

AI Meets Flight: Python Drone Programming and ChatGPT Capabilities

Oleg Dats

Plan

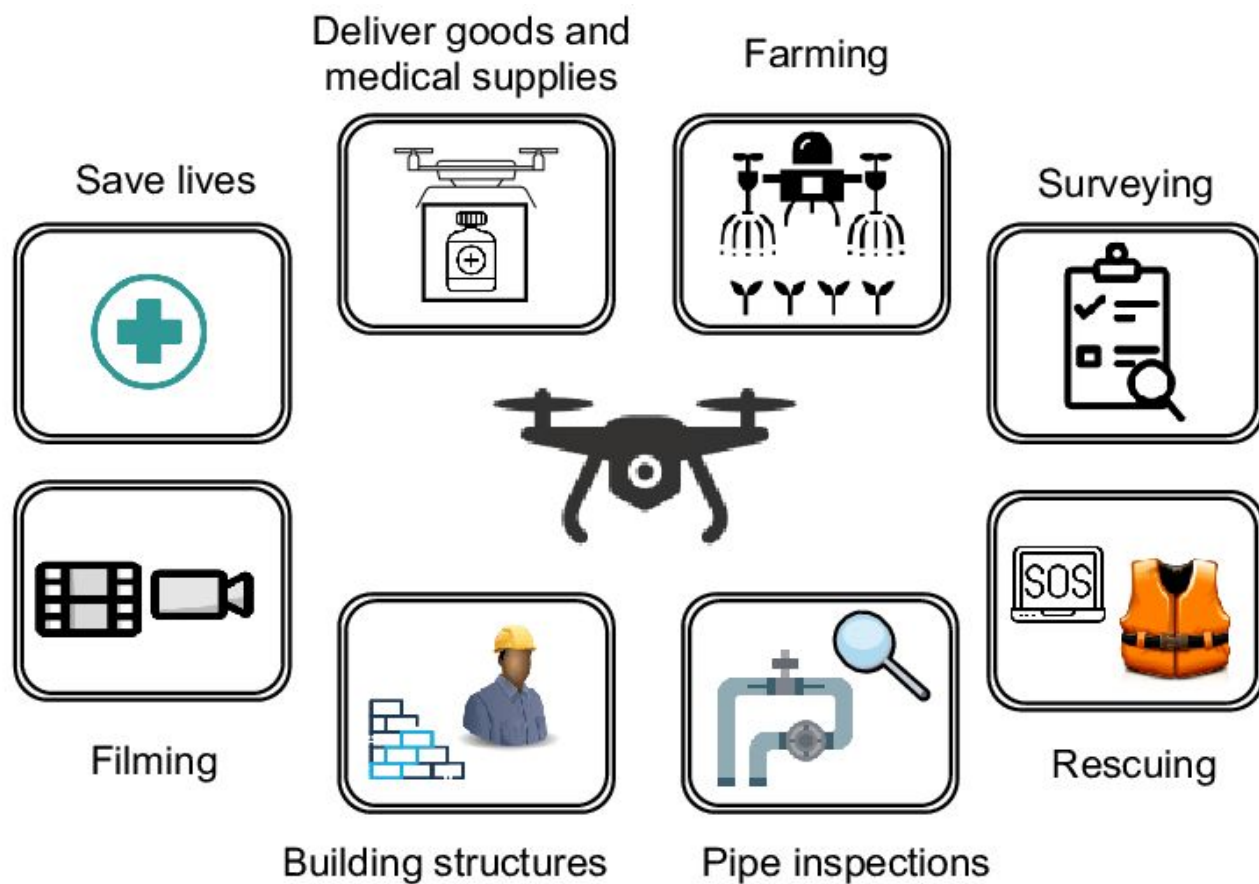
1. UAV (Unmanned Aerial Vehicle): components and basic physics
2. DJI Tello: first flight
3. Classical Robotics: Odometry
4. AI: YOLOv8 object tracking
5. Future of Robotics. ChatGPT for Robotics: Design Principles and Model Abilities

Credits to:

<https://www.youtube.com/watch?v=LmEcyQnfpDA>

5 MILLION VIEWS





Why so popular?

Ukraine's drone production capabilities have grown 100-fold since start of invasion

In 2024, Ukraine will release a million FPV drones

...

