Rooftop Detection Using Aerial Drone Imagery

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Abstract

We present a rooftop detection algorithm using aerial RGBD and near infrared data which uses lower computational resources than algorithms requiring GPUs. The depth data is extracted from multi-view images captured by drones using photogrammetry. Our approach is cost effective as compared to LIDAR surveying and has lower edge blurring. It is also novel in terms of segmenting clutter due to objects such as overhead water tanks on roofs. This helps is determining the actual free roof area that would be available for applications like solar panel deployment. The algorithm was evaluated on the aerial imagery of rooftops on a hill slope of size 12876×10533 pixels and an F1 score of 88.27% was obtained. The algorithm ran in under 2 minutes on a Google Cloud instance with Intel Xeon E5 processor.

Summary of our Approach

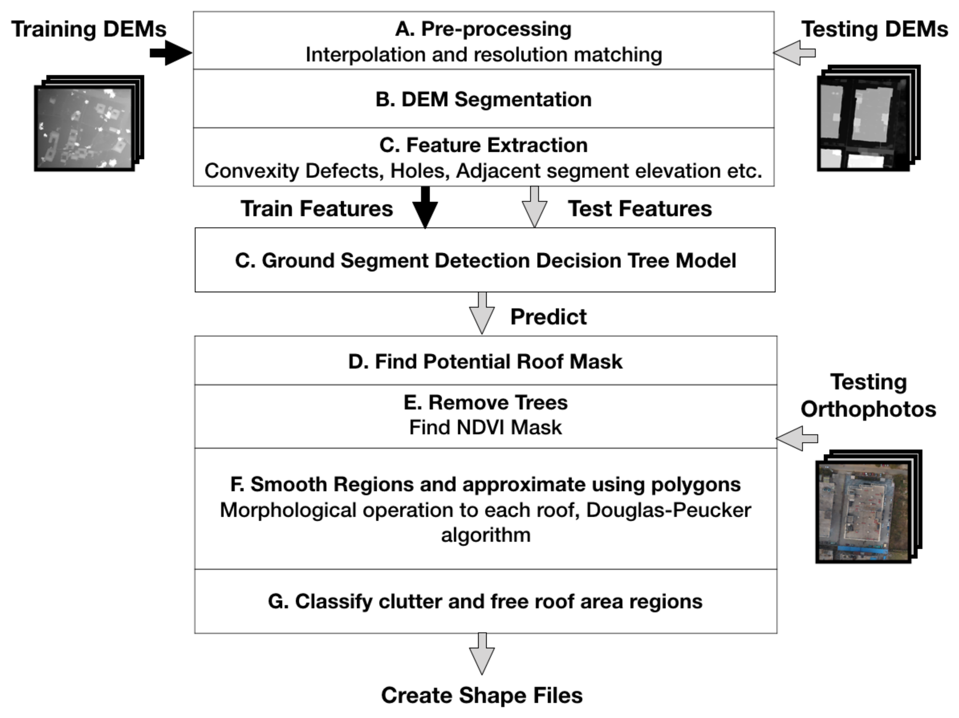

Figure 1: Flow chart of rooftop detection algorithm.

Pre-processing and DEM Segmentation

Steps

1. The DEM was first interpolated to take care of some missing elevation values.
2. The RGB and IR orthophoto were downscaled using bilinear sampling to match the resolution of the DEM.
3. Sharpening followed by the canny edge detector on the sharpened DEM.
4. We might still miss some edges by a few pixels, so we dilate the result and then skelotonize it to prevent the final segments from being too eroded.
5. Finally, we segment the DEM by subtracting the binary output of skeleton of the edges from a all-ones matrix and finally label each unconnected segment.

