Object-Based Augmentation for Building Semantic Segmentation: Ventura and Santa Rosa Case Study

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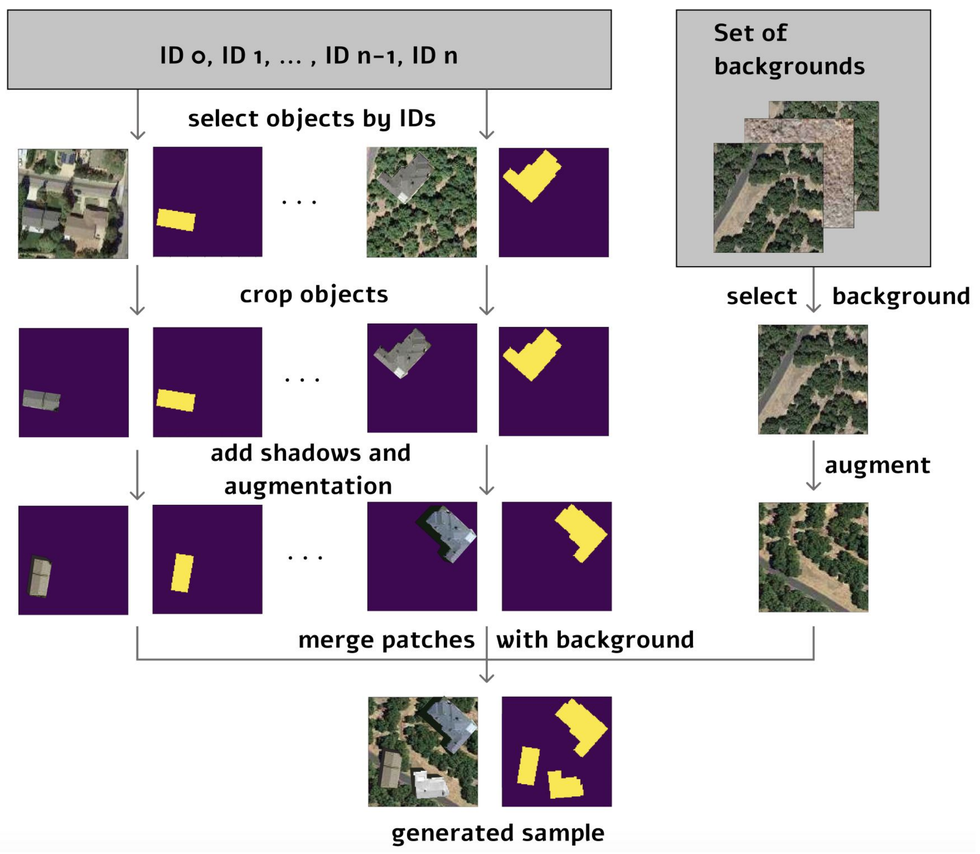
Background

This study focuses on the development and testing of object-based augmentation. The practical usefulness of the developed augmentation technique is shown in the remote sensing domain, being one of the most demanded in effective augmentation techniques. We propose a novel pipeline for georeferenced image augmentation that enables a significant increase in the number of training samples. The presented pipeline is called object-based augmentation (OBA) and exploits objects' segmentation masks to produce new realistic training scenes using target objects and various label-free backgrounds.

Methods

- georeferenced images and markup
- set of backgrounds



Data

We used high-resolution satellite images covering Santa Rosa and Ventura (California)

Train image

Markup

	Train	Validation	Test
Objects number	955	226	282
Area in hectars	390	100	93
Extra background area in hectars	2000	500	500

Difficulties

- Small datasets
- Different environmental conditions
- Rare target objects
- Geo-spatial satellite data specificity (objects distribution, image size, shadows, etc)

Example of training samples

Results

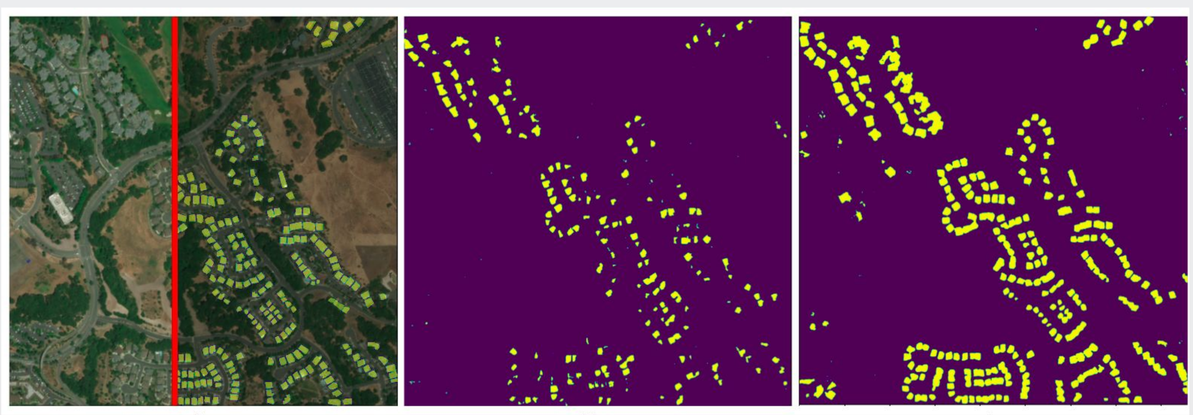
F1-score (per-pixel) is used to assess semantic segmentation quality for different augmentation setups and model's architecture

	Base augm.	Shadow	Extra background
Baseline_no_augm	✗	✗	✗
Baseline	✓	✗	✗
OBA_no_augm	✗	✓	✓
OBA_no_shadow	✓	✗	✓
OBA_no_background	✓	✓	✗
OBA	✓	✓	✓

Standard augmentation	Augmentation	F1-score
No	*Baseline_no_augm*	0.45
	OBA_no_augm	0.66 (+21%)
Yes	*Baseline*	0.788
	OBA_no_shadow	0.811 (+2.3%)
	OBA_no_background	0.81 (+2.2%)
	OBA	0.829 (+4.1%)
	OBA + optimization	0.835 (+4.7%)

	Baseline_no_augm			*Baseline*			*OBA*		
Model	Resnet18	Resnet34	Resnet50	Resnet18	Resnet34	Resnet50	Resnet18	Resnet34	Resnet50
FPN	0.325	0.367	0.186	0.741	0.762	0.784	0.802	0.813	**0.826**
U-Net	0.435	0.45	0.34	0.766	0.788	0.766	0.807	**0.829**	0.824
	Resnet101			Resnet101			Resnet101		
HRNet	0.23			0.741			**0.812**		

Model predictions (F1-score) for different architectures



Input image | Prediction without augm | Prediction with OBA

Conclusions

- We proposed augmentation for building segmentation
- We tested different augmentation configurations
- The proposed object-based augmentation improves the performance of the remote sensing task
- The code is available https://github.com/LanaLana/satellite_object_augmentation

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