GFZ

Helmholtz-Zentrum
POTSDAM

LSS-Algorithm

for detection of aircraft from optical and IR cameras, current state and results

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DiGOS

Agenda

1. Background
2. Algorithm architecture and principle
3. Critical zone definition
4. Data Collection
5. Detection Examples
6. Data analysis
7. Result
8. Redundancy
9. Conclusion and Future Steps

Background

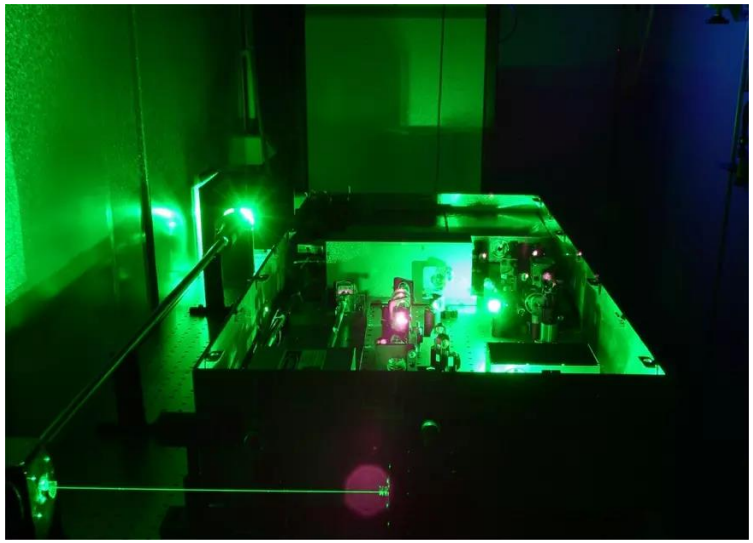
1. Class 4 laser:

   Example: power [0.8 - 1.4 W]

