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Drone Detection System using YOLOv8 and Deep Learning

Introduction

Context
Drones are increasingly present in civil, industrial and entertainment activities. However, cases of unauthorized use, flights over private property, restricted areas or sensitive targets are increasingly common.

Objective
The project aims to develop an automatic drone detection system, based on training a YOLOv8 model using a specific dataset, capable of identifying drones in video sequences.

Materials and Methods

Materials:

- Dataset: - *5000+* images distributed by class as such:
  - Drone: *1727* images
  - Airplane: *1680* images
  - Kite: *1050* images
  - Bird: *588* images
  - Redimensioned images -> *640x640* px
- Python script for testing the model

Methods:

- Image distribution: *70%* train, *20%* val, *10%* test
- Model training on custom dataset
- Applying sharpness filter to emphasize edges in Python script
- Testing the model with 4 videos showing various weather conditions and drones at different distances.

Drone

Kite

Airplane

Birds

Results

The YOLOv8 model detects objects with an average accuracy (mAP@0.5) of 72.3%, and drones with an average accuracy of 98.6%. (Fig 1.)

According to the generated confusion matrix (Fig 2.), the model can detect Drone and Airplane with an omission rate of 3% and 1%, respectively.

The Python script contains a section that determines, for each video, the Mean Confidence, Maximum Confidence statistics, i.e. how confident the model is, on average, that it has found drones, as well as the maximum confidence of detecting a drone in the respective video. (Fig 3.)

The model stabilizes around epoch no. 60.

