Automation of Unmanned Aerial Vehicles Using Deep Learning

Application to Environmental Monitoring

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November 7, 2023

Plan

Plan

Summary Description

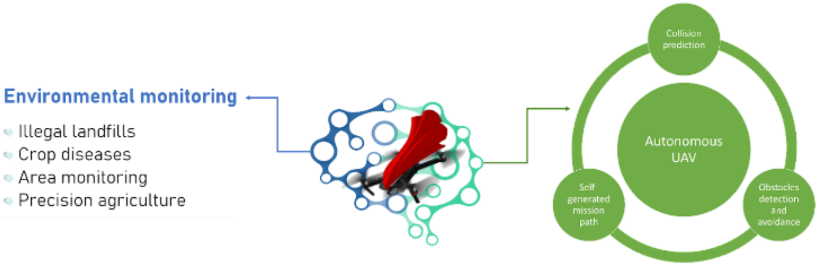

Figure: Summary Description

Existing Solutions and Works

- Smart vehicles (DJI, Uber, Tesla, Google, Amazon, etc...)
- Autopilot models (DroNet, TrailNet, etc...)
- Object detection models (ssd, mask rcnn, yolo, etc...)
- Reinforcement learning

Plan

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Description

- Binary classification model
- Objective: Predict based on an image whether a collision will occur or not
- Architecture: Neural network based on ResNet8
- Shortcomings: Data from the African context

Collision Probability Prediction

Data	
Training	29862
Testing	1576
Validation	534
Total	31972

Confusion Matrix	
tp	327(0.926)
fp	101(0.082)
tn	1122(0.918)
fn	26(0.0736)

Plan

Description

Objective: Detect any object in the drone's field of vision that could prevent the drone from moving forward

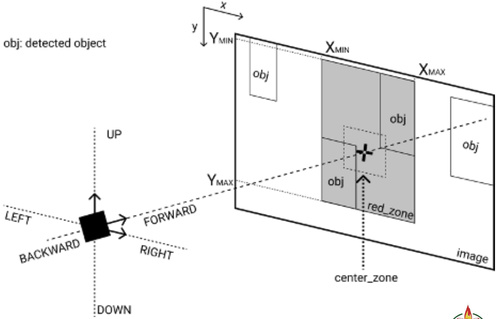


Figure: Approach

Obstacle Detection based on CenterNet and MobilenetV2

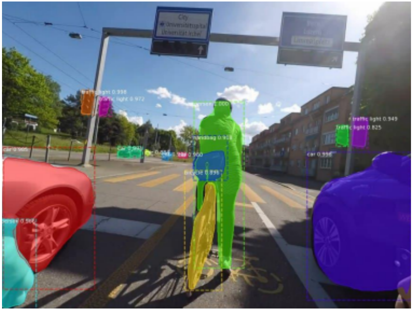


Figure: Mask rcnn

Figure: Detected obstacle

Plan

Flight Plan

Before a mission

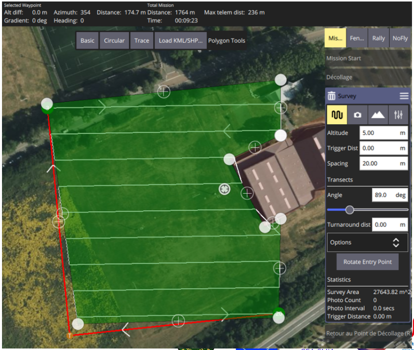
A flight plan is the planned route by the controller at the beginning of the mission. It is a series of coordinates (waypoints) that the drone must follow.