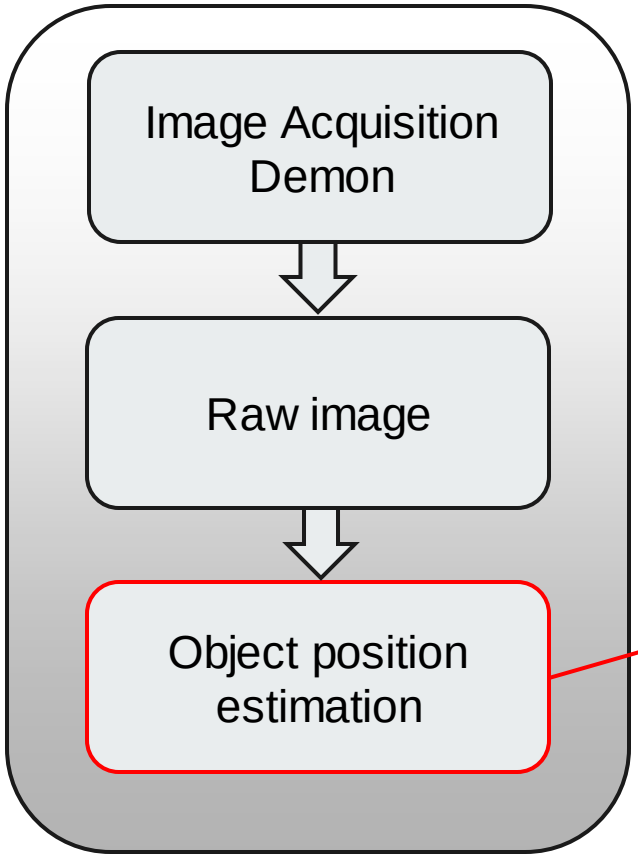
   KHz

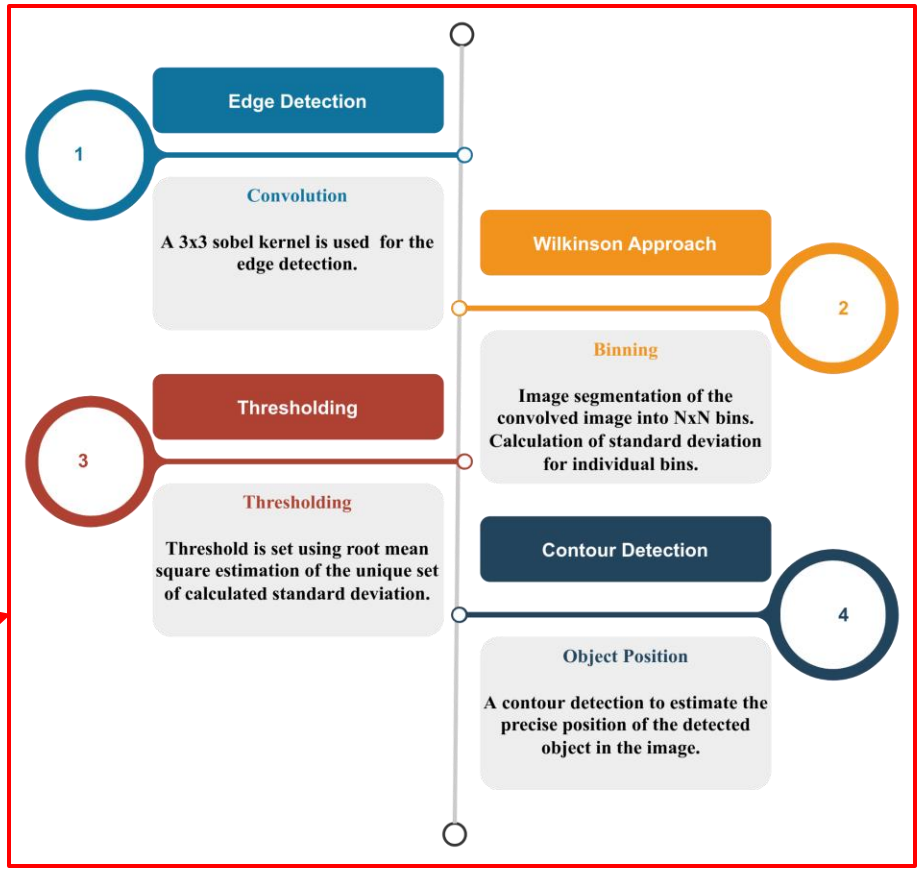
   repetition rate

1. For debris tracking power will be higher.
2. Risk of exposure has to be minimised.



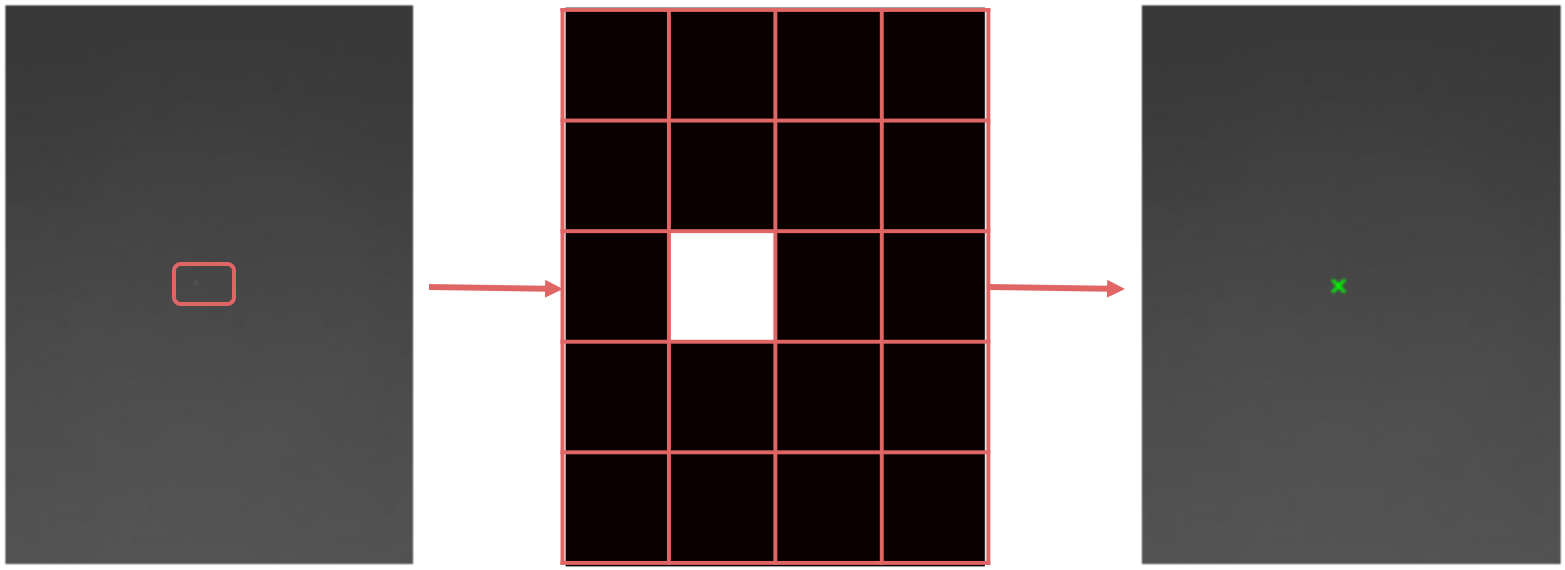
Algorithm architecture and principle





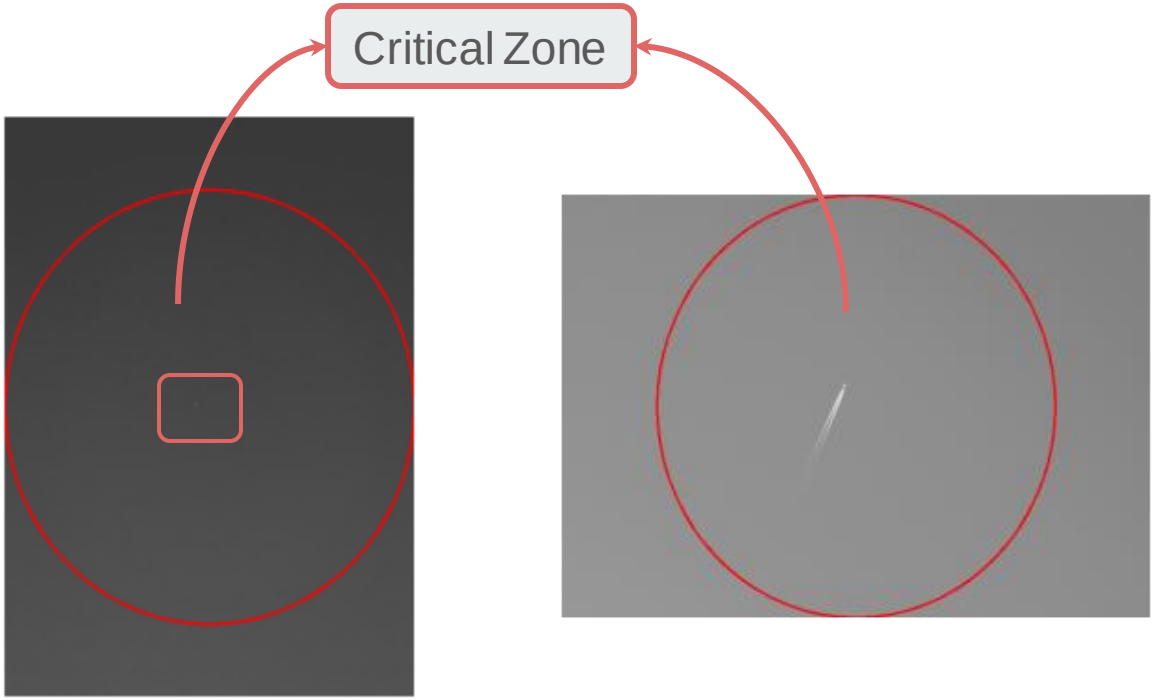
Algorithm architecture and principle

Flow of information for object position estimation



Critical zone definition

1. Any object inside the critical zone will trigger the alarm for the switch off.