Fixed-wings

Hybrid Drone

3 Types of Drones

Rotary-wing

quadcopter

hexacopter

octocopter



Components

Frame

Motors

Propellers

ESC

PDB

Flight Controller

Battery

Receiver

Camera

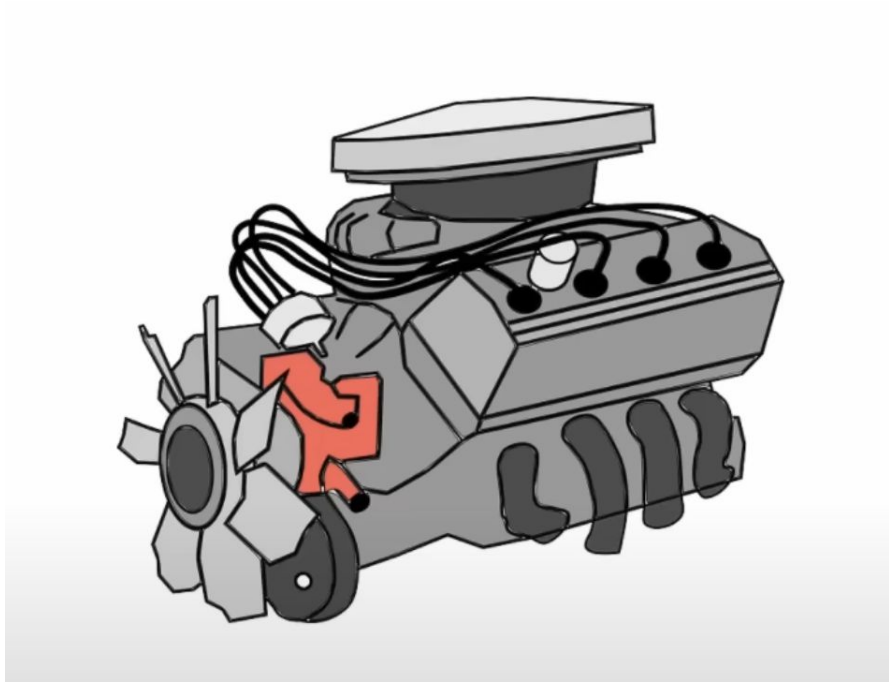
VTX



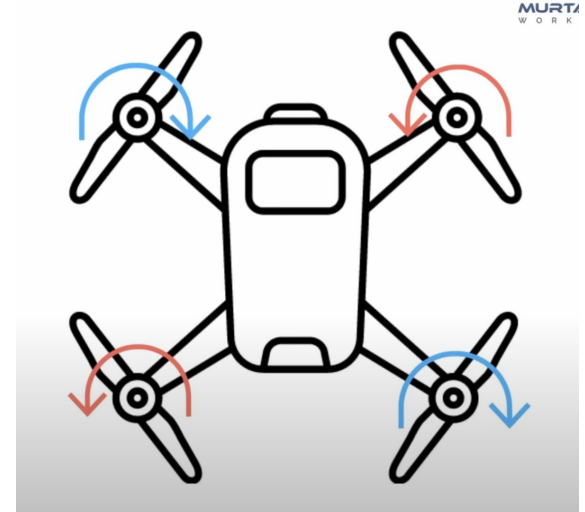
Frame



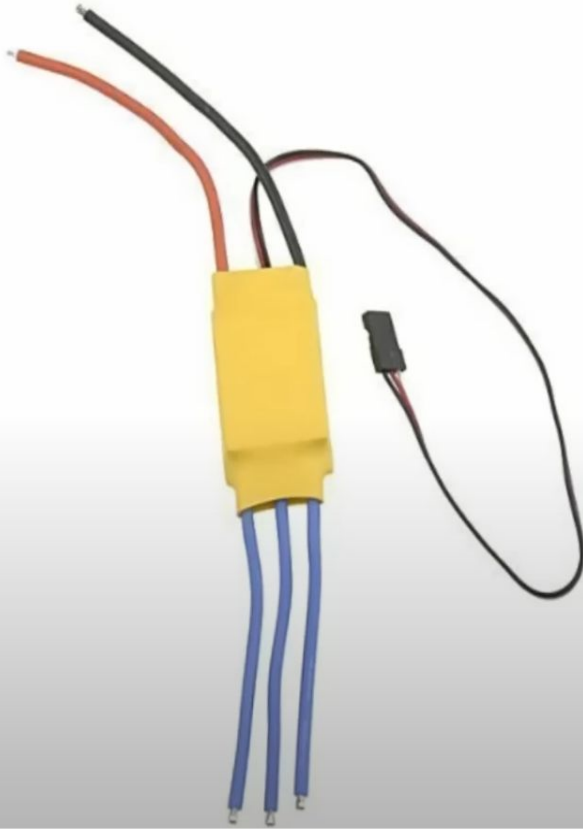
Motor



Propellers



Electric Motor Controller (ESC)