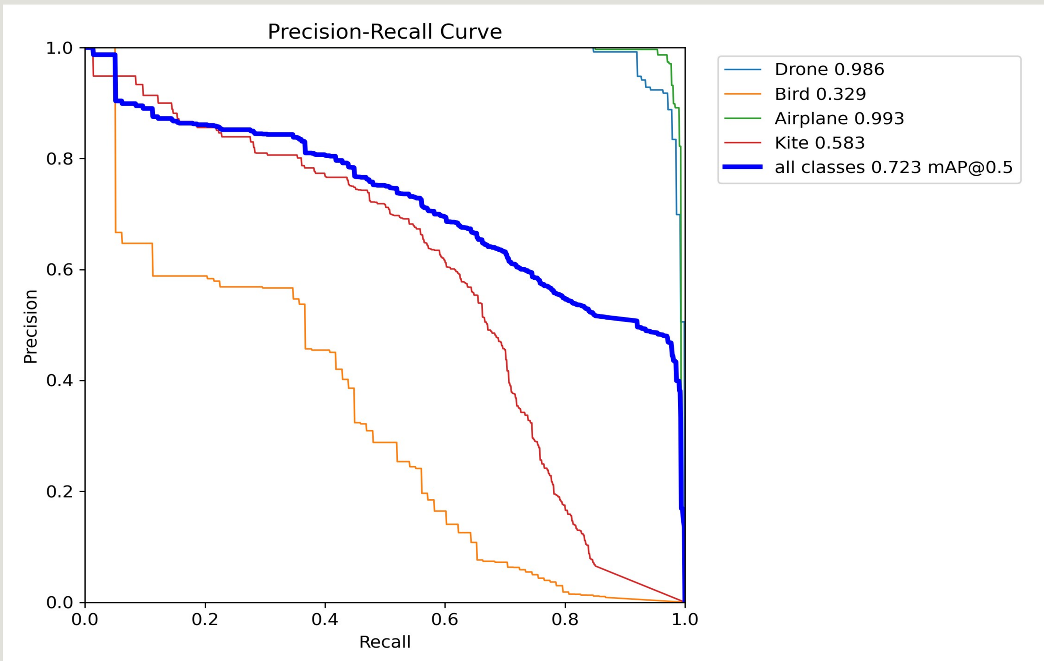

Fig 1. Precision-Recall Curve

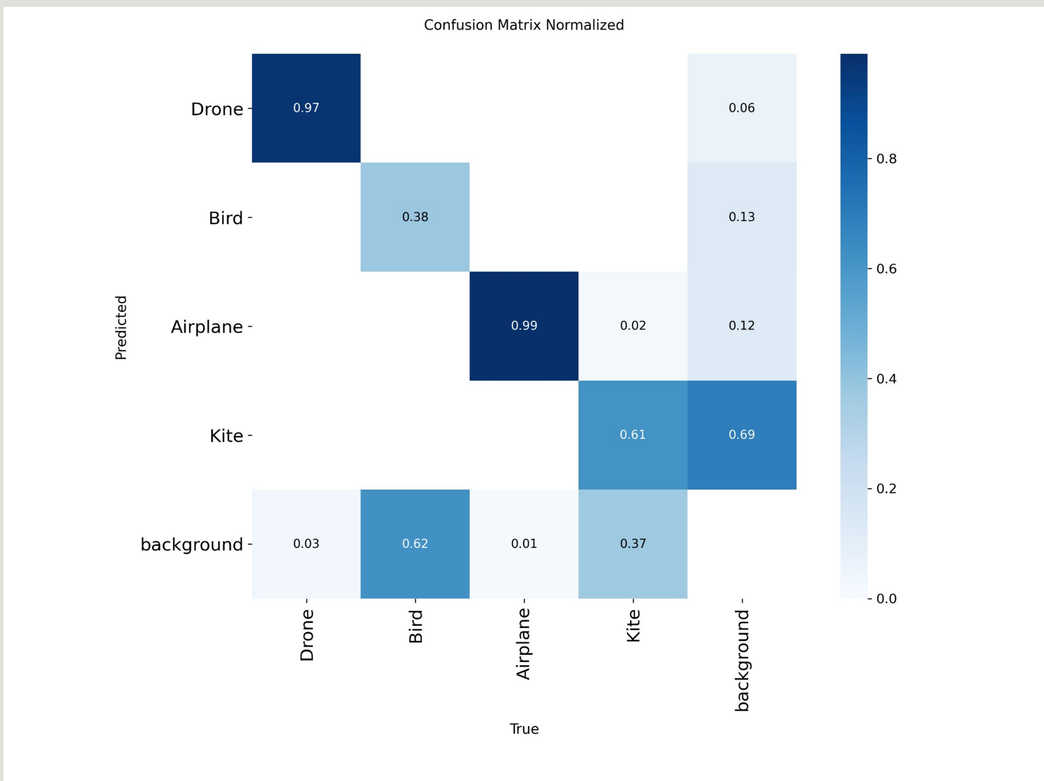

Fig 2. Confusion Matrix

Input	Mean Confidence	Max Confidence
Video 1	88.3%	96.9%
Video 2	77%	91.5%
Video 3	64.5%	93.7%
Video 4	49.4%	88.6%

Fig 3. Practical statistics for drone detection on each video

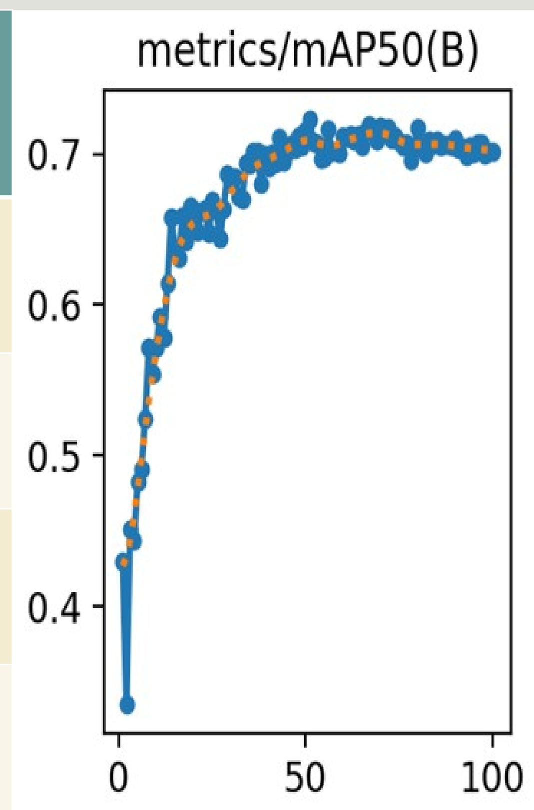

Fig 4. Metrics related to the number of epochs

Discussion

Advantages

- The 98.6% accuracy shows that the model correctly identifies the drone in almost all scenarios.
- The 0% error rate between drones and airplanes shows the model's success in distinguishing the two elements, under all circumstances. It can be seen as a perfect result.
- A very high average accuracy detected also at a practical level, not only at a theoretical level. (88.3%)

Limitations

- Challenges in distinguishing drones from kites
- Performance drops when objects occupy very few pixels in the image (are far away)
- The small number of images with which the model for the Bird class was trained (588 images) limits the model's ability to detect birds (mAP@0.5 -> *32.9%)*

Observations:

- Even though the images were resized to 640x640, the statistics are better at an imgsz=960

Fig 5. Drone detected at close range (Video 1)

Fig 6. Drone detected at greater distance. (Video 2)

Fig 7. Drone mistaken for kite (Video 3)

Conculsions

The YOLOv8 model can be used for drone detection, achieving high performance on the dataset used.

However, practical tests have shown differences between theoretical and practical results. Factors such as filming from a long distance and the variability of the angles from which the filming is done can cause confusion for the model.

The system is an experimental prototype. For improvements, it is necessary to expand the dataset and revise the preprocessing algorithms used.

Contact

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References

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