2. The radius of critical circle depends entirely on the camera FOV and detection time.



[left] TIR image with aircraft inside the red box, [right] Image from visible wavelength camera.

Data Collection

Data Sources:

1. Thermal infrared (VarioCAM HD head 600):
   Images: 20,835
   FOV: 6^0x11^0

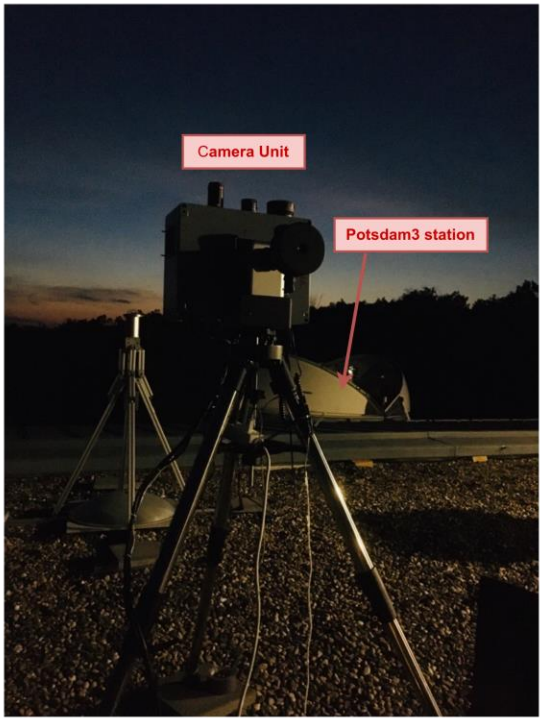
1. Visible wavelength (ASI 178MM) :
   Images: 20,620
   FOV: 9^0x5^0

1. Corresponding ADS-B receiver

Duration: Day and night

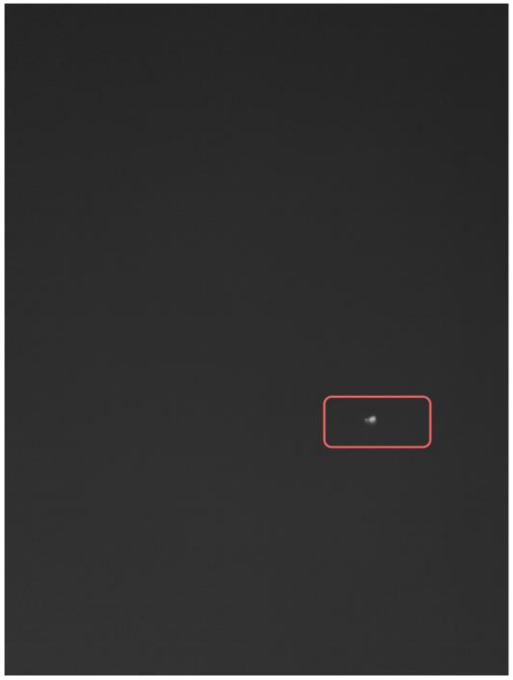
Weather: clear condition

Additional data was recorded under cloudy conditions [Total images: 78000]

