

Research on multi-source detection technologies of UAV targets

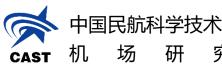
China Academy of Civil Aviation Science and Technology

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UAV Intrusions

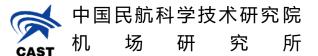


Multi-source detection technologies



Comparison of main performances of various UA detection sensors

Sensor type	Range	Classification ability	Advantages	Disadvantages
Radar	3~5km	Average	has a long effective detection distance. Target classification	There is a certain proportion of false alarm and a certain range of low altitude detection blind area; active radar may cause interference to the airport air traffic control equipment, so frequency licensing is required before use.
Visible light	1~2km	Good	It can capture all kinds of UA, realize real-time and visual monitoring, and has strong target classification ability.	Limited by light conditions, the detection distance is relatively short. It has no ranging function.
Infrared	1~2km	Good	It is not limited by lighting conditions, can achieve real-time, visual monitoring, and has strong target classification ability.	The cost is high and the field of view is small.
Acoustic	150m	Poor	Low cost, suitable for various types of UA, can achieve all day early warning detection.	The noise level of UA is very low. In noisy environments, the applicability of this technology is poor and the detection distance is short.
Radio detection	1~2km	Poor	It is suitable for all types of UA, and can effectively detect the	"Silent" UAV that do not transmit radio signals cannot be detected.



