



Large Scale Computer Vision for Remote Sensing Imagery

Density Map Guided Object Detection in Aerial Images

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Object detection in nature images













Majority of objects has medium/large scale
No/Limited scale variation

Object detection in aerial images



- □ More small objects
- □ The distribution of objects are sparse and non-uniform
- □ Large scale variations



Current practice: generate image crops

Baseline: Random cropping and uniform cropping

Deep learning based: Cropping by identifying difficult regions of detections



Uniform Cropping

Random cropping and uniform cropping



Difficult Region Estimation Network (DREN)



Random Cropping

Question: Can we do better?



Density map guided image cropping

Key idea: generating density crops to improve detection result

- Remove background pixels to reduce the difficulty of detection
- Increase the percentage of small object pixels to make it more recognizable

Uniform Cropping









Density Cropping



Density map guided object detection in aerial images

• Detection Pipeline





Density map generation modular



Global Detection



Image cropping modular



Global Detection



Thresholding





We run a sliding window (2x2 here for demo purpose) on an image and sum all pixels in the window.

If the sum is smaller than the threshold (0.06 here for demo purpose), we set all pixels in the corresponding regions of density mask with a constant value > 0. Else we assign 0 to those cells.



Object detection





Quantitative results on VisionDrone 2018 dataset

Method	Backbone	Test data	#Image	AP	AP ₅₀	AP ₇₅	AP _{small}	AP _{mid}	APlarge
DetecNet+CPNet+ScaleNet [26]	ResNet 50	Original+cluster	2716	26.7	50.6	24.7	17.6	38.9	51.4
DetecNet+CPNet+ScaleNet [26]	ResNet 101	Original+cluster	2716	26.7	50.4	25.2	17.2	39.3	54.9
DetecNet+CPNet+ScaleNet [26]	ResNeXt 101	Original+cluster	2716	28.4	53.2	26.4	19.1	40.8	54.4
DMNet	ResNet 50	Original+density	2736	28.2	47.6	28.9	19.9	39.6	55.8
DMNet	ResNet 101	Original+density	2736	28.5	48.1	29.4	20.0	39.7	57.1
DMNet	ResNeXt 101	Original+density	2736	29.4	49.3	30.6	21.6	41	56.9

• Improvement of 1-1.5 on AP, depending on the choice of backbone

• An improvement of nearly 4 AP for small object detection with ResNeXt 101 backbone



Quantitative result on UAVDT

Method	Backbone	#Image	AP	AP ₅₀	AP ₇₅	AP _{small}	AP _{mid}	APlarge
R-FCN [6]	ResNet 50	15096	7.0	17.5	3.9	4.4	14.7	12.1
SSD [14]	N/A	15096	9.3	21.4	6.7	7.1	17.1	12.0
RON [8]	N/A	15096	5.0	15.9	1.7	2.9	12.7	11.2
FRCNN [17]	VGG	15096	5.8	17.4	2.5	3.8	12.3	9.4
FRCNN [17]+FPN [12]	ResNet 50	15096	11.0	23.4	8.4	8.1	20.2	26.5
ClusDet [26]	ResNet 50	25427	13.7	26.5	12.5	9.1	25.1	31.2
DMNet	ResNet 50	32764	14.7	24.6	16.3	9.3	26.2	35.2

Compared with SOTA method – ClusDet, we achieve **1** AP improvement on UAVDT.



Visual result – object detection examples



Visualization of our DMNet detection results on VisionDrone (first row) and UAVDT (second row)



Conclusion

- Density map guided object detection in aerial images
 - > Utilize density map to help better detect small objects
 - > Achieve state-of-the-art performance on two benchmark datasets
 - > Overall design is simple and clean
 - > Our code will be released soon