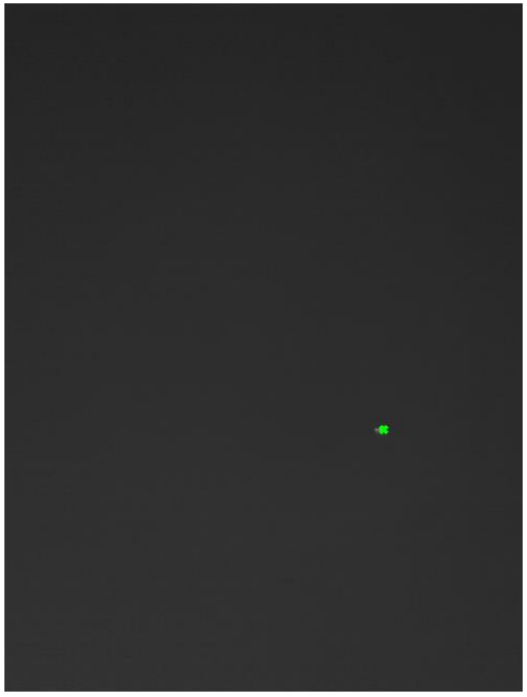


Detection examples (TIR)

Object with no call sign in ADS-B receiver



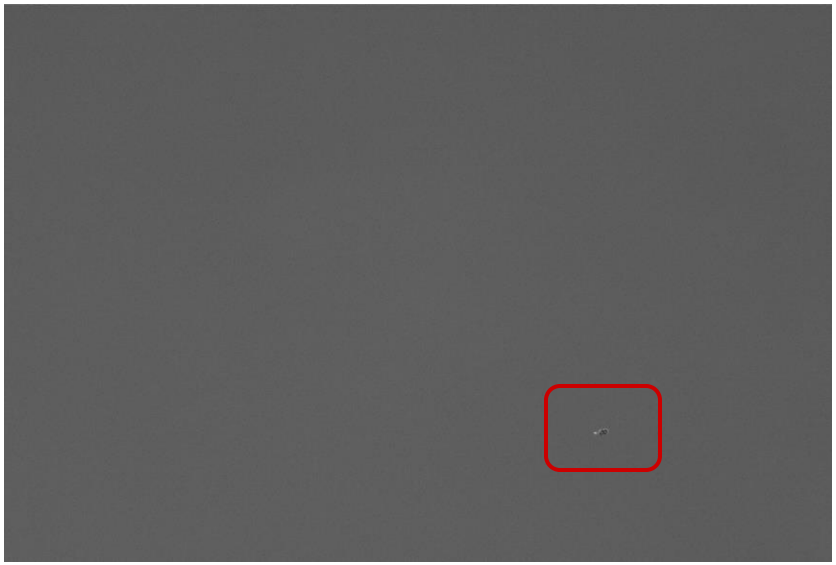
Raw thermal infrared image (Infratec)



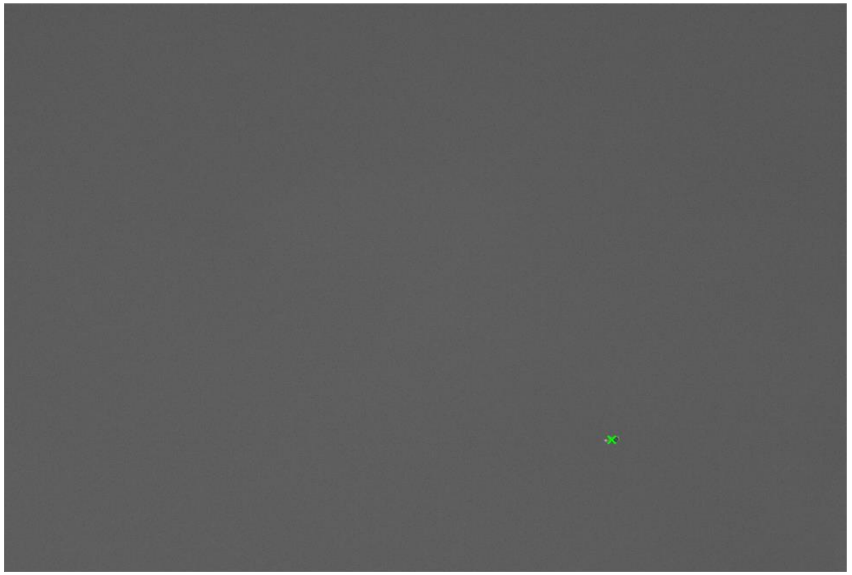
Processed thermal infrared image (Infratec)

Detection examples(Visible)

