The Effects of Super-Resolution on Object Detection Performance in Satellite Imagery

Jake Shermeyer & Adam Van Etten (In-Q-Tel CosmiQ Works)

Significance & Research Questions

- When using super-resolution (SR) as a preprocessing step, how much value does it add in terms of object detection performance?
- Across what ranges of resolutions is SR effective for enhancing object detection performance? Can moderate resolution data be enhanced, does it have utility?
- Can we create even finer imagery than the best commercially available imagery? Does it improve object detection performance?

Experiments

- Degrade imagery and simulate five resolutions of imagery ranging from 30 cm to 480 cm
- Train two SR models (Very Deep Super-Resolution (VDSR) and Random Forest Super-Resolution (RFSR)) to super-resolve imagery for 2, 4 and 8x levels of enhancement
- Use the SIMRDWN object detection framework (specifically YOLT & SSD) to detect 5 classes of objects for both super-resolved and native resolution imagery

Results & Conclusions

- Our experiments show that super-resolving satellite imagery from 30 to 15 cm provides a 13% boost in object-detection performance and 60 to 15 cm provides a 20% boost
- Once super-resolved to 15 cm, object detection performance for 30 and 60 cm imagery is equivalent (within errors)

Dataset

- xView Dataset: 56 locations, 60 classes, 1,415 km² of DigitalGlobe WorldView-3 pan-sharpened RGB imagery - native resolution ~31 cm
- 5 Classes: Small Cars, Trucks & Buses, Large Aircraft, Small Aircraft, Boats

Contact Info

https://github.com/CosmiQ
https://www.cosmiq.com/x-viewing
jashermeyer@iqt.org
akvanetten@iqt.org

5 Classes:
- Small Cars, Trucks & Buses
- Large Aircraft
- Small Aircraft
- Boats
- Parking Lot & Adjacent Airfield

Score object detection performance for native and super-resolved imagery
- True positive for detection defined as IoU >0.25 (appropriate for small objects)
- Calculate Average Precision for each class
- Calculate Mean Average Precision for the full test dataset

Super Resolution Method

- SR is less effective as initial resolution degrades and most valuable in finer resolutions
- Super-resolution is a relatively inexpensive enhancement (0.16 seconds* per 544 x 544 image chip) that can improve object detection performance, particularly for certain classes with distinctive features
- Less computationally expensive super-resolution techniques can be almost as effective as high-resolution techniques

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