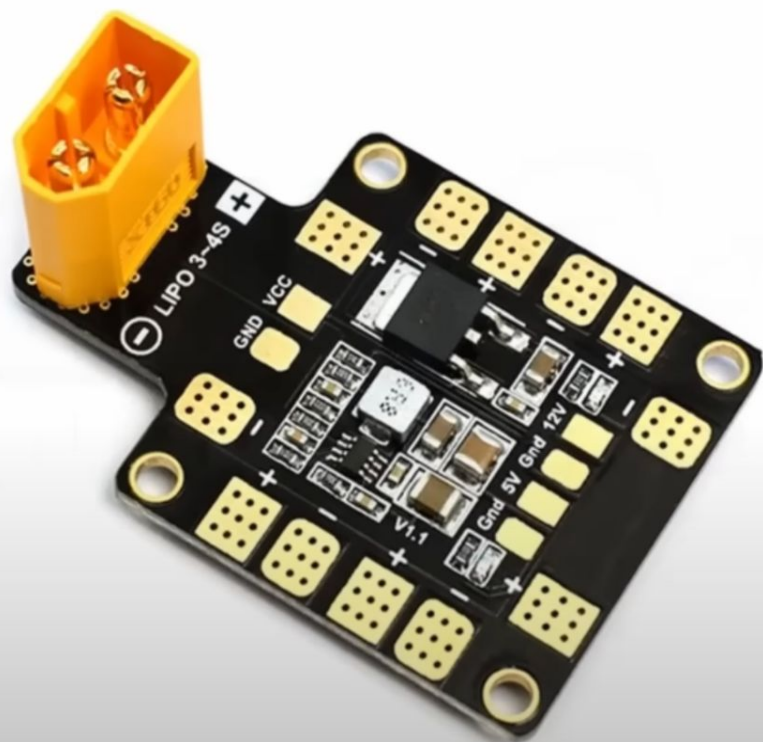


DC

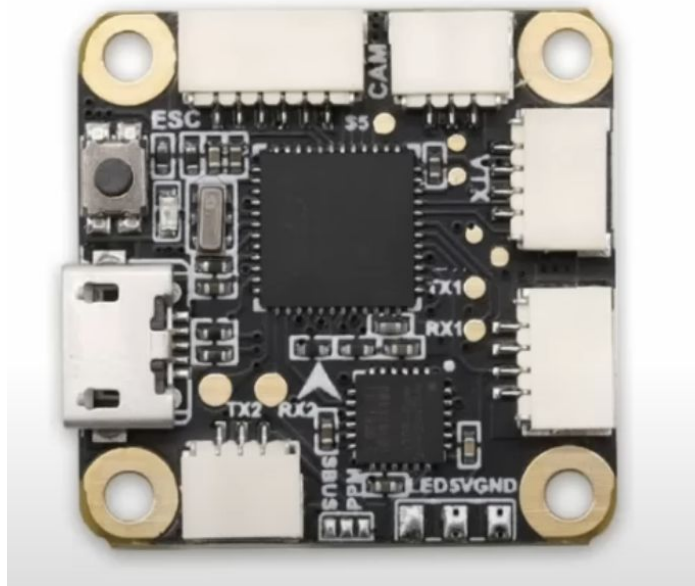


AC

Power Distribution Board (PDB)



Flight controller (*пультник, ex. wind*)



Battery



Receiver



Camera



Video Transmitter (VTX)



Sensors

Pressure

Measure Altitude



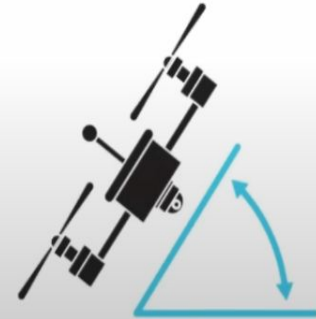
GPS

Locates Position



IMU

Acceleration & Angles



How does a Drone fly?

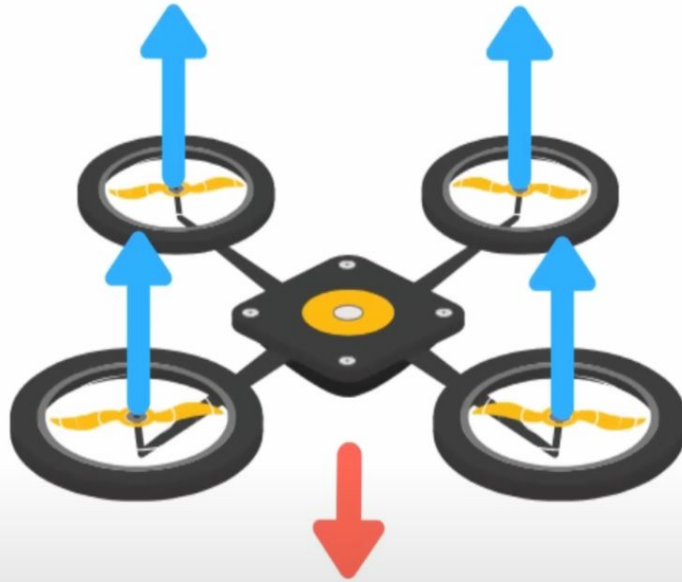
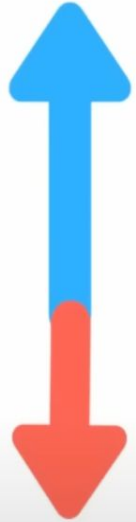
4 DOF