Object with no call sign in ADS-B receiver

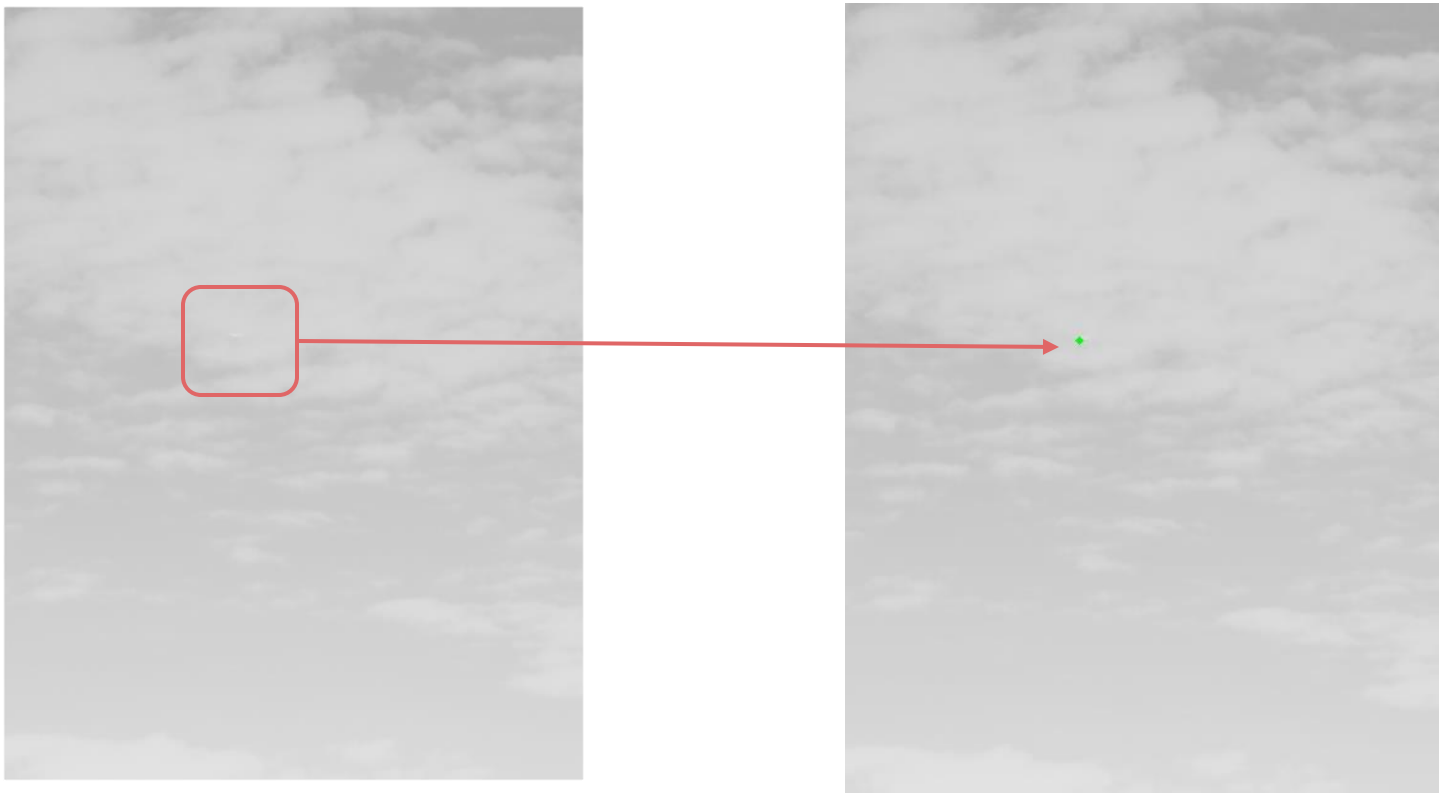


Raw image from visible wavelength camera (ASI178mm)



Processed image

Detection examples (TIR)

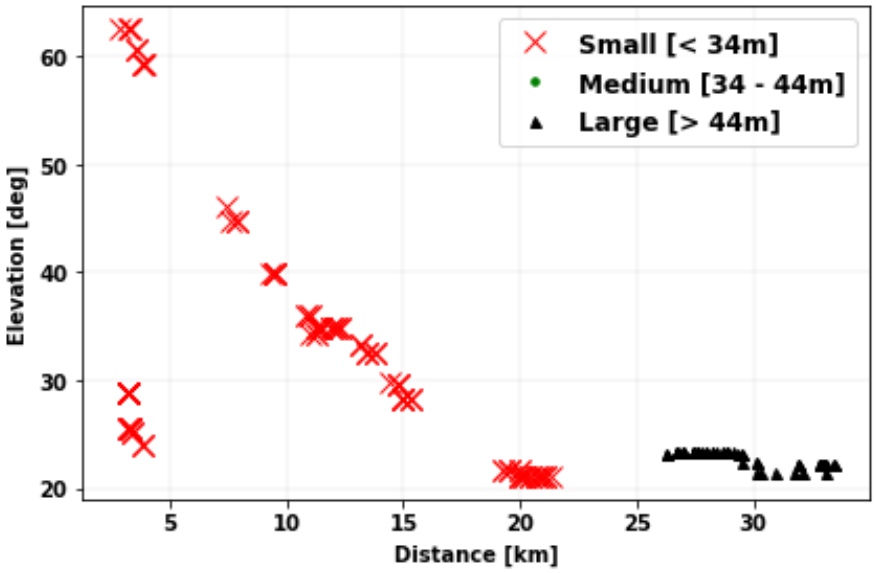


[left] Raw TIR image , [right] Processed image [position highlighted with green marker]

