Automatic Building Extraction from UAV data

Introduction

There is a need to quickly and accurately identify buildings in unplanned settlements to characterize the settlement, support the detailed design of infrastructure interventions, and inspection. The state-of-the-art in building identification from sub-meter remotely-sensed imagery or point clouds have limited performance in areas where buildings are (1) small, (2) irregular, and (3) closely packed together on sloped terrain. These are all characteristic of unplanned settlements in the City of Kigali.
In May 2015, a low-cost UAV acquired imagery over approximately 150 ha of unplanned settlements in the City of Kigali, Rwanda. This provided detailed geospatial data in the form of a dense point cloud as well as a 3 cm ortho-image and Digital Surface Model. We demonstrate how to combine radiometric, textural, and geometric features obtained from UAV data to accurately identify and characterize buildings in the challenging setting of unplanned settlements on steep slopes in the City of Kigali.

Methodology

One thousand reference pixels were labelled and used to train an SVM classifier. A reference dataset of ten 30 x 30 m tiles representing different building typologies was used to test the method.

As input for the classifier, the following features were calculated:

- **Radiometric features:** The Red, Green, and Blue channels of the orthomosaic, the normalized r,g,b and a vegetation index (ExG = 2g-r-b [1]).
- **Texture features:** Local Binary Patterns (LBP) [2] were used, a rotationally invariant texture feature which describes which of the pixels around a central pixel have a higher value. This helps identify edges and corners in the images.
- **Point cloud features:** such as the number of points per pixel and their maximal height difference [4], planar segment features to help identify building roofs [5] when different colors of corrugated iron are used, and geometrical features describing the 3D shape of objects [6].
- **Segment features:** a Mean Shift segmentation [3] was used to group similar pixels, smoothing the classification output and helping identify roof edges.

Conclusions

- The proposed methodology correctly classifies 91% of the dataset.
- Buildings have a completeness of 94% and correctness of 98%
- Structures such as walls are more difficult to identify

Table 1: The confusion matrix of the final classification.

Predicted class → ↓ Reference label	Buildings	Vegetation	Terrain	Structures	Clutter	**Completeness**
Buildings	4,694,094	8,286	141,455	43,932	80,760	**0.94**
Vegetation	4,768	647,153	39,022	6,944	3,969	**0.92**
Terrain	77,497	35,012	2,672,806	50,415	179,571	**0.89**
Structures	3,408	488	12,200	36,957	2,867	**0.66**
Clutter	8,539	2,478	52,181	6,359	97,446	**0.58**
Correctness	**0.98**	**0.93**	**0.92**	**0.26**	**0.27**	**0.91**

References

[1] Woebbecke, D., Meyer, G., Von Bargen, K. & Mortensen, D. 1995. Color indices for weed identification under various soil, residue, and lighting conditions. Transactions of the ASAE, 38, 259-269.

[2] Ojala, T., Pietikainen, M. & Maenpaa, T. 2002. Multiresolution gray-scale and rotation invariant texture classification with local binary patterns. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 24, 971-987.

[3] Comaniciu, D. & Meer, P. 2002. Mean shift: A robust approach toward feature space analysis. Pattern Analysis and Machine Intelligence, IEEE Transactions on, 24, 603-619.

[4] Serna, A. & Marcotegui, B. 2014. Detection, segmentation and classification of 3D urban objects using mathematicalmorphology and supervised learning. ISPRS Journal of Photogrammetry and Remote Sensing, 93, 243-255.

[5] Vosselman, G. 2013. Point cloud segmentation for urban scene classification. ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 1, 257-262.

[6] Weinmann, M., Jutzi, B., Hinz, S. & Mallet, C. 2015. Semantic point cloud interpretation based on optimal neighborhoods, relevant features and efficient classifiers. ISPRS Journal of Photogrammetry and Remote Sensing, 105, 286-304.

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Input data

Figure 1: An input RGB image (a) and corresponding dense point cloud (b) obtained from the UAV.

