Lecture 12: Experimentation IV

So, hi to everyone. So far, you have passed 2 weeks of the course NPTEL course on experimental robotics and I hope you are happy to step up into the third week of this course in which we will be exploring a new concept called an aerial robotics and here in the introduction part, we will be seeing why a drone is as an aerial address, as an aerial robot and then, later on we will be stepping up into the field to do some field experiments. So, I hope we can start right away. So, what is a drone? A drone is an unmanned aerial vehicle that can fly on its own and complete a mission and return back to its original point or land somewhere else safely that is called as a drone. So, what is an aerial robot? An aerial robot is much more than a drone, which can do some other activity addition to flying. For example, if you survey a land using a drone primarily, there comes the part of image processing.

So, that additional work of image processing makes a drone into an aerial robot. Next thing is for aerial grasping object. If you put a manipulator arm as an additional tool attached to the bottom of a drone, it becomes an aerial robot. So, for multiple purpose mission, we need something more than a drone.

So, that is where we use the word aerial robot. That is how we address a drone to be an aerial robot. I hope you understand this concept and now what is there inside a drone, so that we can make it into the next step of making it a aerial robot. So, we will see. So, for example, here I have a drone.

So, when do we call this drone an aerial robot? We basically are going to do a mission now with the help of this camera. So, that image processing part is what it makes it intelligent and suitable for some other application other than flight. So, this is how we address a drone to be an aerial robot. In the next part, we will see what are the components of an aerial robot and we will see later. So, in the last session, we ended up with the question, what makes an aerial robot, and how does it make it fly? So, here we are with the answer what is inside a drone.

The first primary component is a flight controller board. So, a flight controller board controls the movements of the drone and basically how the drone is moving up, down, forward, left and everything is determined by the flight controller. So, this is basically a component of a drone. So, to make a drone into an aerial robot, we need something additional that is called as flight computer. While a flight controller basically controls the movements of the drone, a flight computer gives it much more than that.

It gives intelligence to the drone and makes it an aerial robot suitable for making it usable for some other purpose. So, the most crucial component that is needed for the flight is the motors. So, the common type of motor that we use in any aerial robot or drone is called as BLDC motor, a brushless DC motor that can run for a long period of time when supplied

with more ampere compared to a normal DC motor, so that it will survive the entire process without any thermal wear and tear. The motors are connected to two primary parts. One is ESC and other is the propeller.

So, what is an ESC? An ESC is an electronic speed controller that basically controls the ampere supply to the DC motor. So, when as you all know the basic law of electrical systems, V is equal to IR. The electrical power of this motor, where does this thing? Voltage is a constant property of the motor, BLDC motor and as much as I is increasing, the rotational speed of the motor is increasing. So, based on that our propeller speed, which is very stiffened, very tightly attached to the motor, the speed of the propeller is determined by the rotational speed of the motor. So, how do we control it? If we just have to control the ampere, what is the technique there? So, to do that process, we have something called as ESC.

An ESC is basically comprised of something called as MOSFETs. The MOSFET acts like a tap that controls the flow of water. Just like how a tap controls the flow of water, a MOSFET controls the flow of ampere. That means the current, the flow of current through that gate. So, this ESC is connected to this flight controller and as much speed of the propeller is needed, the ESC will be providing ampere to the motors, so that we can get it as an output through the propeller.

So, here we have to consider two powers. One is the mechanical power and other is the electrical power. As I mentioned earlier, electrical power is something demanded by the motor. Mechanical power is what is demanded by the flight. So, the efficiency of a drone motor is calculated as mechanical power divided by electrical power or sometimes as the inverse electrical power divided by mechanical power depending on the situation.

A typical component that is used in an aerial robot is the addition of camera. Camera gives the drone the ability to see its surroundings and survey it and to interact with it sometimes. For example, if you are enabling the gesture control module in a drone, that makes it into an aerial robot. So far, we had identified this. I want to now display these components to you.

So, this is the drone that we saw earlier and inside this is the flight controller and this one is the camera and these are the propellers and the BLDC motors. I want to say something about these propellers. So, if you notice this, I am having two propellers here. So, one is having these inclined surfaces or there in the blade. So, one is thicker than the other part.

So, the thicker part is where the wind is going to get hit and it will flow over this blade and it will pass under the blade also. But, since the blade is rotating at very high speed, two pressure zones are created. One is the low pressure zone on the top of the blade and the other is the high pressure zone under the bottom of the blade. So, here, you can see these two blades have their structure opposite to each other. One is a clockwise blade and other

is an anti-clockwise blade.

How do I say the direction of the blade? See here. So, the thick side is here, thick side is here. So, if the wind is to hit from this side, the blade is to go in the opposite direction. So, this is the direction of the blade. So, this is how we say the direction of the blade.

So, I hope you are all comfortable with identifying the parts of a drone and now, we will be moving on to the field experiments. Thank you. So, as discussed in the last class, here we are in the field to test out the capabilities and the maneuvers of the drone, so that we can start right now. So, as you can see there, there is a drone in the landing pad and now that drone has to go over this field and it will do the aerial survey and then, we will land that drone back in this landing pad. So, this is our first task and then, later on, we will go for each maneuver one by one.

So, now we have taken off. First, we will go around the perimeter of the paddy field. So, we will go around the perimeter of the paddy field.

Thank you. So, this is our task one and here we have successfully landed it from one landing pad to another landing pad. So, this is for the task one, we have completed. In the last session, we saw how we can manually survey a field using this remote control and that aircraft. So, now we are going to use the same aircraft to how we can capture waypoints and later on execute an autonomous mission without any human interference.

So, let's start. So, I am here recording this waypoint as my first waypoint. So, another waypoint has been defined as a third waypoint. So, now we are going to go around the perimeter of the paddy field. So, now it is going to execute that mission, which has been recorded. So, here it is going to the first waypoint and I am not operating, it is going on its own.

So, now we are going to go around the perimeter of the paddy field. So, now we are going to go around the perimeter of the paddy field. So, now we are going to go around the perimeter of the paddy field. So, now we are going to go around the perimeter of the paddy field. So, now we are going to go around the perimeter of the paddy field. Might be of combination of all these sensors together put to help the motion of the drone, it is called Sensor Fusion.

And other concepts related to this will be explained to you by Professor D. K. Pratihar in his presentation. Here in this video, we can see the drone following me as I move forward. This is done with the help of object detection and moving frame estimation techniques. The object detection is done using classic AI techniques and both it and the move frame estimation are deployed on the flight computer. The flight computer then computes the state estimates of the drone and passes it on to the flight controller which tracks them in real time.

In the next clip, you can see the same drone following Professor Pratihar as he moves forward and backward. So, SD card is full, so this is how circular trajectories are traced using this drone, so Signing off, I am Ronald. I am from Professor D. K. Pratihar's lab. I am also a PhD student working under him specifically in aerial robotics. Thank you.