Data analysis (Daytime)

Potential aircraft based on ADS-B data = 14

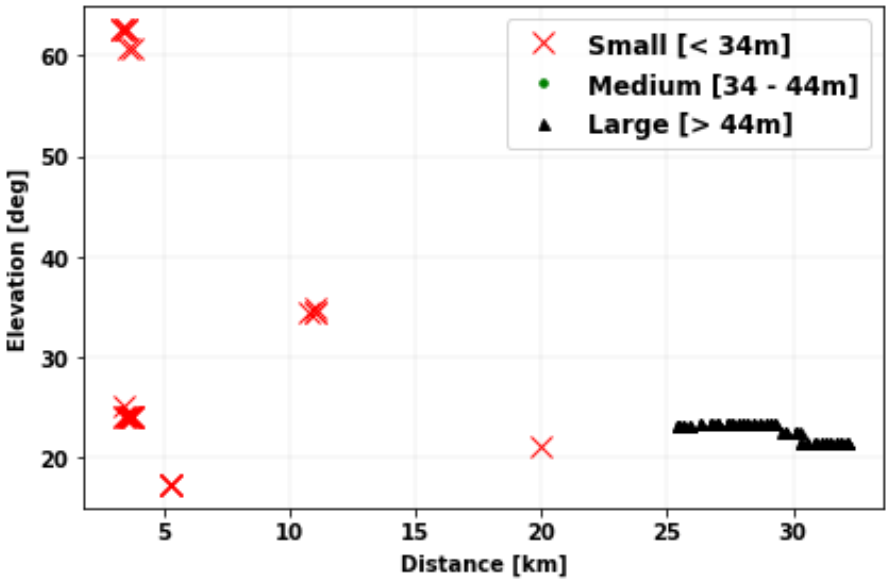
Number of detected aircraft = 14



Distribution based on TIR image data

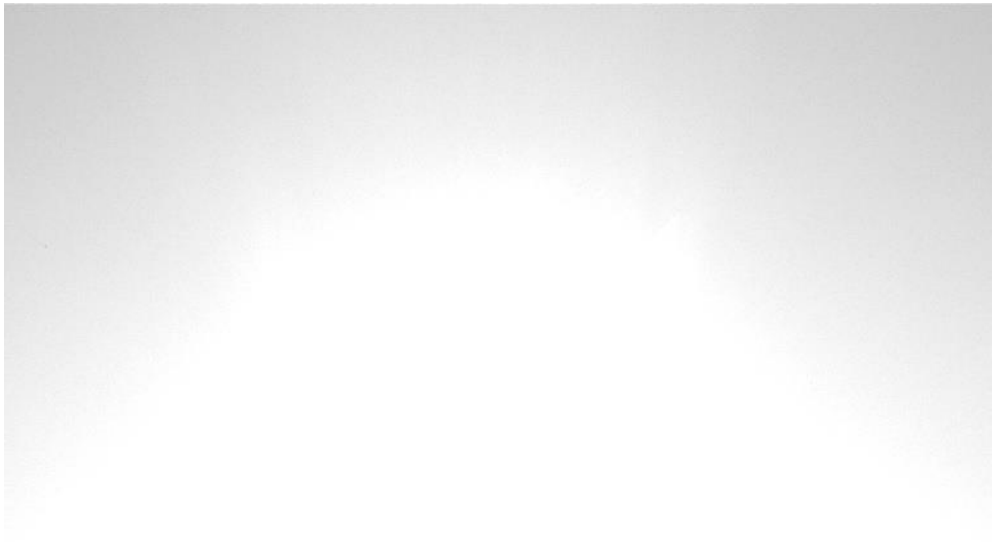
Potential aircraft based on ADS-B data = 10

Number of detected aircraft = 9



Distribution based on visible camera image data

Missed Opportunity



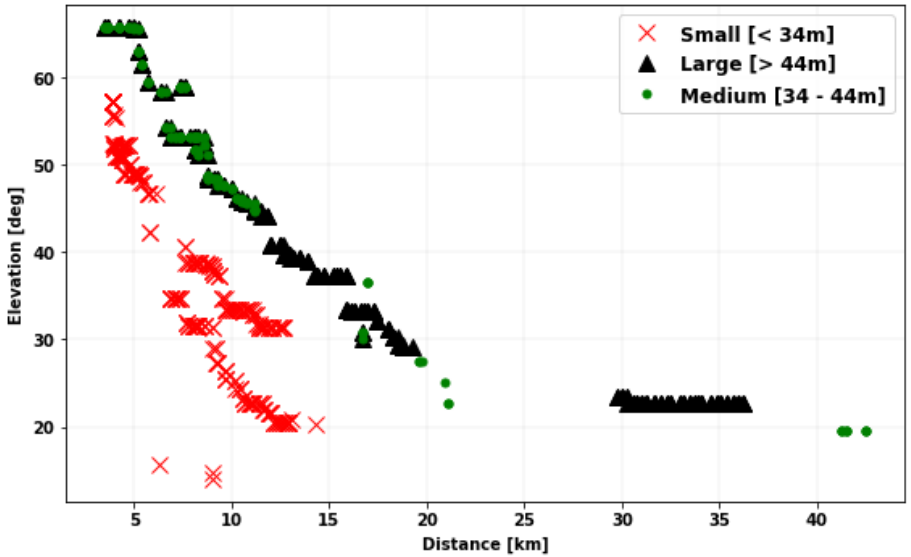
Data analysis (Nighttime)