3 Translations

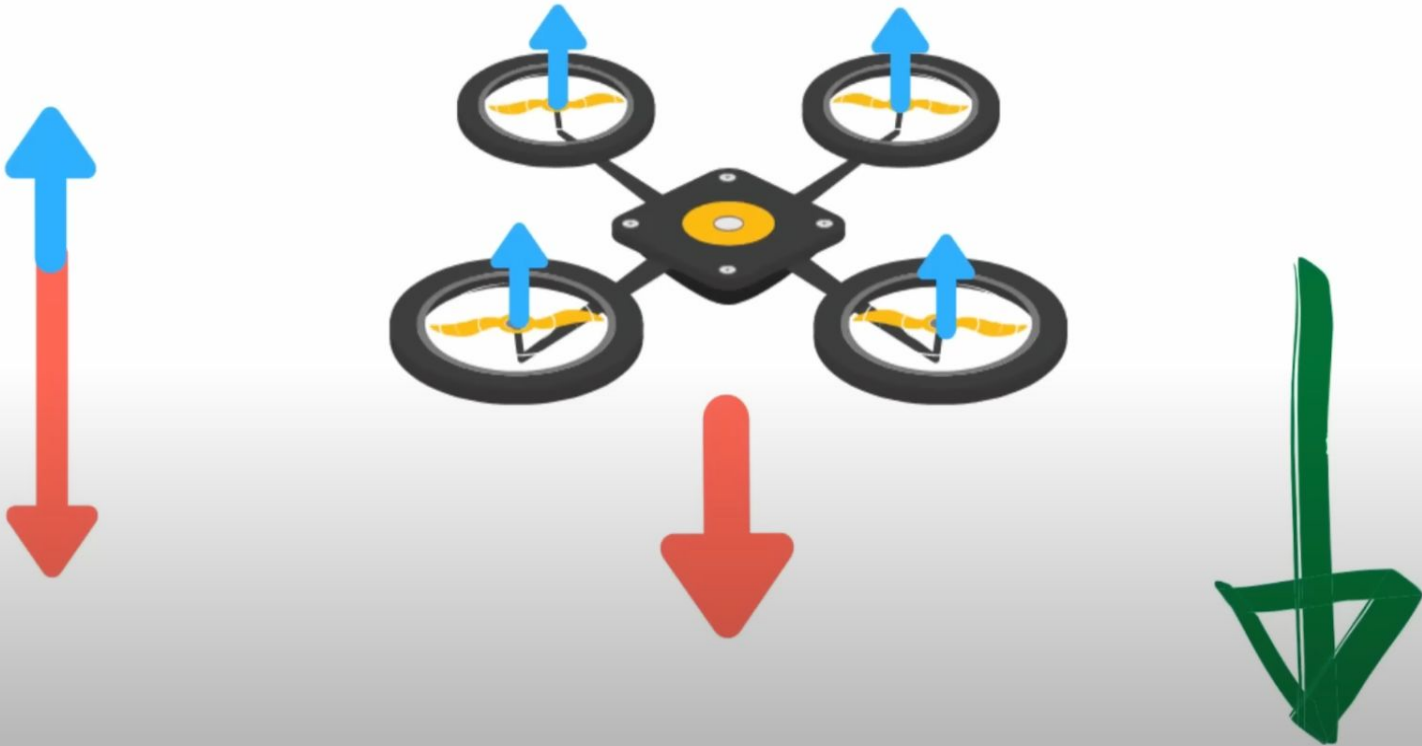
1 Rotation

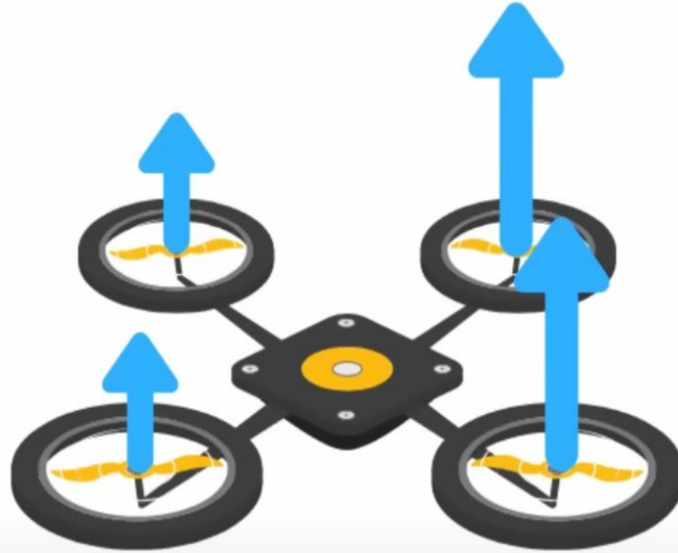


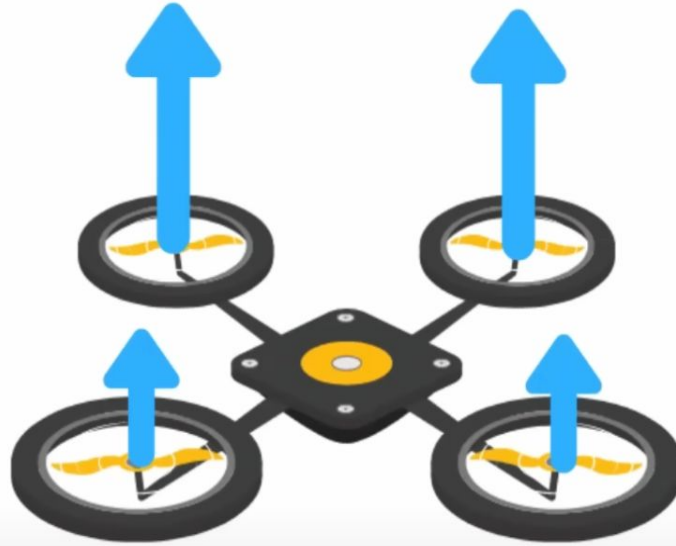


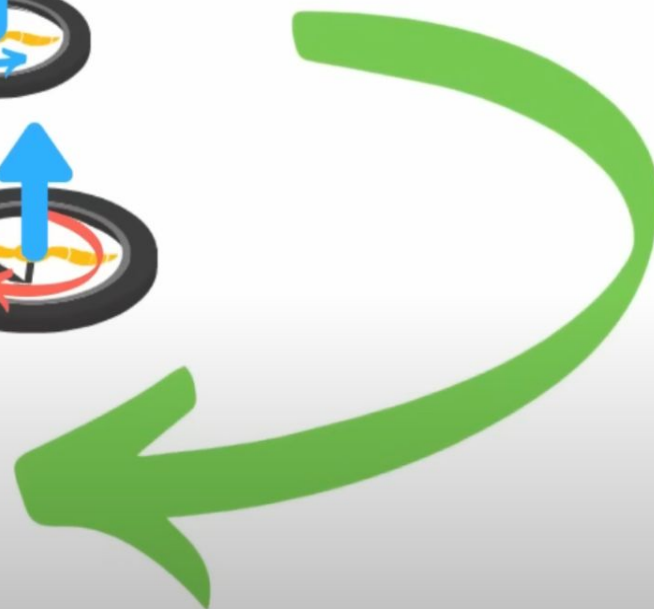
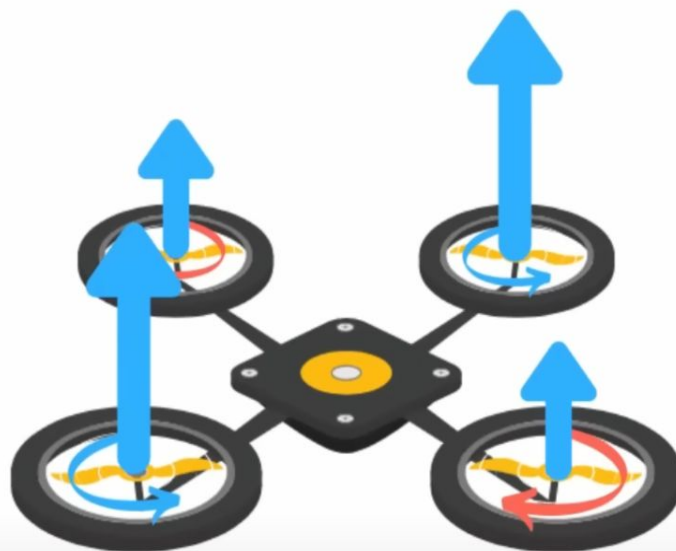