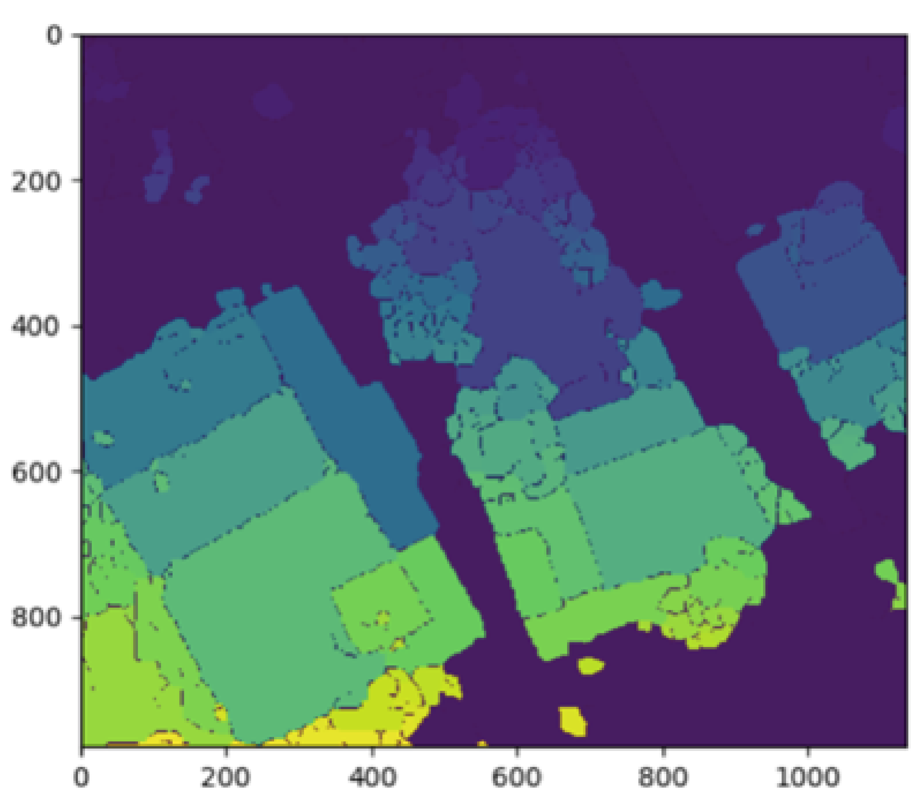

Figure 2: Segmented DEM.

Features for Ground Segmentation

1. Convexity defects: The ground segments usually have convexity defects with large depth and may also have a large number of total number of defects. This is common in cases when a ground segment has many adjacent building segments. An example has been shown in Fig. 4. The ground segment is highlighted in yellow with its convex hull plotted in red. The large convexity defects have also been marked with yellow lines.
2. Holes: Ground segments tend to have many holes in them due to presence of buildings, trees, cars etc. The example in Fig. 4 also has many holes marked with a white bounding box. The number of holes, average area of holes, and number of large holes were used as features.
3. Number of adjacent segments which are taller by h_{min}.

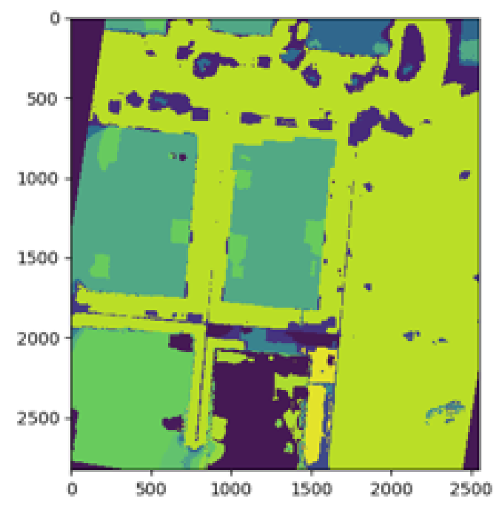

Figure 3: Label matrix of segmented DEM

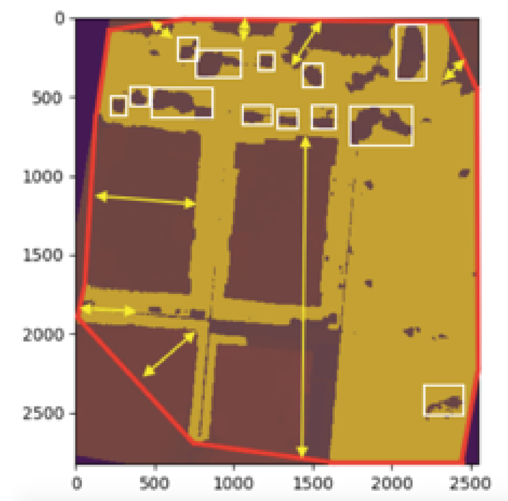

Figure 4: Ground segment

Creating Roof Mask

Steps

1. Removing false positives due to trees

$$NDVI = \frac{NIR - R}{NIR + R} \qquad (1)$$

2. Smoothing roof tops and approximating using polygons

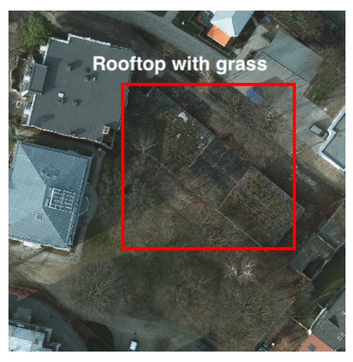

Figure 5: Orthophoto

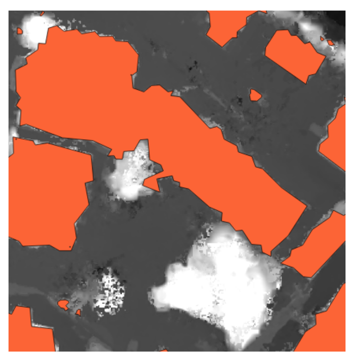

Figure 6: Rooftop overlaid on DEM

Results

We tested our algorithm on a dataset where there is slope in the ground level. The DEM of the region (Surajpur, Greater Noida, Uttar Pradesh, India) is shown in Fig. 7 below. The elevation level (around 280m above sea level) of the buildings in the left is comparable to the elevation level of the ground on the right. The result of running the algorithm on this data has been overlayed on the orthophoto and shown in Fig. 10. By clustering the DEM and comparing each potential roof segment to nearest adjacent ground segment, the variation in the elevation of the ground level is taken care of. We then manually labelled the ground truth by visual inspection (shown in Fig. 9) in QGIS [1] and found the precision, recall and F1 score to be 87.33, 89.23 and 88.27