Potential aircraft based on ADS-B data = 21

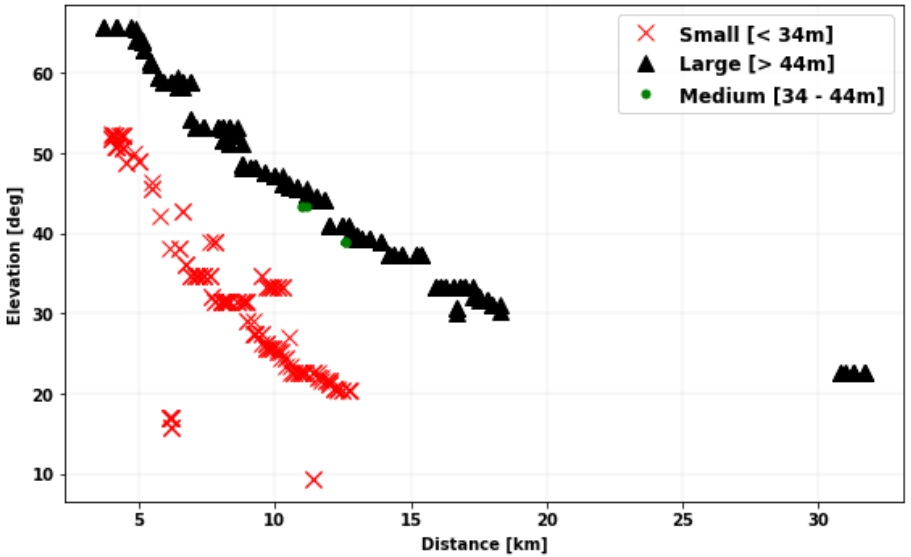
Number of detected aircraft = 19

Potential aircraft based on ADS-B data = 24

Number of detected aircraft = 19



Distribution based on TIR image data

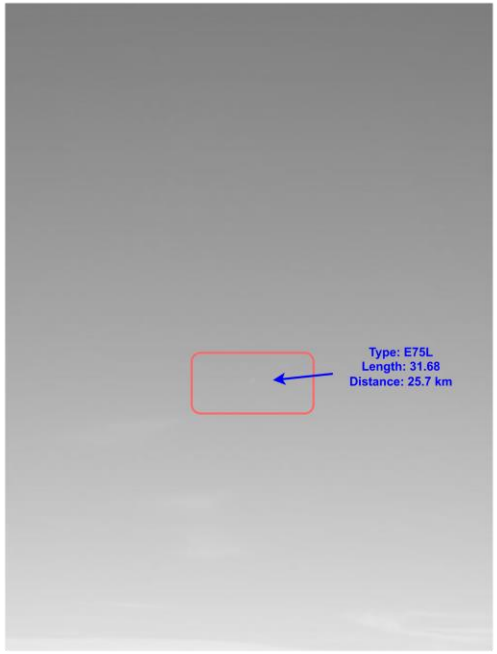


Distribution based on visible camera image data

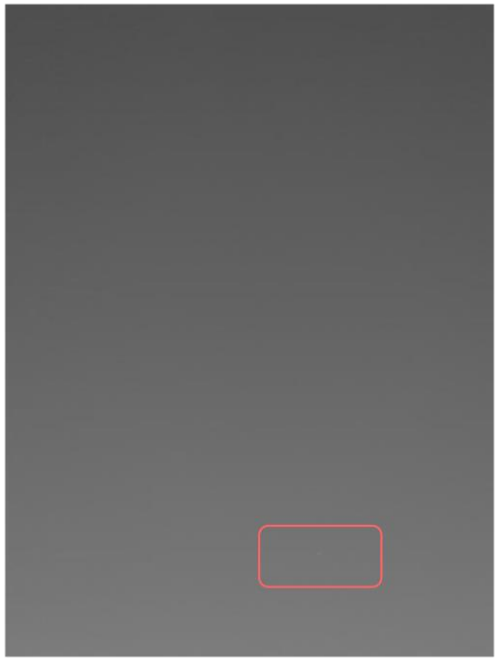
Data analysis (Nighttime)

Missed Opportunity (TIR)

Type	Length [m]	Elevation [deg]	Distance [km]
Unknown	Unknown	16.8	32.1
E75L	31.68	6.52	25.7



