor and outdoor design configurations

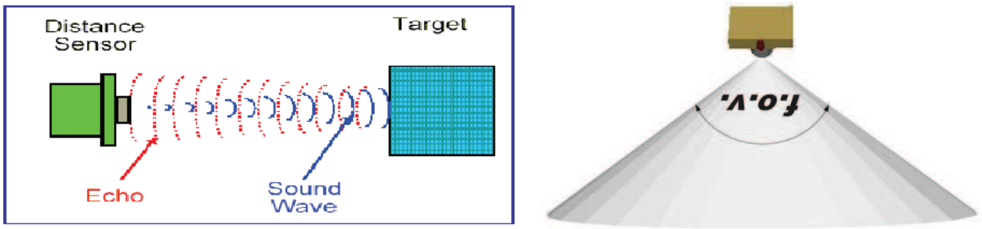
When flying outdoor the AR.Drone can be set in a light and low wind drag configuration (2.2b). Flying indoor requires the drone to be protected by external bumpers (2.2a).

When flying indoor, tags can be added on the external hull to allow several drones to easily detect each others via their cameras.

## 2.3 Engines

The AR.Drone is powered with brushless engines with three phases current controlled by a micro-controller

The AR.Drone automatically detects the type of engines that are plugged and automatically adjusts engine controls. The AR.Drone detects if all the engines are turning or are stopped. In case a rotating propeller encounters any obstacle, the AR.Drone detects if any of the propeller is blocked and in such case stops all engines immediately. This protection system prevents repeated shocks.



(a) Ultrasound sensor (b) Camera

Figure 2.3: Drone Sensors

## 2.4 LiPo batteries

The AR.Drone uses a charged 1000mAh, 11.1V LiPo batteries to fly. While flying the battery voltage decreases from full charge (12.5 Volts) to low charge (9 Volts). The AR.Drone monitors battery voltage and converts this voltage into a battery life percentage (100% if battery is full, 0% if battery is low). When the drone detects a low battery voltage, it first sends a warning message to the user, then automatically lands. If the voltage reaches a critical level, the whole system is shut down to prevent any unexpected behaviour.

## 2.5 Motion sensors

The AR.Drone has many motions sensors. They are located below the central hull.

The AR.Drone features a 6 DOF, MEMS-based, miniaturized inertial measurement unit. It provides the software with pitch, roll and yaw measurements.

Inertial measurements are used for automatic pitch, roll and yaw stabilization and assisted tilting control. They are needed for generating realistic augmented reality effects.

An ultrasound telemeter provides with altitude measures for automatic altitude stabilization and assisted vertical speed control.

A camera aiming towards the ground provides with ground speed measures for automatic hovering and trimming.

## 2.6 Assisted control of basic manoeuvres

Usually quadrotor remote controls feature levers and trims for controlling UAV pitch, roll, yaw and throttle. Basic manoeuvres include take-off, trimming, hovering with constant altitude, and landing. It generally takes hours to a beginner and many UAV crashes before executing safely these basic manoeuvres.

Thanks to the AR.Drone onboard sensors take-off, hovering, trimming and landing are now completely automatic and all manoeuvres are completely assisted.

User interface for basics controls on host can now be greatly simplified :

- When landed push *take-off* button to automatically start engines, take-off and hover at a pre-determined altitude.
- When flying push *landing* button to automatically land and stop engines.
- Press *turn left* button to turn the AR Drone automatically to the left at a predetermined speed. Otherwise the AR Drone automatically keeps the same orientation.
- Press *turn right* button to turn the AR Drone automatically to the right. Otherwise the AR Drone automatically keeps the same orientation.
- Push *up* button to go upward automatically at a predetermined speed. Otherwise the AR Drone automatically stays at the same altitude.
- Push *down* to go downward automatically at a predetermined speed. Otherwise the AR Drone automatically stays at the same altitude.