Feature Extraction

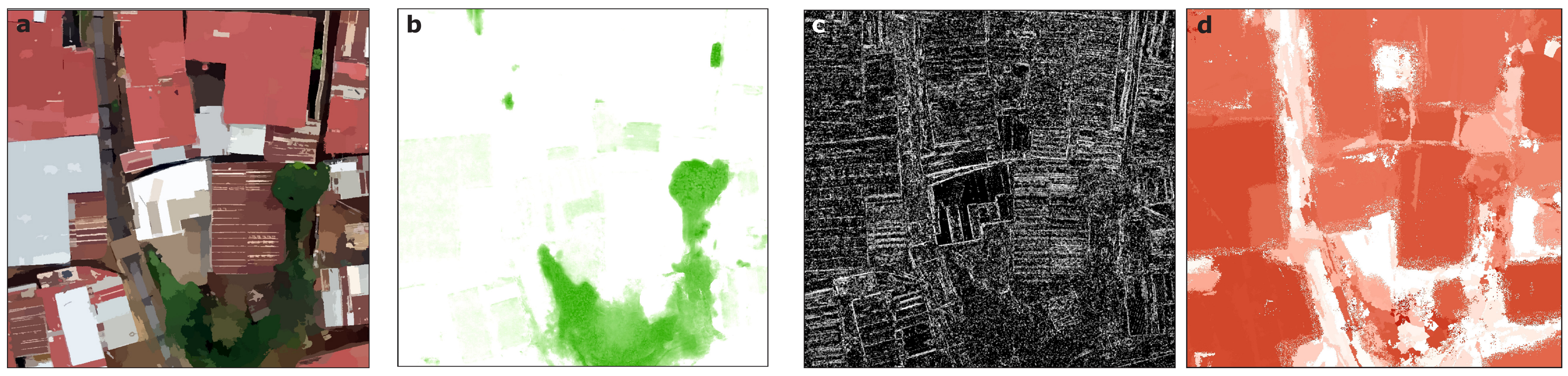

Figure 2: The RGB image is used for the segmentation (a), to obtain radiometric features such as a vegetation index (b), and to obtain texture features (c). Geometric attributes from the point cloud are projected into 2D image space, for example the maximum height above the ground for planar segments (d).

Classification

Figure 3: The output classification map displayed over the input RGB image.

