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

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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?

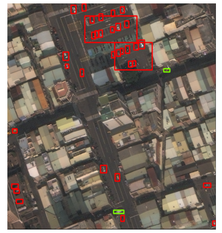
60cm Input | 30cm Super-Res Output | 30cm Ground Truth

Dataset

- xView Dataset: 56 locations, 60 classes, 1,415 km^2 of DigitalGlobe WorldView-3 pan-sharpened RGB imagery- **native resolution ~31 cm**
- **5 Classes:** Small Cars, Trucks & Buses, Large Aircraft, Small Aircraft, Boats

Marina and coastal roadway

Parking Lot & Adjacent Airfield



Mixed Data Quality

Contact Info

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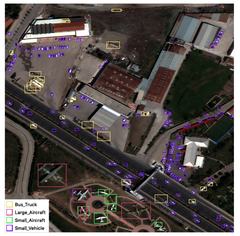
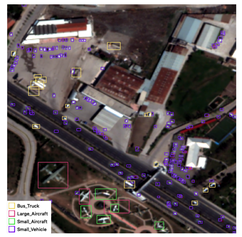
Experiments

- 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



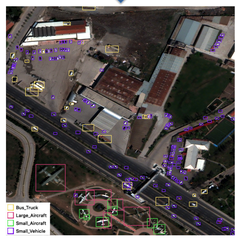
30cm Imagery



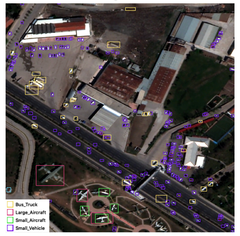
120cm Imagery

480cm Imagery

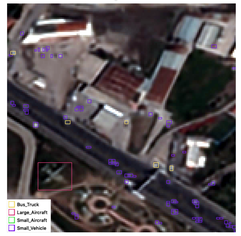
2x 2x 2x



15cm Super-Resolved Imagery



60cm Super-Resolved Imagery

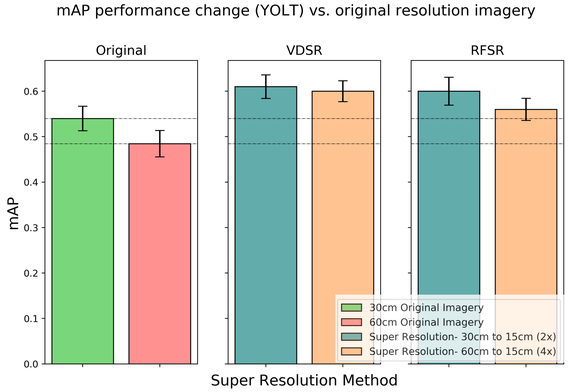


240cm Super-Resolved Imagery

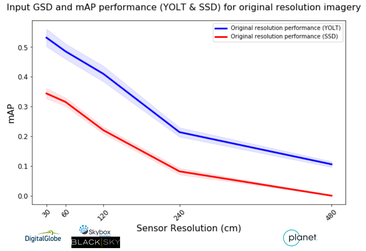
- Score object detection performance for native and super-resolved imagery
  - True positive for detection defined as IoU >=0.25 (appropriate for small objects)
  - Calculate Average Precision for each class
  - Calculate Mean Average Precision for the full test dataset

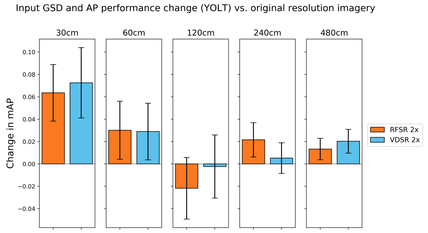
Results & Conclusions

- 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)



- 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

- *Inference speed for VDSR on NVIDIA Titan XP GPU