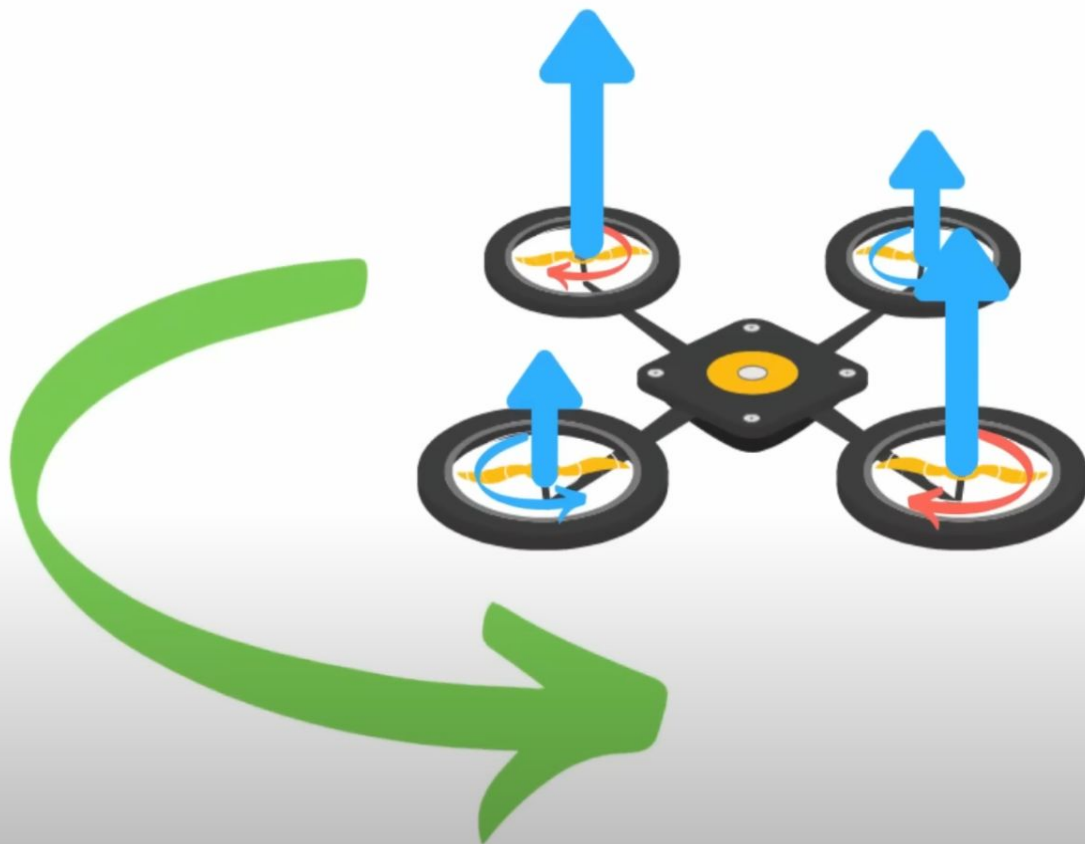
4













Relax! Tello's Super Safe.

Fly from Tello App

Create project

VSC

```
conda create --name uav python=3.10
```

```
conda activate uav
```

```
pip install djitellopy opencv-python pygame numpy ultralytics onnx
```

