Real-Time Drone Detection and Tracking With Visible, Thermal and Acoustic Sensors

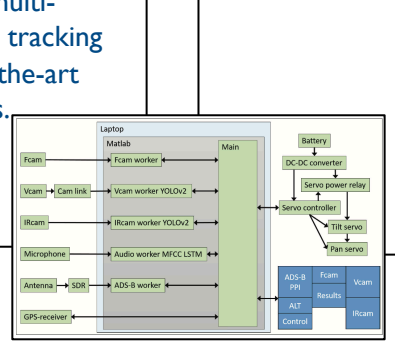
Problem formulation and Aim

- Both private and commercial usage of drones is increasing.
- Monitoring crop, forest, powerlines, fences, photography, surveillance and delivery etc.
- How can we make sure drones are not misused, intentionally or unintentionally?
- This paper explores the possibilities and limitations of designing and constructing an automatic multi-sensor drone detection and tracking system building on state-of-the-art machine learning techniques.

Solution

Five workers – functions

- Fcam
  - ELP 8 megapixel 180° fish-eye lens 1024×768
  - Gaussian mixture model (foreground/background)
  - Multi-object Kalman filter tracker
- Vcam
  - CNN (YOLO v2)
  - Sony HDR- CX405 video camera
    - Elgato Cam Link 4K frame grabber 1280×720
- IRcam
  - CNN (YOLO v2)
  - FLIR Breach PTQ-136 using the Boson 320×256 pixels detector
- Audio
  - MFCC Features feed into LSTM
- ADS-B
  - Antenna and a NooElec Nano 2+ Software Defined Radio receiver



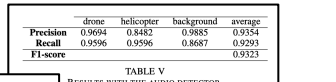
Results

Evaluation individual sensors

precision,
recall and
F1-score

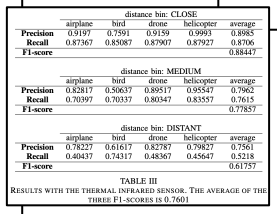
2 x ((precision x recall) / (precision+recall))

CLOSE: 0 m – 15 px in IRcam
MEDIUM: 15 px-5 px in IRcam
DISTANT: 5 px- 1 px in Ircam



	drone	helicopter	background	average
Precision	0.9694	0.8482	0.9885	0.9354
Recall	0.9596	0.9596	0.8687	0.9293
F1-score				0.9323

TABLE V
RESULTS WITH THE AUDIO DETECTOR.



distance bin: CLOSE

	airplane	bird	drone	helicopter	average
Precision	0.9197	0.7591	0.9159	0.9993	0.8985
Recall	0.87367	0.85087	0.87907	0.87927	0.8706
F1-score					0.88447

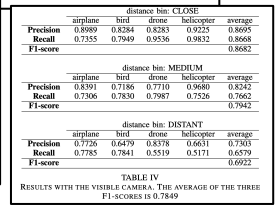
distance bin: MEDIUM

	airplane	bird	drone	helicopter	average
Precision	0.82817	0.50637	0.89517	0.95547	0.7962
Recall	0.70397	0.70337	0.80347	0.83557	0.7615
F1-score					0.77857

distance bin: DISTANT

	airplane	bird	drone	helicopter	average
Precision	0.78227	0.61617	0.82787	0.79827	0.7561
Recall	0.40437	0.74317	0.48367	0.45647	0.5218
F1-score					0.61757

TABLE III
RESULTS WITH THE THERMAL INFRARED SENSOR. THE AVERAGE OF THE THREE F1-SCORES IS 0.7601



distance bin: CLOSE

	airplane	bird	drone	helicopter	average
Precision	0.8989	0.8284	0.8283	0.9225	0.8695
Recall	0.7355	0.7949	0.9536	0.9832	0.8668
F1-score					0.8682

distance bin: MEDIUM

	airplane	bird	drone	helicopter	average
Precision	0.8391	0.7186	0.7710	0.9680	0.8242
Recall	0.7306	0.7830	0.7987	0.7526	0.7662
F1-score					0.7942

distance bin: DISTANT

	airplane	bird	drone	helicopter	average
Precision	0.7726	0.6479	0.8378	0.6631	0.7303
Recall	0.7785	0.7841	0.5519	0.5171	0.6579
F1-score					0.6922

TABLE IV
RESULTS WITH THE VISIBLE CAMERA. THE AVERAGE OF THE THREE F1-SCORES IS 0.7849

Conclusion

- We explored the possibility to design and build a **multi-sensor drone detection system** utilizing state-of-the-art machine learning techniques and sensor fusion,
- The system incorporates common **video** and **audio** sensors, and a thermal **infrared** camera,
- A **fish-eye** lens camera with a wider field-of-view is used to steer the sensors in any direction,
- An **ADS-B** receiver allows to keep track of cooperative aircrafts in the surrounding airspace,
- Results confirm that machine learning techniques can be applied to input data from infrared sensors, making them well suited for the drone detection task,
- The **infrared detector achieves a F1-score of 0.76**, showing similar performance as the **visible video detector with a F1- score of 0.78,**
- The **audio classifier achieves a F1-score of 0.93,**
- A multiclass dataset is published for other researchers to use and compare results with.

https://github.com/DroneDetectionThesis/Drone-detection-dataset

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