- > Radar
- > Photoelectric
- > Acoustic
- > Radio detection

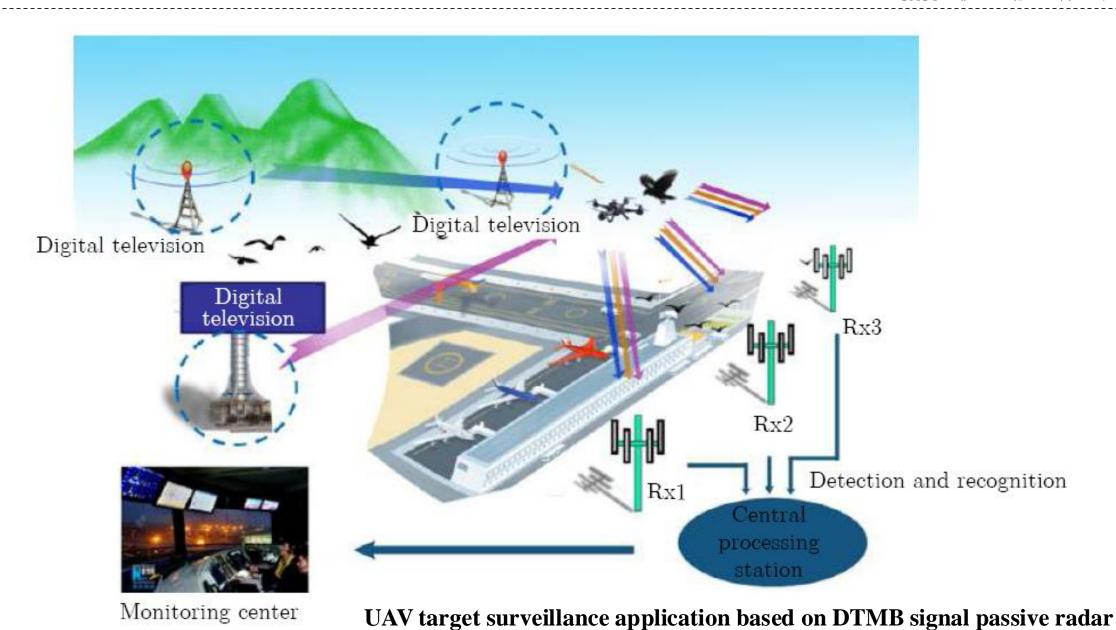
Radar: UAV detection system



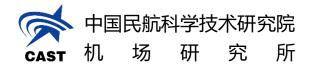




Radar: UAV detection system



Radar: avian radar system

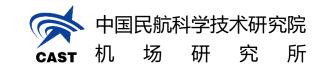


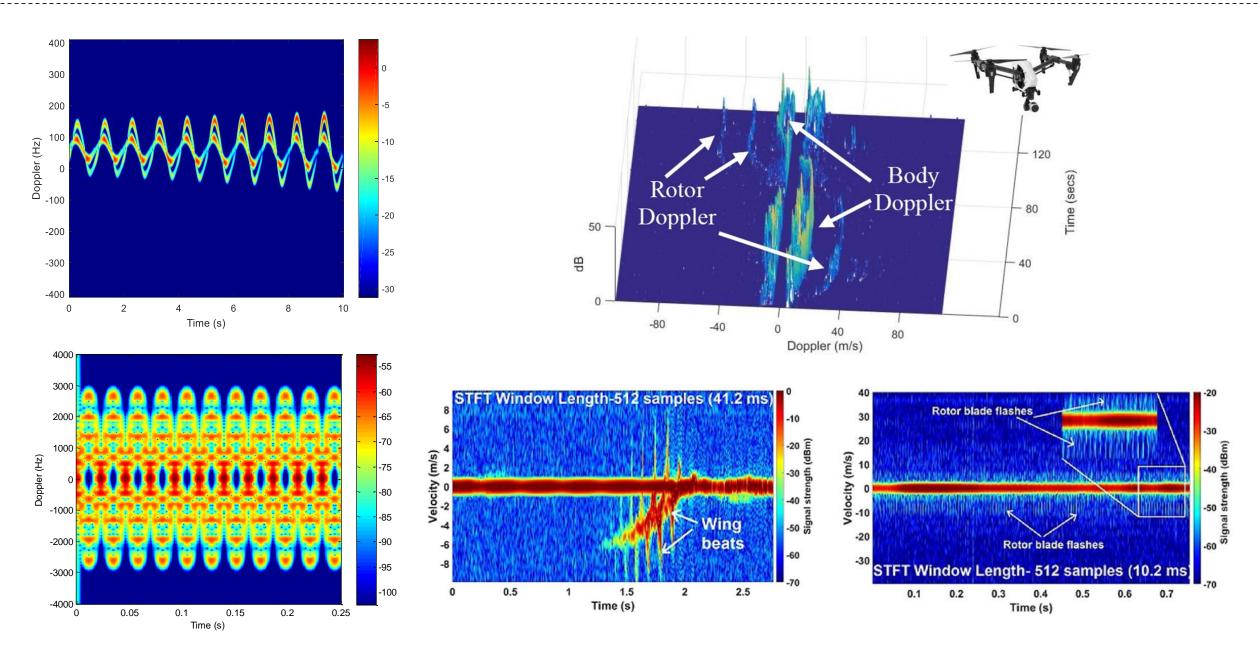




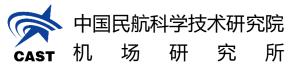


Radar: M-D feature extraction



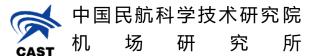


Radar: classification of UAV and birds



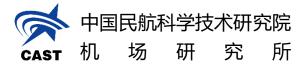
Radar based classification of UAV and birds in existing literatures

