A Feasibility Study of Real-Time Image Processing Techniques for Small Flying Object Detection in Drones

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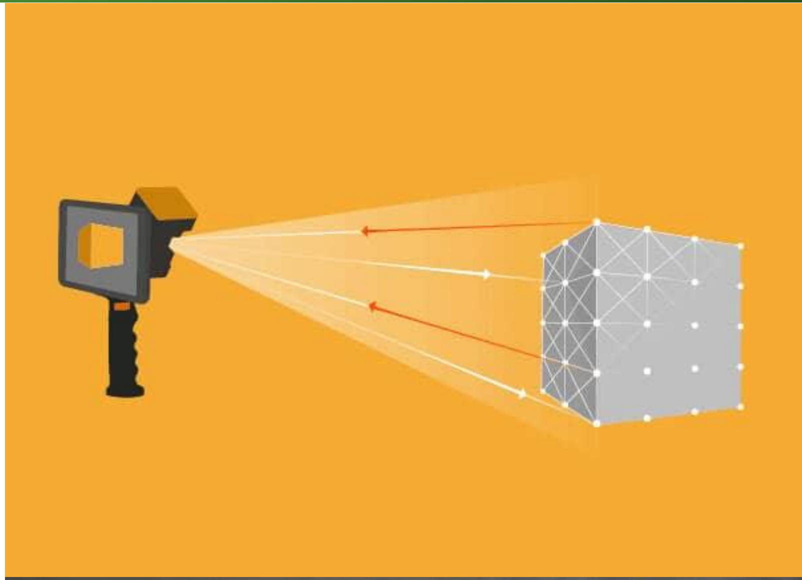
Background

Higher drone use in recent years has led to an increased chance of collisions with aerial wildlife.

Most methods of hazard detection require special equipment.

By utilizing image processing, drones can detect hazards using only their video cameras.



Objective

- Benchmark Machine Learning model for real time detection.
  - Test on multiple levels of hardware.
  - Test on livestream.

Model Architecture: YOLO

The selected model ML was YOLOv7

Three custom models trained on bird images.

Benchmarked for speed and accuracy.

Custom Training Process

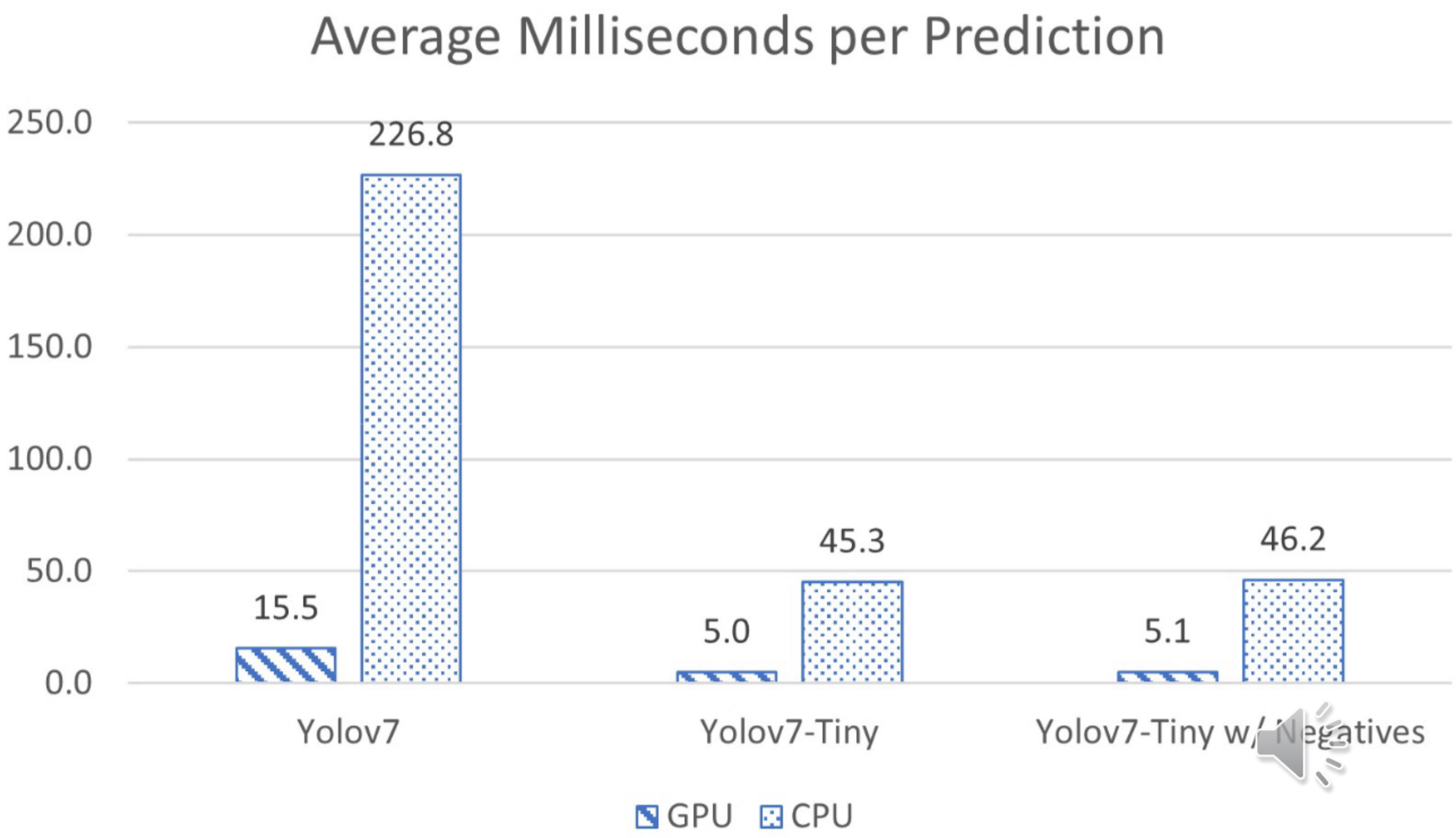
- YOLOv-7 retrained on close to 400 images.
  - Majority contain birds, main target of detection.
  - About 50 are empty sky (negative images).
- Retrained model focused solely on bird detection.