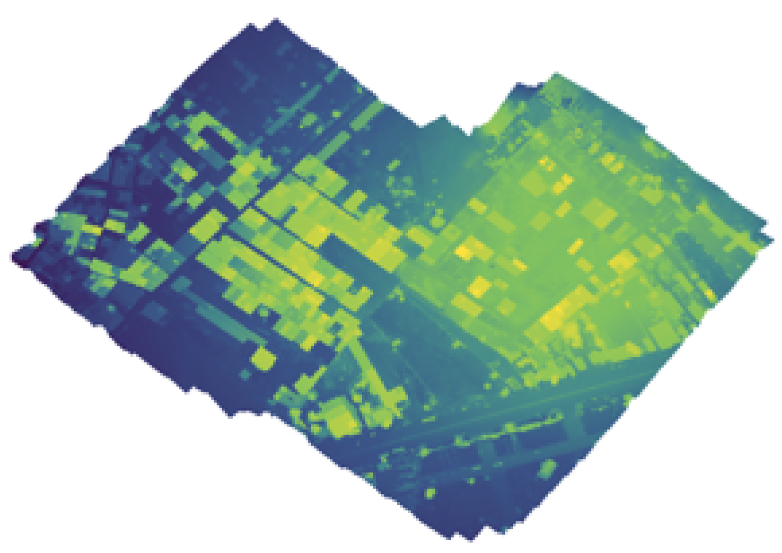

Figure 7: DEM from Photogrammetry

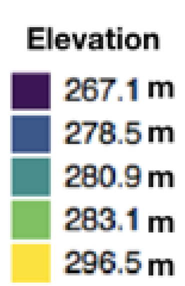

Figure 8: Ref

Figure 9: Ground Truth

Figure 10: Result imposed on orthophoto

Figure 11: Orthophoto

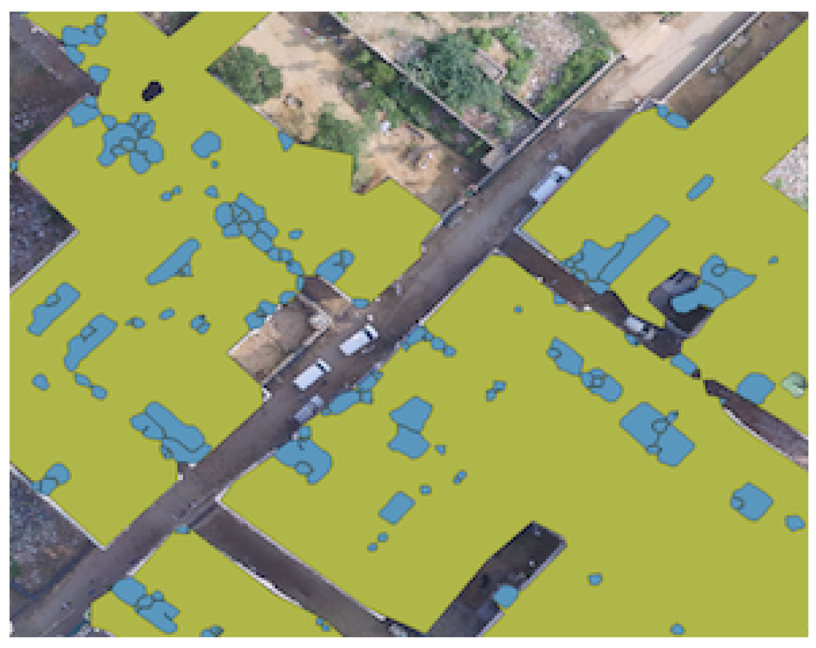

Figure 12: Clutter segregated from actual rooftop solar installation area

Conclusions

We presented a rooftop detection algorithm which uses comparatively lower computational resources as no GPU was used and is cost effective as compared to LIDAR based methods. The algorithm is able to handle cases when grass is present on roofs and is also able to segregate clutter present on rooftops. It also does not require a DTM for detecting roof segments. As future work, support for LIDAR DEM source would also be incorporated.

The code for the work presented in this paper is available at: https://github.com/kritiksoman/Rooftop-Segmentation .

References

[1] QGIS Development Team et al. Qgis geographic information system. *Open Source Geospatial Foundation Project. Disponível em:¡ http://www. qgis. org/¿. Acesso em*, 27, 2015.

[2] Fei Yuan and Marvin E Bauer. Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in landsat imagery. *Remote Sensing of environment*, 106(3):375–386, 2007.