A number of flight control parameters can be tuned:

- altitude limit
- yaw speed limit
- vertical speed limit
- AR.Drone tilt angle limit
- host tilt angle limit

## 2.7 Advanced manoeuvres using host tilt sensors

Many hosts now include tilt motion sensors. Their output values can be sent to the AR.Drone as the AR.Drone tilting commands.

One *tilting* button on the host activates the sending of tilt sensor values to the AR.Drone . Otherwise hovering is a default command when the user does not input any manoeuvre command. This dramatically simplifies the AR.Drone control by the user.

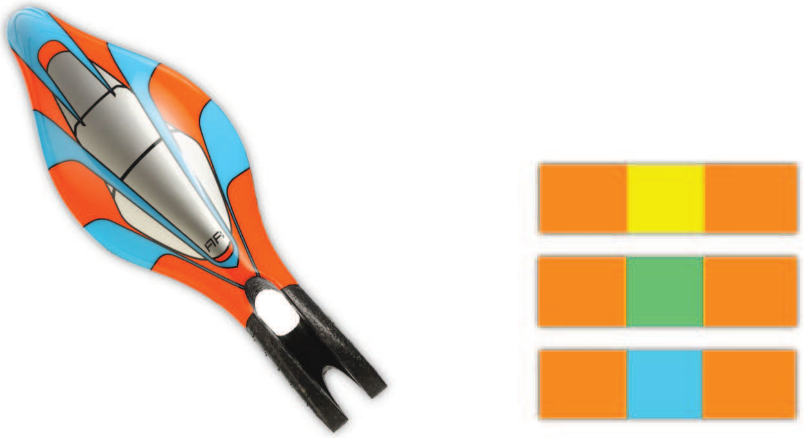
The host tilt angle limit and trim parameters can be tuned.

## 2.8 Video streaming and tags detection

The frontal camera is a CMOS sensor with a 90 degrees angle lens.

The AR.Drone automatically encodes and streams the incoming images to the host device. QCIF and QVGA image resolutions are supported. The video stream frame rate is set to 15 Hz.

Tags painted on drones can be detected by the drone front camera. These tags can be used to detect other drones during multiplayer games, or to help a drone find its way in the environment. Both tags on the external and internal hull can be detected.



(a) 2D tags on outdoor shell (b) 2D tags on indoor shell

Figure 2.4: Drone shell tags

## 2.9 Wifi network and connection

The AR.Drone can be controlled from any client device supporting the Wifi ad-hoc mode. The following process is followed :

1. the AR.Drone creates a WIFI network with an ESSID usually called ***adrone_xxx*** and self allocates a free, odd IP address.
2. the user connects the client device to this ESSID network.
3. the client device requests an IP address from the drone DHCP server.
4. the AR.Drone DHCP server grants the client with an IP address which is :
   - the drone own IP address plus 1 (for drones prior to version 1.1.3)
   - the drone own IP address plus a number between 1 and 4 (starting from version 1.1.3)
5. the client device can start sending requests the AR.Drone IP address and its services ports.

The client can also initiate the Wifi ad-hoc network. If the drone detects an already-existing network with the SSID it intented to use, it joins the already-existing Wifi channel.

## 2.10 Communication services between the AR.Drone and a client device

Controlling the AR.Drone is done through 3 main communication services.

Controlling and configuring the drone is done by sending *AT commands* on UDP port 5556. The transmission latency of the control commands is critical to the user experience. Those commands are to be sent on a regular basis (usually 30 times per second). The list of available commands and their syntax is discussed in chapter 6.

Information about the drone (like its status, its position, speed, engine rotation speed, etc.), called *navdata*, are sent by the drone to its client on UDP port 5554. These *navdata* also include tags detection information that can be used to create augmented reality games. They are sent approximatively 30 times per second.

A video stream is sent by the AR.Drone to the client device on port 5555. Images from this video stream can be decoded using the codec included in this SDK. Its encoding format is discussed in section 7.2.

A fourth communication channel, called *control port*, can be established on TCP port 5559 to transfer critical data, by opposition to the other data that can be lost with no dangerous effect. It is used to retrieve configuration data, and to acknowledge important information such as the sending of configuration information.