Dataset Documentation

AVOIDDS: A dataset for vision-based aircraft detection

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Short Description: The AVOIDDS dataset is a collection of 72,000 labeled photo-realistic images of aircraft in mid-air from a nearby aircraft's point of view. The dataset was created for training and testing vision-based aircraft detection models.

Abstract: Aircraft collision avoidance systems rely on sensor information to detect and track intruding aircraft so that they may issue proper collision avoidance advisories. While typical surveillance sensors for manned aircraft include transponders and onboard radar, autonomous aircraft will require additional sensors both for redundancy and to replace the visual acquisition typically performed by the pilot. As a result, the community has proposed detecting other aircraft using vision-based sensors such as cameras. These sensors require the development of techniques to process images of the environment to detect intruding aircraft. To boost this development, this artifact provides a dataset of 72,000 labeled images of intruder aircraft with various lighting conditions, weather conditions, relative geometries, and geographic locations. For more information on the generation of this dataset as well as benchmark models and a full simulator, see https://github.com/sisl/VisionBasedAircraftDAA.
Keywords: machine learning, object detection, aviation

Dataset Specifics

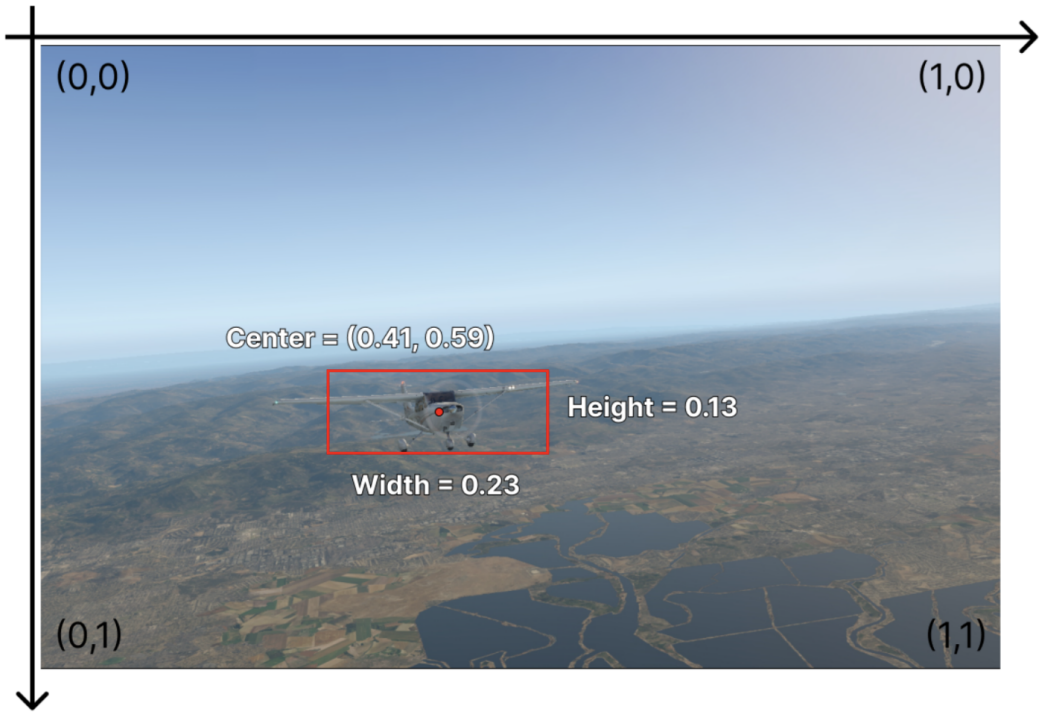
File Formats: Images in jpg | labels in txt | metadata in json, csv, and yaml | bundled as zip
Instances: 72,000 images, 72,000 labels (64800 training, 7200 validation)
Collection Window: February 2023
Hosting and Maintenance: The dataset is hosted by the Stanford Digital Repository which provides long term preservation of data.