Verification

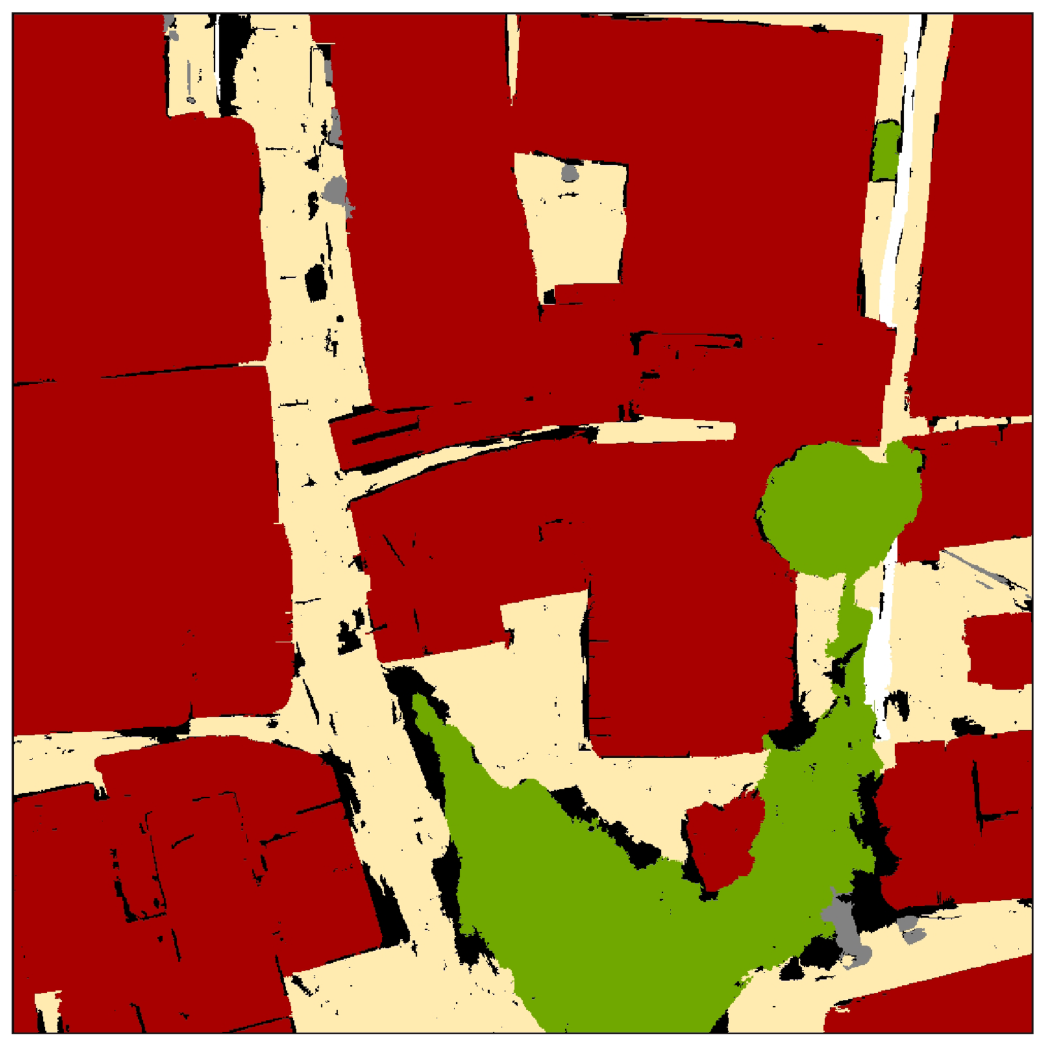

Figure 4: The reference labels used to compute the classification accuracy.

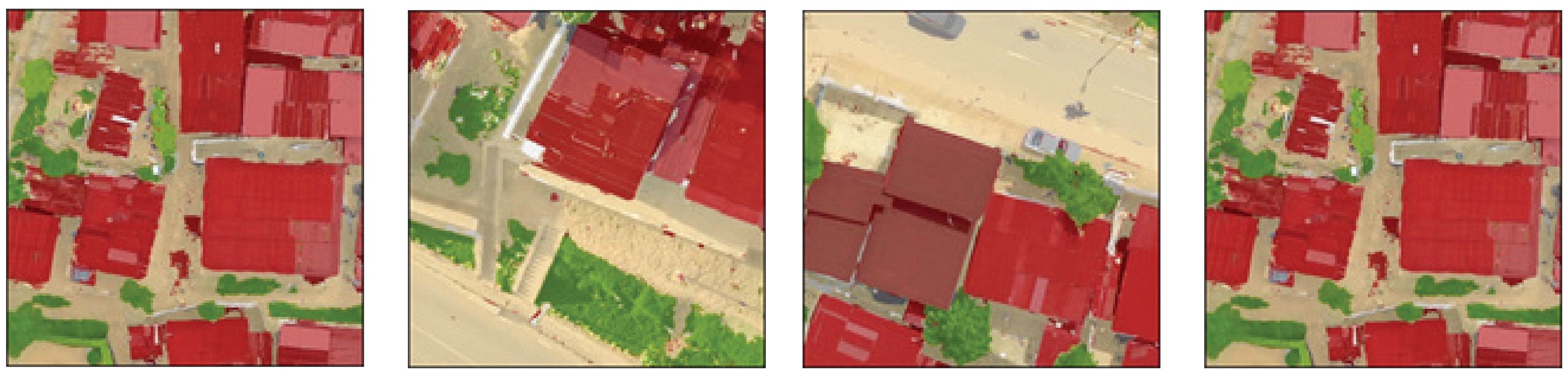

Figure 5: Other examples of classification results.

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