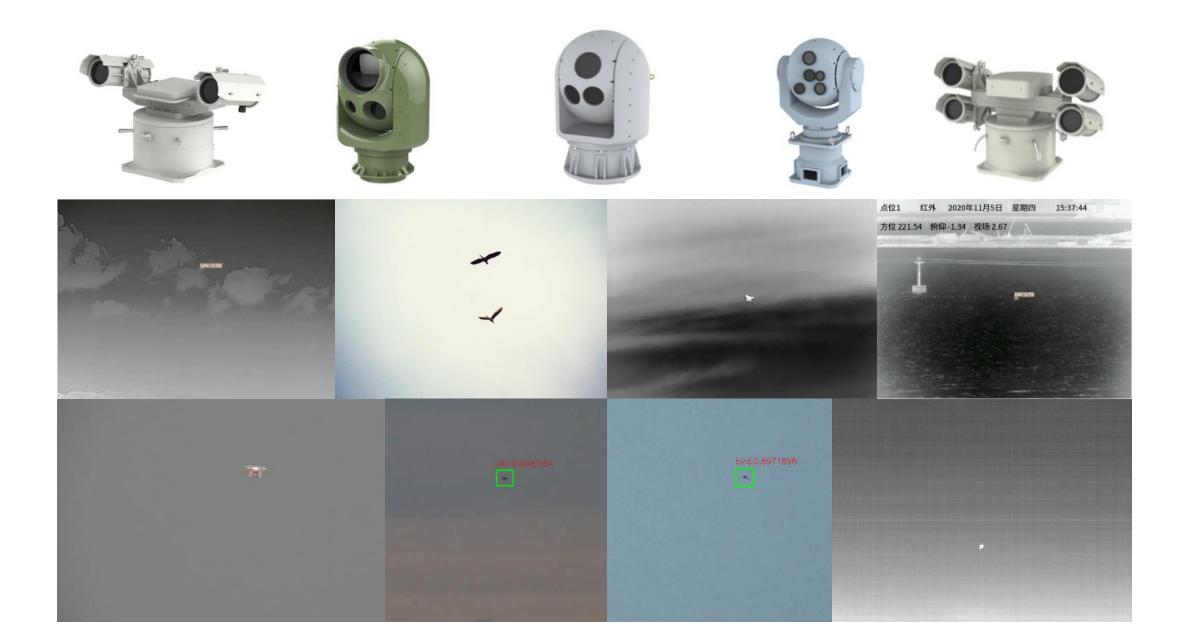
Target type	Type number (UAV+Bird)	Classification method	Reference
UA type vs. Bird		m-D + Nonlinear SVM	[26]
UA type vs. Bird	10+1	m-D (EMD) + SVM	[32]
UA type vs. Bird		m-D (EMD), Entropies of EMD+SVM	[33]
UA vs. Bird	1+1	m D (CVD) + CVM	[20]
UA type	2	m-D (SVD) + SVM	[29]
UA vs. Bird	1+1	Fourier transform + Subspace reliability analysis	[31]
UA type + positioning	66	m-D (PCA) + Random forest	[34]
UA (loading vs. unloading)	3	m-D+DAC	[35]
UA type	3	Dual radar m -D (PCA) + SVM	[36]
UA type	3	Dual radar m-D (PCA) + SVM	[37]
UA type vs. Bird	3+1	Radar polarization + Nearest neighbor	[49]
UA type vs. Bird	5+1	m-D (CVD) + CNN	[50]
UA type vs. Bird	2+1	SCF	[51]
UA type	2	IQ + MLP	[54]
UA type	3	Point cloud + MLP	[55]
UA vs. Bird	1+1	Motion model, speed and RCS + MLP	[56]
UA type vs. Bird	2+1	Motion model, speed and tracking + SVM	[48]



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Photoelectric: Visible light & Infrared

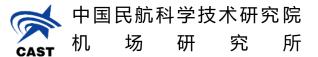




Photoelectric: classification of UAV and birds cast n 场 研 究 所

Photoelectric based classification of UAV and birds in existing literatures

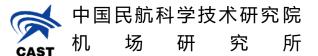
Target type	Type number (UAV+Bird)	Classification method	Reference
Visible light	3 birds	CNN	[51]
Visible light	16 birds	Faster R-CNN+RetinaNet	[52]
Visible light	Bird+UAV	Deformable DETR	[53]
Visible light (SOD4SB)	Birds	Swin Transformer	[54]
Visible light (CUB-200)	Birds	DNN	[55]
Visible light	Birds	Faster R-CNN	[56]
Visible light	Birds	DC-YOLO	[57]
Visible light	Birds (penguin)	YOLO-Pd	[58]
Visible light	10 birds	ResNet34	[59]
Visible light (AVSS2017)	UAV	CNN	[60]
Visible light (AVSS2019)	UAV	Motion Model Network+CNN	[61]
Visible light (AVSS2019)	UAV	Super-resolution processing+CNN	[62]
Visible light (AVSS2017)	UAV	YOLO	[63]
Visible light	UAV	CNN	[64]
Visible light	UAV	CNN	[65]
Visible light	UAV	Le Net-5	[66]
Visible light	UAV	YOLOv3	[67]
Visible light	Bird+UAV	YOLO	[68]
Infrared	UAV	YOLOv7	[69]
Infrared	UAV	IDOU-YOLO	[70]
Infrared	UAV	Spatiotemporal scale filtering	[71]
Infrared	UAV	Spatiotemporal domain characteristics	[72]
Infrared	UAV	Multi scale U-Net	[73]
Infrared	UAV	Residual image prediction	[74]
Infrared	UAV	Shape prior segmentation+multi-scale features	[75]
Infrared	UAV	Asymmetric attention fusion mechanism	[76]
Infrared	UAV	YOLOv5	<mark>[77]</mark>