To achieve this, we proposed a modified version of QGroundControl that allows to:

- define no-fly zones on a map
- automatically generate a flight plan from point A to point B while avoiding no-fly zones. The path generation algorithm is based on RRT* (optimized rapidly exploring random trees)

Results


T 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46


Selected Waypoint
Alt diff: 0.0 m Azimuth: 354 Distance: 174.7 m
Gradient: 0 deg Heading: 0
Total Mission
Distance: 1764 m Max telem dist: 236 m
Time: 00:09:23
Basic
Circular
Trace
Load KML/SHP...
Polygon Tools
Mis...
Fen...
Rally
NoFly
Mission Start
Décollage
Survey
Altitude 5.00 m
Trigger Dist 0.00 m
Spacing 20.00 m
Transects
Angle 89.0 deg
Turnaround dist 0.00 m
Options
Rotate Entry Point
Statistics
Survey Area 27643.82 m^2
Photo Count 0
Photo Interval 0.0 secs
Trigger Distance 0.00 m
Retour au Point de Décollage

Trajectory Planning

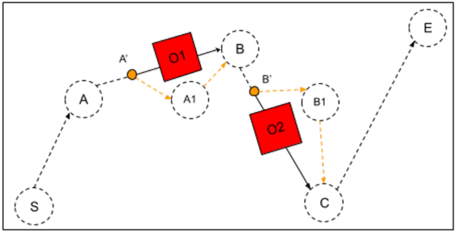
During a mission

The flight plan is often modified during a mission for various reasons (obstacles, weather, battery, etc.). It is important to implement a strategy for modifying and adapting the flight plan. We worked on the case of obstacles.

During flight, it is therefore necessary to:

- Detect obstacles
- Propose a new direction
- Generate new waypoints

Results



Path: (S->A); (A->A'); (A'->A1); (A1->B); (B->B'); (B'->B1); (B1->C); (C->E);

$$lon = cur\_lon + \frac{180}{\pi} \times \left(\frac{d \times \sin\alpha}{earth\_radius \times \cos\beta} \right) \quad (1)$$

$$lat = cur\_lat + \frac{180}{\pi} \times \left(\frac{d \times \cos\alpha}{earth\_radius} \right) \quad (2)$$

Description of variables

- cur_lon is the current longitude of the UAV;
- cur_vel is the current velocity of the UAV;
- cur_lat is the current latitude of the UAV;
- $earth\_radius = 6378137.0$ meters;
- d is the new waypoint distance to the current position to avoid the obstacle;

$$d = cur\_vel \times (1 - direction\_safety) \text{ meters}$$

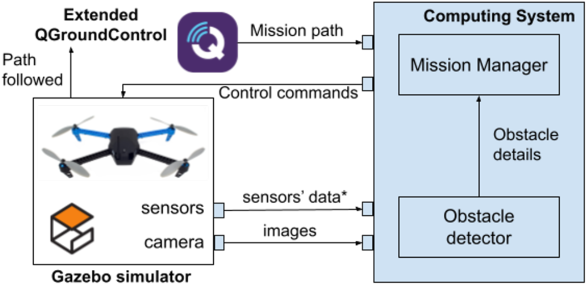
- θ is the current heading of the UAV in degree;
- β is the current latitude in radian;
- α is the rotation angle in radian.

$$\alpha = \begin{cases} \frac{\pi}{180} \times ((\theta - 90) \mod 360) & \text{if } direction = \text{"left"} \\ \frac{\pi}{180} \times ((\theta + 90) \mod 360) & \text{if } direction = \text{"right"} \\ \frac{\pi}{180} \times \theta & \text{Otherwise} \end{cases}$$

Plan

Setting up a Simulation Environment

- ROS
- Gazebo
- PX4
- QGroundControl



Extending FCPNet

- Collection of new collision data in the simulator
- Training our models with both real data and data from the simulator (1419 new data including 1152 with obstacles)

Assembling a Drone

- Raspberry Pi 4
- Flight controller Mamba Mk2
- Single lens camera

Plan

Ongoing Work

- Experimentation and improvement of our algorithms in a simulator
- Setting up a model for the detection of buildings and no-fly zones on a map
  - Collection of satellite images
  - Review of existing works
  - Identification of building detection models
- Detection and neutralization of a drone in a no-fly zone

Upcoming

- Implementation of anomaly detection models in a given environment
- Comparative study between the performances of models in virtual and in a real environment
- Testing the vulnerability of our system to strengthen security

THANKS!

Questions? Comments?

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