

# Project Summary: Fine-Tuning YOLOv8 for Military Aircraft Detection

## Introduction

This project fine-tunes the YOLOv8 model to detect military aircraft, specifically targeting F15, F16, and F18 variants. Using a dataset of cropped aircraft images, the goal is to achieve accurate detection by optimizing the model's learning rate and evaluating its performance on a validation set.

## Dataset and Preprocessing

- **Source:** The dataset was downloaded from Kaggle ("Military Aircraft Detection Dataset" by a2015003713).
- **Selection:** Only the F15, F16, and F18 subfolders from the "crop" directory were used.
- **Labeling:** Images were automatically labeled with a script, assuming a single centered aircraft per image (YOLO format: class ID, center coordinates 0.5 0.5, width/height 1.0 1.0).
- **Split:** The dataset was divided into 80% training (3,989 images) and 20% validation (996 images) using `splitfolders` with a fixed seed (42).
- **Cleanup:** Corrupt images (e.g., dimensions <10 pixels) were excluded during training.

## Model and Training

- **Model:** YOLOv8 (`yolo11n.pt`), a lightweight variant, was fine-tuned on a CPU.
- **Parameters:**
  - Epochs: 4
  - Image Size: 640x640
  - Batch Size: 16
- **Learning Rates:** Three rates were tested—0.001, 0.01, and 0.1—to determine the optimal setting.
- **Optimizer:** AdamW (auto-selected by YOLOv8 with  $lr=0.001429$ ,  $momentum=0.9$ ).

## Results

The model's performance was evaluated using  $mAP@0.5$ ,  $mAP@0.5:0.95$ , precision, and recall. Key findings:

Learning Rate	mAP@0.5	mAP@0.5:0.95	Precision	Recall
0.001	0.843	0.817	0.738	0.782
0.01	0.742	0.735	0.586	0.781
0.1	0.843	0.828	0.707	0.778

- **Best Performance:** A learning rate of 0.1 yielded the highest mAP@0.5:0.95 (0.828), with an mAP@0.5 of 0.843, indicating robust detection across IoU thresholds.
- **Class-Specific Metrics (lr=0.1):**
  - F15: mAP@0.5: 0.794, Precision: 0.579, Recall: 0.839
  - F16: mAP@0.5: 0.879, Precision: 0.721, Recall: 0.852
  - F18: mAP@0.5: 0.855, Precision: 0.823, Recall: 0.638

## Conclusion

The project successfully fine-tuned YOLOv8 to detect F15, F16, and F18 aircraft, achieving an mAP@0.5 of 84.3% with a learning rate of 0.1. This rate provided the best balance of precision and recall, with F16 showing the highest mAP@0.5 (0.879). Future enhancements could involve increasing epochs, applying data augmentation, or testing additional hyperparameters to further boost performance.