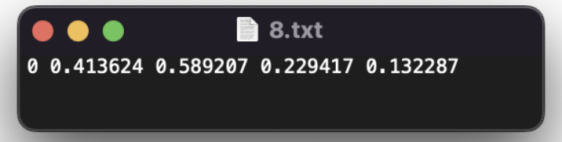
Structure Overview: See the dataset formatting document for more specific information about the dataset format and structure as well as details about the information included about each image. Each image is a screenshot from X-Plane in jpg format and each label is a txt file with the bounding box coordinates in normalized XYWH format. In other words, the txt files contain the normalized X and Y coordinates of the intruder aircraft in frame as well as the width and height, in pixels, of the bounding box. Below is a high-level overview of the contents of the dataset folder.

1. **images:** folder containing the training and validation images in the dataset
2. **labels:** folder containing the labels for the training and validation images in the dataset

3. **metadata.json:** a supplemental file containing the command line arguments used to generate the dataset
4. **starter_dataset.yaml:** a file containing information about the dataset required by the YOLO model
5. **state_data.csv:** a supplemental file containing the position and environment information for each image in the dataset

Example of Data Point:
The following is an example of an image in the dataset and its associated label overlaid.





Collection Process: We used the data generation portion of our VisionBasedAircraftDAA repository. The following procedure was followed when generating the dataset:

1. Establish connection to X-Plane 11 flight simulator: This depends on X-Plane Connect (XPC), an open source tool created by NASA for connecting to and controlling parameters in the simulator.
2. Sample aircraft positions and environmental variables: See “Data Sampling” section

3. Position the aircraft in the simulator and adjust environmental variables: The sampled information from the previous step is sent through XPC to X-Plane to result in the associated aircraft states being reflected on the X-Plane interface.
4. Take a screenshot and save the associated data: A screenshot of the interface is taken and the information about that image is stored in alignment with the formatting document linked above. This includes storing label information for each image.

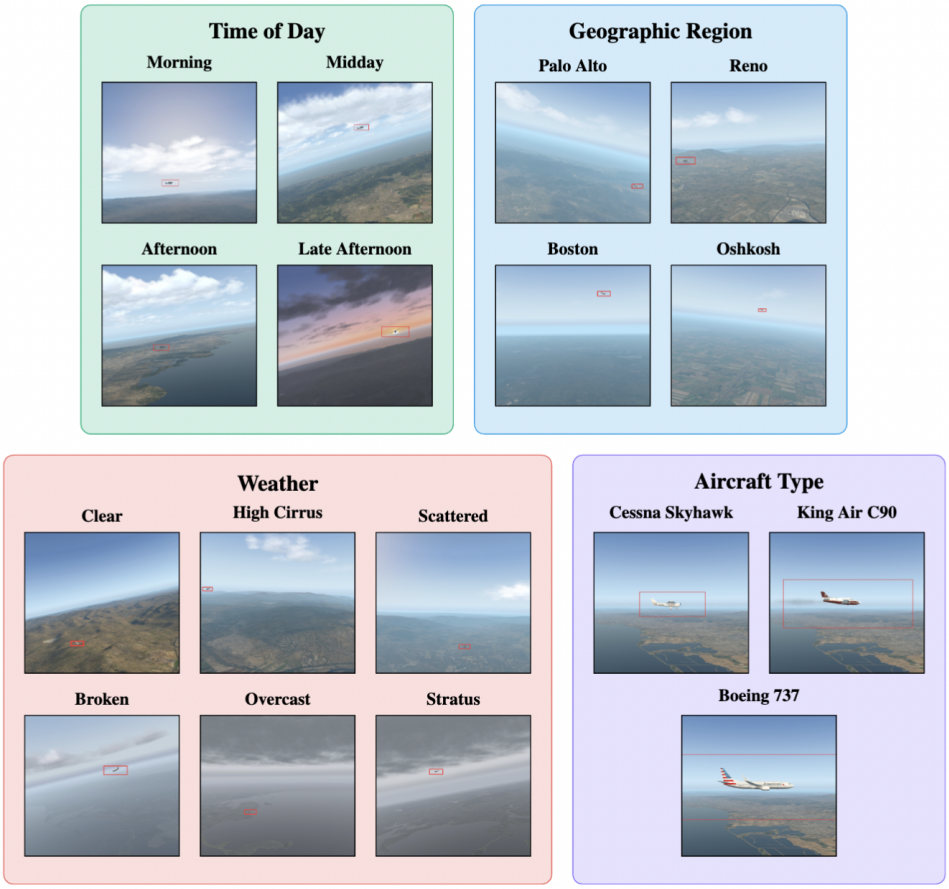
Data Sampling:

