Request ID: 1a15fb

Project Title:

Exploration of advanced computer vision techniques applied to forest ecosystems monitoring

Project Organisation: Universidade de Santiago de Compostela

Main work lines

- Super-resolution model for Sentinel 2 images

- Prediction of forest timber volume from Sentinel images

General methodology

- Sentinel 2 multispectral imagery from SentinelHub API (Python package)

- Storage and preproccessing of images using Lightning-Memory Databases (LMDB)

- Convolutional neural networks using Tensorflow and GPU acceleration

Super-resolution model for sentinel 2 images

- Aim → artificially increase resolution of low-res bands to improve subsequent modeling from images

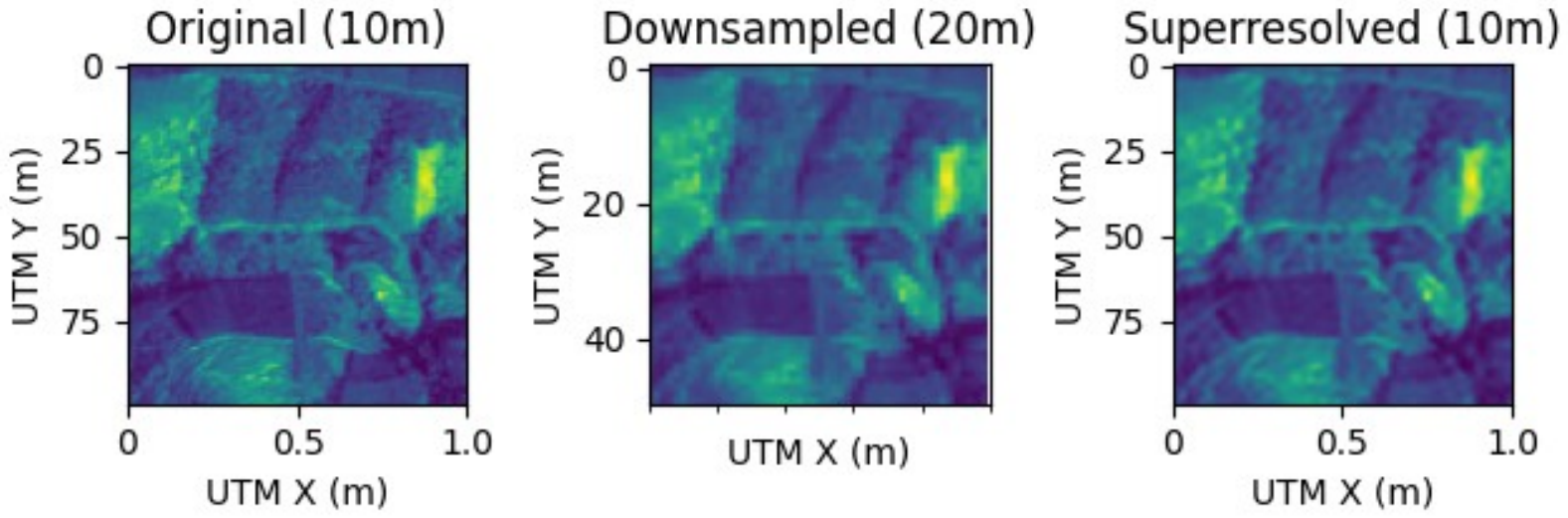
- Download 10000 Sentinel 2 256 x 256 images for 10m bands and 128 x 128 images for 20 bands. Areas with significant forest cover + cloud free + level 1C.

- Storage as LMDB

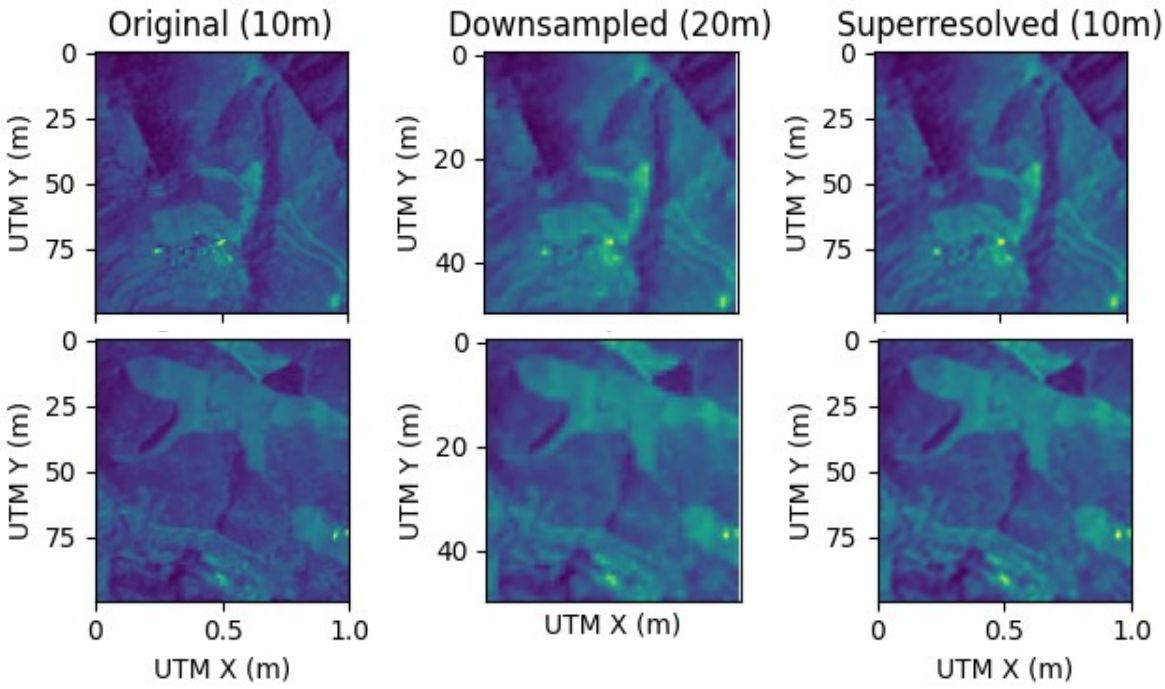
- Convolutional approach: single-image predictions of downsampled 10m images. Super-resolved reconstructions evaluated with Mean Absolute Percentage Error (MAPE). Model inspired by ResNet, with 3x3 kernels and residual blocks.

