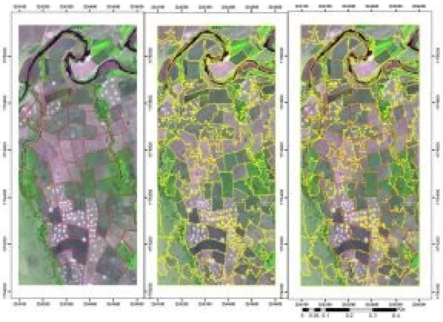
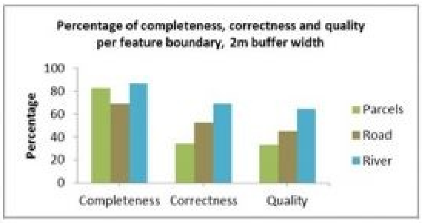
INITIAL INVESTIGATIONS OF IMAGERY, ALGORITHMS AND PERCEPTIONS

Towards Automated Detection of Visual Cadastral Boundaries





The technology push behind emerging automated feature identification and line generation techniques provides a new opportunity for the domain of fit-for-purpose land administration. It could help to further automate the process of boundary generation in cadastral systems – particularly in contexts where large areas remain unmapped and cadastral boundaries align with topographic or visual boundaries.

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Fit-for-purpose land administration aims to align cadastral policies, administration and technology selection with the prevailing societal needs and capacity within a country context. It seeks to aid delivery of more rapid and low-cost cadastral boundary mapping in support of widespread land tenure security. The mindset promotes high-resolution satellite images (HRSI) as an initial source for creating cadastral boundary information. Efforts are now focusing on whether emerging automatic boundary detection techniques can further expedite the process.

The First Wave

The first wave of fit-for-purpose implementations – see Rwanda, amongst others – made extensive use of imagery and paper-based procedures. The use of HRSI for interpreting parcel boundaries presented a rapid method that did not require professionals to undertake the fieldwork. Large numbers of parcels could be mapped – and then registered – in less time and with lower costs than before. Compared with conventional methods, the use of HRSI is estimated to cost just one-third for rural areas and one-fifth for urban areas. It is ideal in contexts where large parts of the jurisdiction remain unmapped and only limited numbers of land professionals are available.

Enter Automation

Even though the fit-for-purpose approach has been shown to work, it is still intensive in terms of labour, processes and logistics – and therein lies the opportunity to further reduce the costs and time involved. One way is to use emerging techniques for automatically extracting features from imagery and apply them in cadastral mapping. In other words, where there is a high degree of alignment between visible boundaries and cadastral boundaries, software can be used to automatically generate an estimated parcel fabric. This means a ‘first go’ cadastral map, overlaid on imagery, can be created automatically in the office, taken into the field and then edited by communities, rather than being produced and digitised from scratch. The savings are suggested to be considerable, but the workflow relies on the quickly generated ‘first go’ being of sufficiently high spatial quality in order to keep the editing time low.

Proof of concept

To assess the viability of the concept, a semi-automated workflow was developed and tested. The workflow was based around the use of a mean-shift segmentation application plug-in in QGIS. A case location was selected in the Amhara region of Ethiopia. The location was regarded as an ‘easier’ case for trialling the concept. It consisted of a rural area with subsistence agricultural land use and was considered representative of many other smallholder areas in parts of Ethiopia specifically and Sub-Saharan Africa more generally. Various features represent cadastral boundaries: water bodies, bushes and parcels covered by bare soil and grasses. WorldView-2 satellite images were acquired for the test areas. The parameters used to extract these boundaries were determined by trial and error. Importantly, an existing cadastral parcel fabric dataset was already available for the area. The data was used as control and enabled comparison of the semi-automated machine-generated cadastral data.

Images and outputs

The imagery and outputs can be seen in Figure 1, which shows the automatically extracted boundaries (right-hand side) and the reference boundaries (left-hand side). The relationship between extracted boundaries, reference boundaries and the land cover information can also be seen. For the reference image (left), the reference boundaries lie between parcels that tend to have differences in brightness and colour. However, there are also parcels containing two different plots; a colour difference and subsequent false parcel identification is evident. The middle image reveals that the applied technique enables boundaries between parcels to be extracted based on colour and brightness. The segments formed are polygons; they are non-overlapping and there are no gaps between them. Due to brightness and/or colour differences along pixels, and the effect of haystacks and bushes, false boundaries are also observed. The third image provides more information about the capability of the algorithm to extract cadastral boundaries; some cadastral boundaries almost perfectly overlapped with the extracted boundaries. In the case of a different colour for the land cover near the boundaries, the extracted boundaries matched with reference boundaries (Figure 2). For a comparative view of qualities of the extracted boundaries – against the reference boundaries – the percentage of completeness, correctness and qualities of parcel boundaries, road boundary and river boundary were compiled (Figure 3).

Professionals' Views

During interviews, land administration professionals shared their experiences with the current land registration approach employed in Ethiopia and on the nature of cadastral boundaries in rural areas. They explained that techniques based on orthophotos, total stations and GPS are being used in the Amhara region (and satellite images are being used in other regions). Ongoing challenges are errors from the first registration, time and cost issues, and a lack of skilled manpower. With respect to the visibility of cadastral boundaries from HRSI, they also explained that – except for a few cases – rural boundaries in general are visible from HRSI. The issue of non-visible boundaries was one of their concerns, although not of this study. It was suggested that in rural areas roughly one in five parcels have a visibility problem. It was indicated that if it were possible to achieve even 40% or 50% by extraction methods, the 'missed' boundaries could be fixed by other methods. It was suggested that the time needed for editing automatically extracted boundaries would be much shorter than for digitising from scratch. However, all interviewees underlined the importance of field verification to successfully implement the automatic approach. The benefit of this method during difficult weather conditions is another advantage over conventional methods.

Looking ahead

In general, the mean-shift segmentation can be implemented on both multispectral and panchromatic images to produce vector files ready to be used in a GIS environment. The method can also capture arbitrarily shaped boundaries and produce closed polygons mainly in non-vegetated and flat terrain. The results obtained are vector files satisfying many cadastral boundary requirements and are ready to be used in a GIS environment. The results suggested that the method worked well for river boundary extraction, road boundary extraction and for boundaries of parcels in relatively open and flat terrain (showing brightness/colour difference around boundaries of parcels). For vegetated areas and for areas with non-visible cadastral boundaries, however, the use of other methods is more advisable. Moreover, more robust comparisons of cost, time and quality – against conventional methods – are needed. Procedures for field verification would also need to be developed.

Further Reading

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- Hyunil, Y., & Handon, J. (2012). An approach to effective land registration based on satellite photogrammetry: case study in Baharly, Ahal Velayat, Turkmenistan. FIG Working Week Rome
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