First fly by Python code

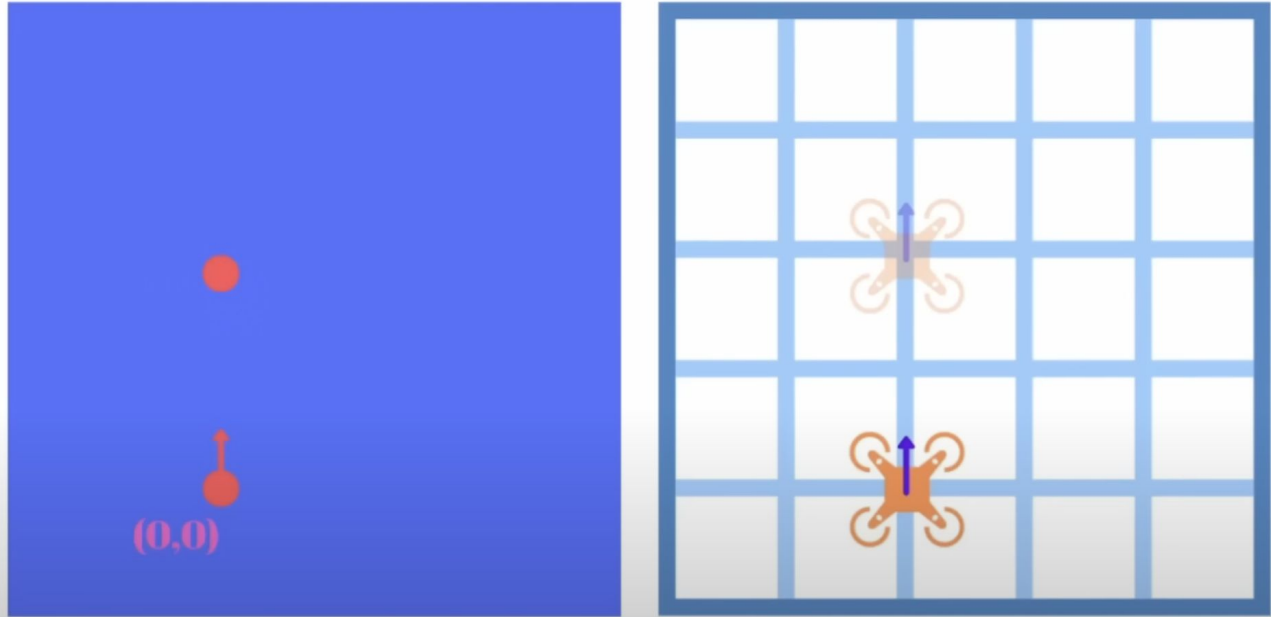
Image Capture

Keyboard Control

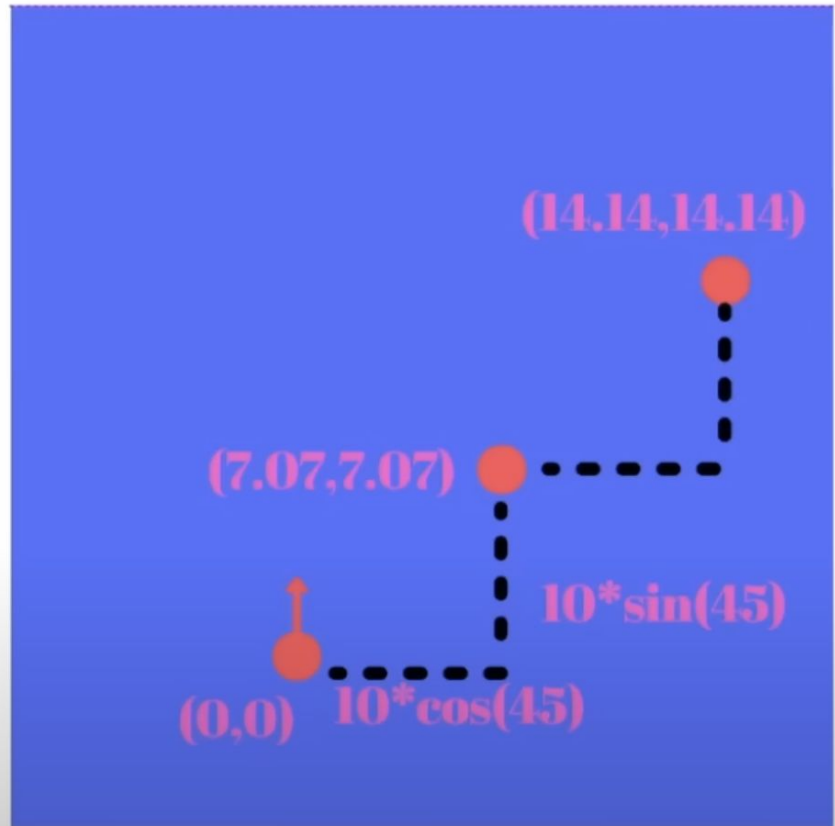
Surveillance

Odometry

Odometry is the use of data from motion sensors to estimate change in position over time.

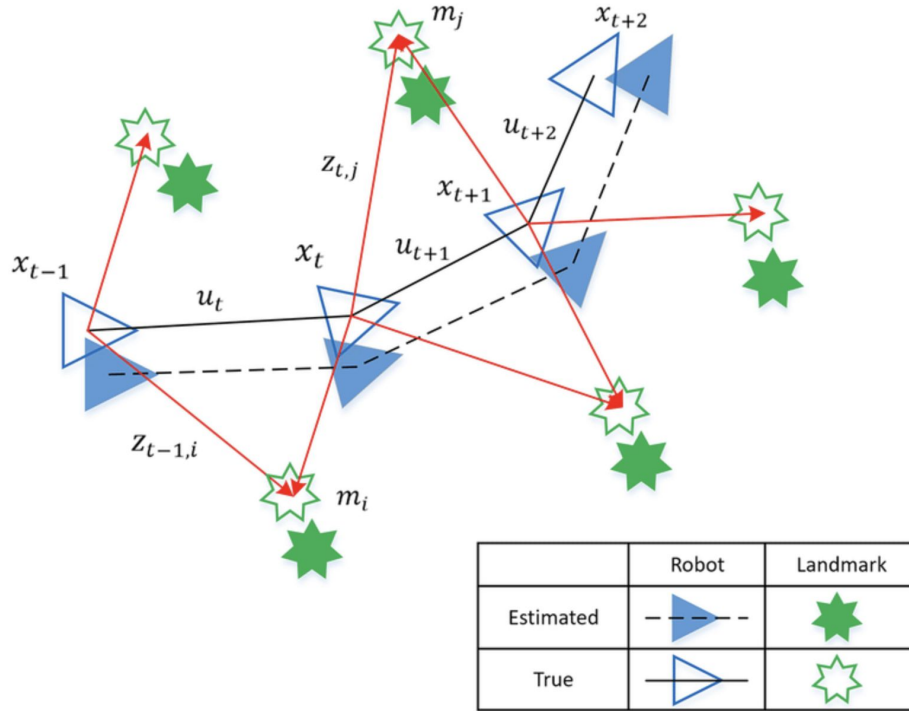


Distance = 10 cm
Angle = 45 deg



Run code.