The images were sampled to include variation in the weather, region, aircraft type, range, intruder relative altitude, and time of day. More specifically, equal batches of each combination of weather type, region, and intruder aircraft type were collected, with the remaining characteristics randomized using the distributions in the table below. The ranges in meters between ownship and intruder were sampled from $\Gamma(2, 200)$ for the Cessna Skyhawk and King Air C90 and $\Gamma(3, 200)$ for the Boeing 737-800. This difference in distributions skews the Boeing 737-800 intruders to be slightly further away from the ownship to account for its larger size in the frame. The exact quantities of each category in the dataset are outlined in the second table below.

Parameter	Minimum	Maximum	Distribution	Unit
Ownship distance east/north from origin	-5000	5000	$\mathcal{U}(-5000, 5000)$	meters
Ownship distance vertically from origin	-1000	1000	$\mathcal{U}(-1000, 1000)$	meters
Ownship and intruder heading	0	360	$\mathcal{U}(0, 360)$	degrees
Ownship pitch	-30	30	$\mathcal{N}(0, 5)$	degrees
Ownship roll	-45	45	$\mathcal{N}(0, 10)$	degrees
Time of day	08:00	17:00	$\mathcal{U}$(08:00, 17:00)	hours

		Number of images		
Attribute	Value	Total	Training	Validation
All	-	72,000	64,800	7200
Clouds	Clear	12,000	10,800	1200
	High Cirrus	12,000	10,800	1200
	Scattered	12,000	10,800	1200
	Broken	12,000	10,800	1200
	Overcast	12,000	10,800	1200
	Stratus	12,000	10,800	1200
Region	Palo Alto, CA (PAO)	18,000	16,200	1800
	Boston, MA (BOS)	18,000	16,200	1800
	Oshkosh, WI (OSH)	18,000	16,200	1800
	Reno, NV (RNO)	18,000	16,200	1800
Aircraft type	Cessna Skyhawk	24,000	21,600	2400
	Boeing 737-800	24,000	21,600	2400
	King Air C90	24,000	21,600	2400
Range	$0-150$ m	9124	8268	856
	$150-500$ m	35,932	32,303	3629
	>500 m	26,944	24,229	2715
Intruder rel. alt.	Below	36,048	32,482	3566
	Above	35,952	32,318	3634
Time of day	Morning	15,930	14,385	1545
	Midday	24,142	21,722	2420
	Afternoon	15,954	14,269	1685
	Late Afternoon	15,974	14,424	1550

The following figure shows examples of images and associated bounding box labels collected in select condition categories.



Dataset Usage

Intended Use: The AVOIDDS dataset is intended for use in training YOLO object detection models. This dataset captures the variability in conditions that aircraft may face in order to ensure that the associated model can perform optimally in different conditions as well.

Usage Instructions: Refer to the model portion of our VisionBasedAircraftDAA repository for information on how to train models using the dataset and use the dataset for test set evaluation.

Risks: No human information is included in this dataset, so there are no concerns regarding improper usage of personal details. There is also no content that might be upsetting in the images. The only risk would be the result of a low-performing model being deployed for the aviation downstream task, causing lack of safety for any passengers in the aircraft. However, we have made explicit that this dataset is only meant to serve as an example to motivate further research on vision-based models for real-world, high-stakes tasks. There are safeguards in place to ensure that premature deployment of any vision-based model in aviation does not occur.