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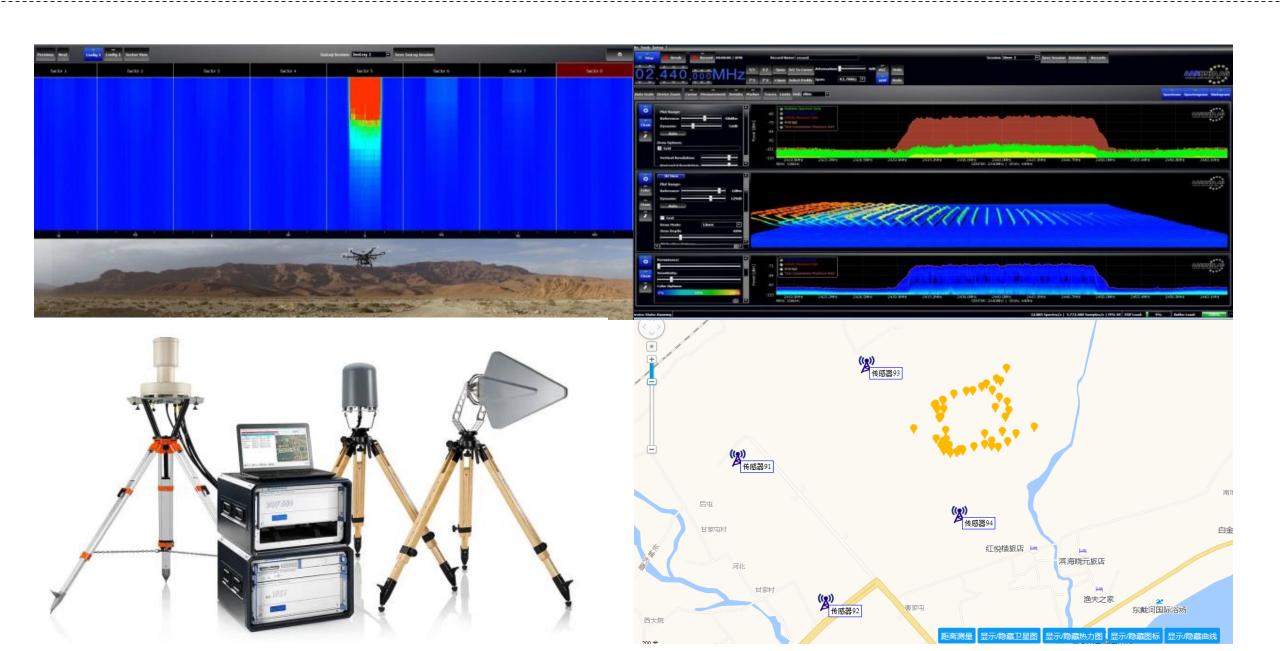
Acoustic



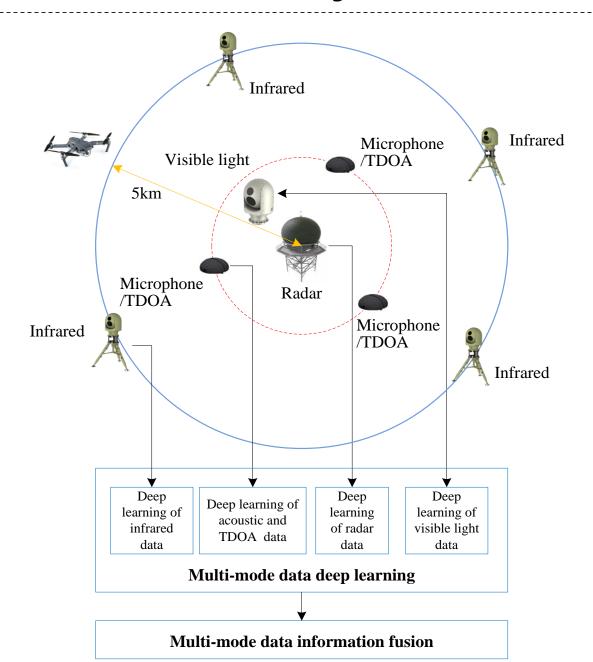


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Radio detection



Proposal of UAV surveillance system



Many thanks!

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