SLAM (Simultaneous localization and mapping)



AI: YOLOv8 object tracking (*You Only Look Once, fast*)

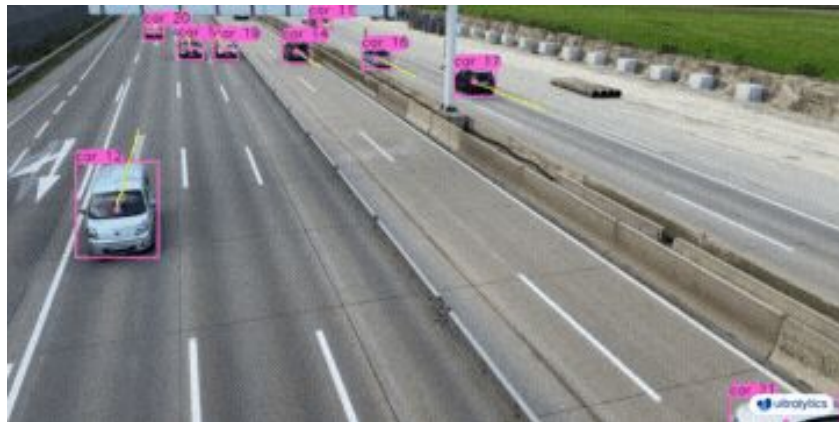


Image Classification

Is this a dog or a person?



Neural
Network
Output

Dog = 1
Person = 0

Object Localization

Where exactly is the dog in
this image?



Neural
Network
Output

Dog = 1
Person = 0
+
Bounding
Box

Object Localization



P_c	1
B_x	50
B_y	70
B_w	60
B_h	70
C_1	1
C_2	0

C_1 = Dog class
 C_2 = Person Class

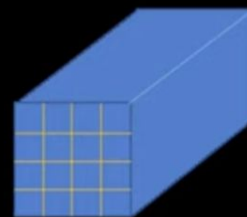


1
30
28
28
82
0
1

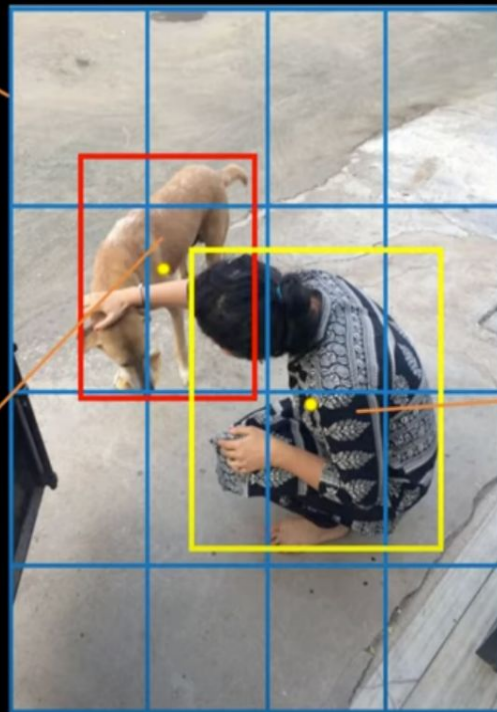


0
-
-
-
-
-
-

4 by 4 by 7

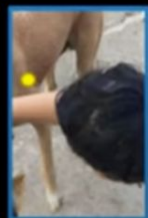


$$\begin{bmatrix} p_c \\ B_x \\ B_y \\ B_w \\ B_h \\ C_1 \\ C_2 \end{bmatrix} \begin{bmatrix} 0 \\ - \\ - \\ - \\ - \\ - \\ - \end{bmatrix}$$

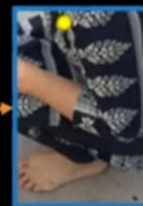


$$\begin{bmatrix} 1 \\ 0.05 \\ 0.3 \\ 2 \\ 1.3 \\ 1 \\ 0 \end{bmatrix}$$

(0,0)



(1,1)