Super-resolution model for sentinel 2 images - Results

- MAPE = 3%



Super-resolution model for sentinel 2 images - Results



Prediction of forest timber volume from Sentinel images

- Aim → Predicting standing timber volume (m3/ha) of forests from multispectral imagery

- 2000 forest plots with high variability in sizes. Mostly eucalyptus and pine plantations

- Download Sentinel 2 images for every forest plot, requested by bounding box. 10M, 20m, and 60m bands. Areas with significant forest cover + cloud free + level 1C.

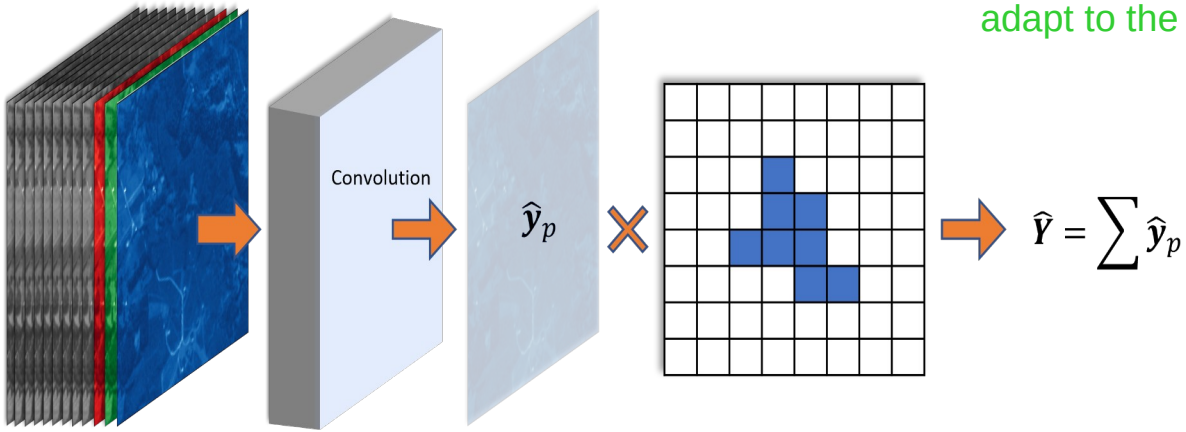
- Storage as LMDB

- Comparison of naive upsampling + bilinear + bicubic interpolations + superresolved

Prediction of forest timber volume from Sentinel images

- Fully convolutional approach: input = 10m bands + upsampled 20 m and 60m bands + a mask of the plot (a matrix of zeros and ones representing the area of the plot). The convolutional part makes pixel-level predictions that then are multiplied by the mask and sumed to get the plot-level prediction

The main advantage is to make predictions using different image sizes to adapt to the size of the forest plot



Prediction of forest timber volume from Sentinel images - Results

- Prediction results were poor overall, with higher errors in small forest plots

- Bicubic interpolation for low-res bands was better than super-resolved images

- Tests with an XGBoost model using zonal statistics also showed poor predictive performance, revealing that the problem is not the convolutional model

- A test using aerial orthoimagery showed better results

Conclusion:
The differences in errors between big and small forest plots suggests that Sentinel 2 resolution is too low for estimating forest variables in the usually small forest parcels in the northwest of Spain (area < 2000 m2 on average) → Complementary remote sensing data sources are necessary (higher-res satellites or aerial imagery) for improving these results in the future

Regarding the use of the cloud platform
The Sentinel-Hub API used for accessing satellite imagery was crucial for this project due to the dispersion and reduced size of the study areas. The possibility of requesting images by bounding box significantly reduces the difficulty of acquiring and processing imagery for such specific and sparse areas. The ability to filter by cloud coverage is also a key feature for remote-sensing based environmental inference in very rainy and cloudy areas, such as the northwest of Spain, especially when the logging activity takes place during winter.