On-Board vs Remote Detection

- Two approaches:
  - On-board detection device.
  - Detection on a remote computer.
- For this study, we focused on the second approach.

Average Detection Time Per Model

- GPU time (in ms): with GTX 1060
- CPU time: time without GPU.
- GPU represents ideal case.
- 45 ms is approximately 22 FPS.



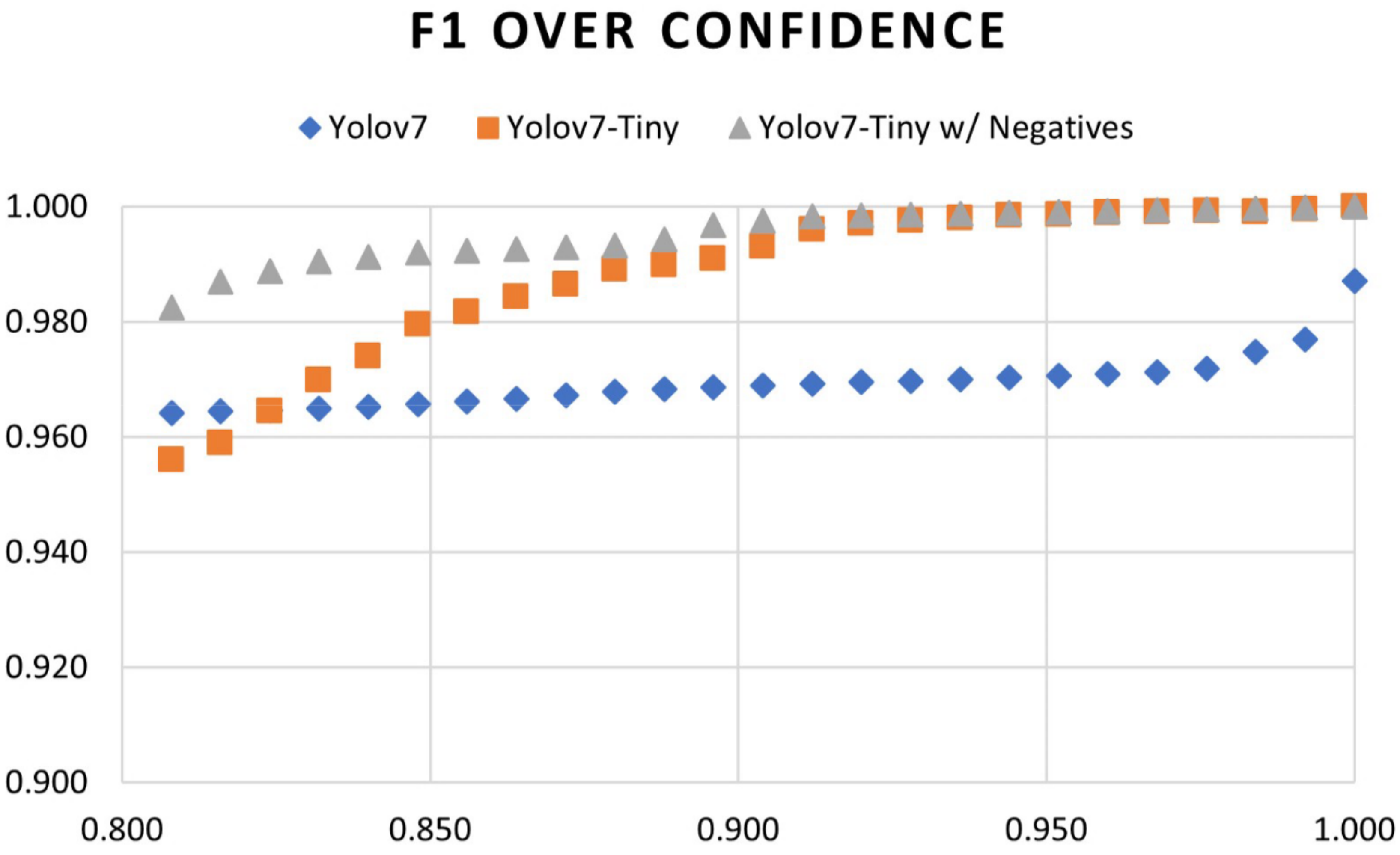
Detection Metrics

Precision: $P = \frac{TP}{FP+TP}$ Recall: $R = \frac{TP}{TP+FN}$ F1: $F = 2\frac{P*R}{P+R}$

Precision: Percent of detections which are correct.

Recall: Percent of true objects detected.

Model F1 Over Confidence



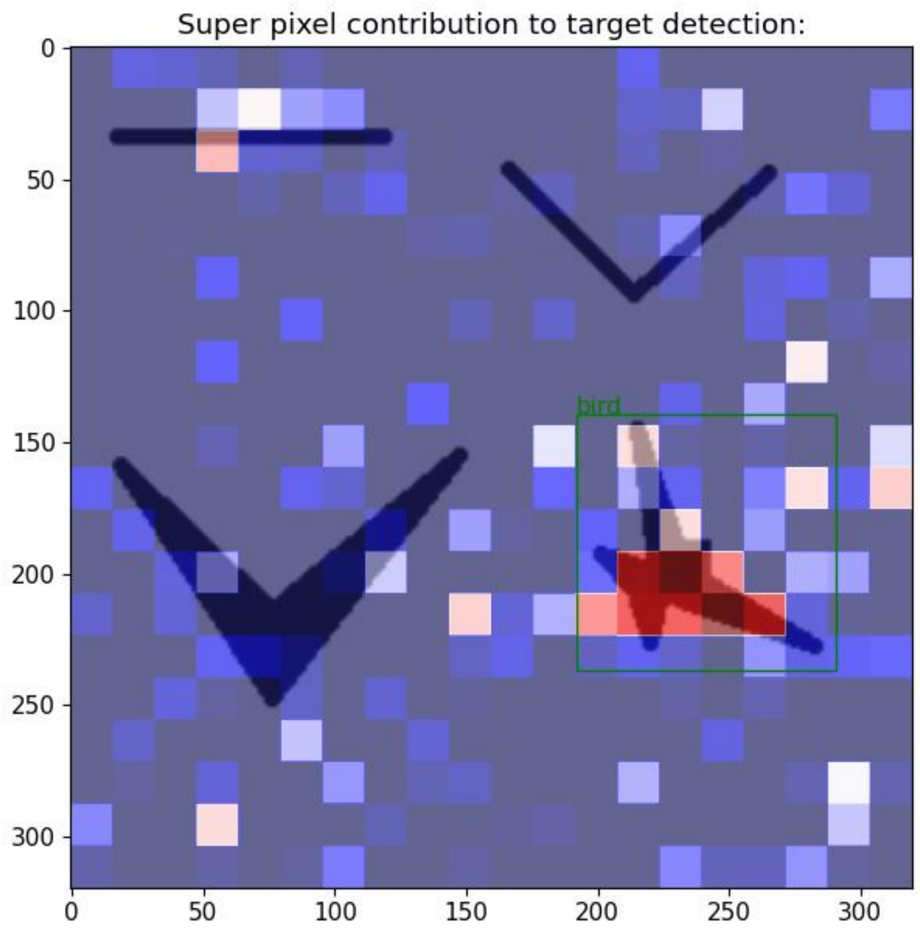
Detection Demonstration

- Receives video stream from drone or http.

- Runs ML model and displays results to the user.

External Detection Explanation

- Shapley Additive Explanations.
- Super pixel graph displays which areas had the most influence.
- Results seem to emphasize bend between wing and tail



Limitations

- Object distances are not calculated, and threat cannot be determined
- Image processing must happen remotely, causing small delays.
- Drone communications are very basic, only working at close ranges and in one direction

Future Work

- The program must determine the threat of each detected object
  - Done through distance or other means
- Detection can be done on-board with an additional microcomputer
  - Would eliminate delays and allow for easy two-way communication
- The drone must take evasive action when a threat is detected

Conclusion

- Yolov7 performs at speeds which are viable for video livestreams, including from drone cameras.
- Yolov7 can perform accurately on single object detection tasks.
- Yolov7 is feasible for drone objection detection.