TIR image highlighting aircraft type: E75L



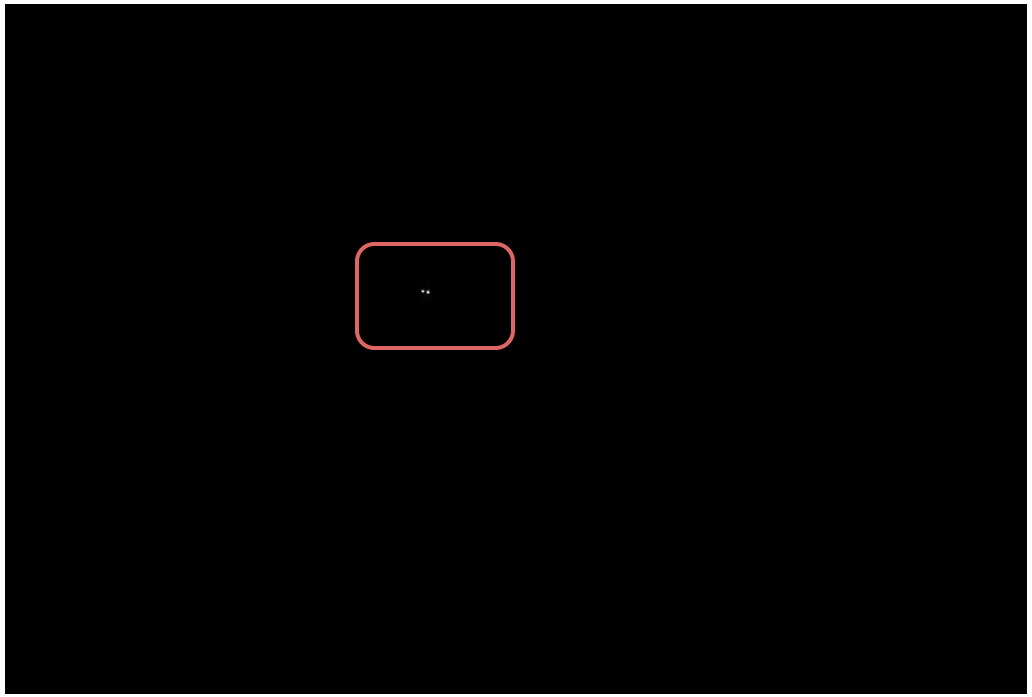
TIR image highlighting aircraft with type: Unknown

Data analysis (Nighttime)

Missed Opportunity (Visible camera)

Type	Length [m]	Elevation [deg]	Distance [km]
B350	14.2	11.6	39.6
B738	36.2	16.9	36.0
Unknown	Unknown	18.5	32.1
A320	37.5	12.8	22.5
A319	A319	21.4	13.6

Nighttime image from visible camera (ASI)



The blinking lights of an aircraft captured by ASI 178MM camera.

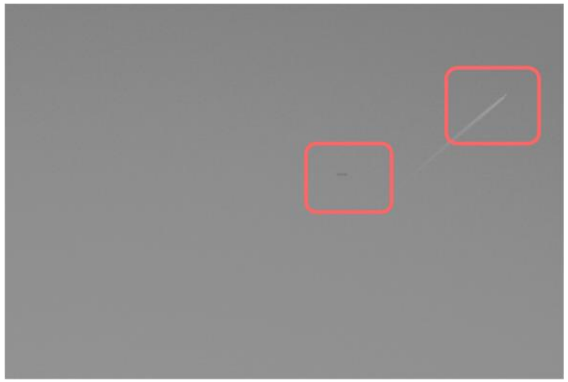
Results

Percentage of successful detection from both TIR (Infratec) and Visible wavelength (ASI 178MM) camera

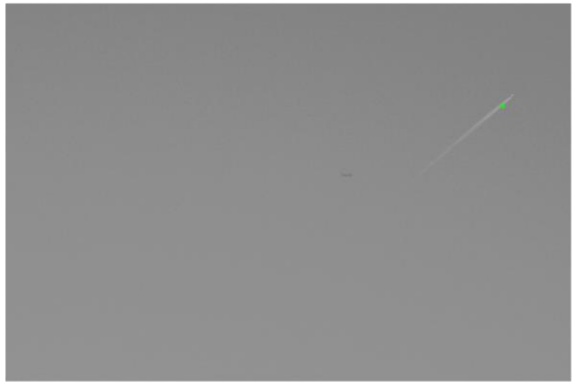
Infratec		**Overall percentage**	94.2 %
		Above 20 deg elevation	100 %
ASI	**Day**	**Overall percentage**	90 %
	Night	**Overall percentage**	80%
		Above 20 deg elevation	95 %

[Detection percentage is based on the aircraft seen in the ADS-B receiver]

Redundancy



Raw visible wavelength image



Processed visible wavelength image

Conclusion

1. The developed algorithm has performed significantly with TIR camera.
2. The ASI camera has shown some shortcoming during nighttime operations.
3. The combination of TIR and vis wavelength camera recommended for both day and night time operations.
4. Aircrafts detected flying above 20^0 elevation has higher detection probability.
5. Theoretically the algorithm have no false detection so far.

Future Steps

1. Cross-comparison between visible and TIR camera outputs.
2. Data collection near the airport to capture close range aircrafts.


Thank you