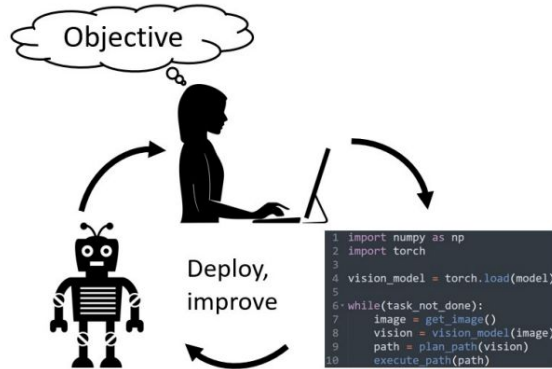


$$\begin{bmatrix} 1 \\ 0.32 \\ 0.02 \\ 3 \\ 2 \\ 0 \\ 1 \end{bmatrix}$$

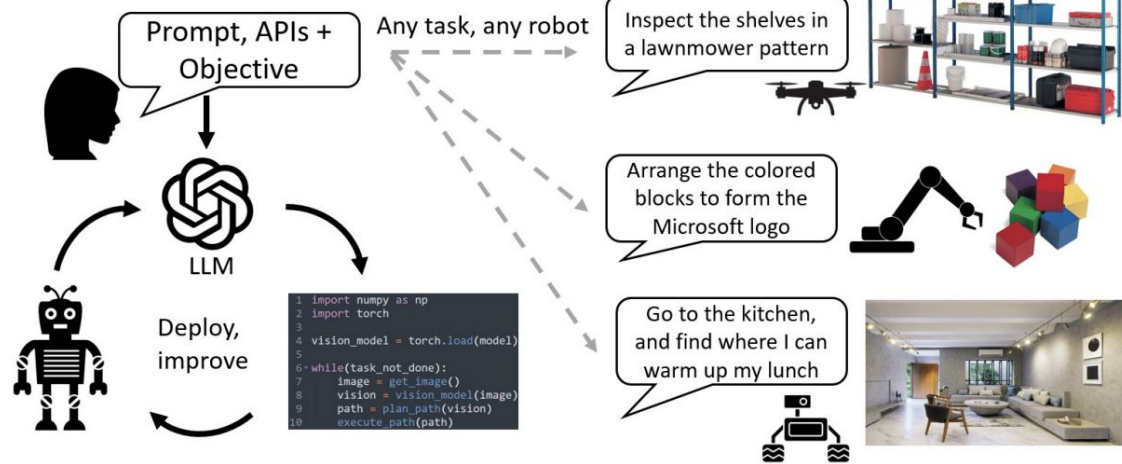
Run code.

Future of Robotics: LLM, VLM, Multimodal

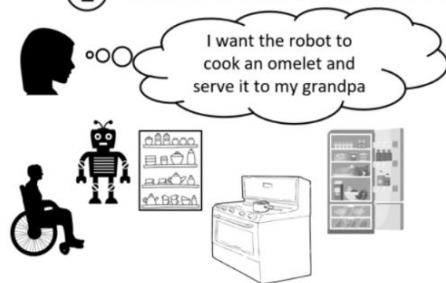
Robotics today: engineer *in the loop*



Goal with ChatGPT: user *on the loop*



① Define a task-relevant robot API library*



```
1 def locate_object(obj_name):
2     # do something
3     return
4
5 def move_to_location(X,Y,Z):
6     # do something
7     return
8
9 def cook_item(obj_name):
10    # do something
11    return
12
13 def grab_object(obj_name):
14    # do something
15    return
```

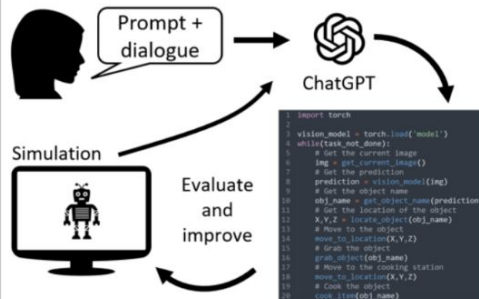
Consider you are a home assistant robot. Your goal is to prepare an omelette for an elderly person. You are equipped with functions:
`locate_object(obj_name)`: returns a X,Y,Z tuple representing the location of the desired object defined by string "obj_name";
`move_to_location(X,Y,Z)`: moves the robot's hands to a specific X,Y,Z location in space. Returns nothing;
`cook_item(obj_name)`: cooks a particular item defined by "obj_name". Returns nothing;
`grab_object(obj_name)`: picks a particular object defined by "obj_name". Returns nothing;
Output python code with the sequence of steps that achieves your objective.

*APIs should be easily implementable on the robot and have descriptive text names for the LLM. They can be chained together to form more complex functions.

② Build prompt following engineering principles

Consider you are a home assistant robot. Your goal is to prepare an omelette for an elderly person. You are equipped with functions:
`locate_object(obj_name)`: returns a X,Y,Z tuple representing the location of the desired object defined by string "obj_name";
`move_to_location(X,Y,Z)`: moves the robot's hands to a specific X,Y,Z location in space. Returns nothing;
`cook_item(obj_name)`: cooks a particular item defined by "obj_name". Returns nothing;
`grab_object(obj_name)`: picks a particular object defined by "obj_name". Returns nothing;
Output python code with the sequence of steps that achieves your objective.

③ User *on the loop*: iterate on solution quality and safety



④ Execute!



Imagine we are working with a household robot. The job of this robot is to make an omelette. The objects available around are:

fridge, bowl, pan, oil, stove

The main functions you can use are:

`locate_object(object_name)`: Returns the XYZ coordinates of an object of interest.

`go_to_location(object_name)`: Moves robot to a location specified by XYZ coordinates. Returns nothing.

`pick_up(object_name)`: Picks up the object of interest. Returns nothing.

`use_item(object_name)`: Takes the name of an object as input. Performs an appropriate action on the object at hand (pour oil, crack eggs). Returns nothing.

Can you make use of these to write code to go to the kitchen and make an omelette?

 Sure, here is an example Python code that utilizes the provided functions to prepare an omelette for an elderly person:

```
fridge_location = locate_object("fridge")
bowl_location = locate_object("bowl")
pan_location = locate_object("pan")
stove_location = locate_object("stove")
oil_location = locate_object("oil")

# Start the omelette-making process
go_to_location(fridge_location)
pick_up("eggs")
go_to_location(bowl_location)
use_item("eggs") # Crack eggs into the bowl
go_to_location(pan_location)
```

Run code.

Learn more at:

Overview: <https://www.youtube.com/watch?v=tgpAK3yCPbA>

Book: https://www.roboticsbook.org/S44_logistics_perception.html

Lectures: <http://ais.informatik.uni-freiburg.de/teaching/ss21/robotics/>

Questions?