Spatial data exploration of large-area VHR satellite classification results and derivates through cartographic visualization

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Abstract

Kakamega Forest in western Kenya and its surrounding farmland was the main study area of the BIOTA East Africa project, which aimed at a sustainable use and conservation of biodiversity in Africa [www.biota-africa.de]. For the highly structured agricultural land very high resolution (VHR) QuickBird imagery has been acquired covering 473 km². After thorough pre-processing including corrections of atmospheric and terrain influences as well as mosaicing of two adjacent image swaths [1], the imagery has been classified by means of object-based image analysis. During classification special focus was placed on the optimization of segmentation parameters [2] and the selection of relevant features as part of an integrative work-flow [3].

The classification resulted into 15 classes of land use/cover and a total of over 700,000 individual polygons. When displayed in ArcGIS the dataset needs about 20 seconds to load. A suitable representation of the classification result is possible between the scales of approx. 1:5,000 and 1:25,000, depending on the purpose, leading to map sizes of approx. 7.6 m by 5.4 m and 1.5 m by 1.1 m respectively. This indicates that for overview visualizations the pure display of the classification result is not at all effective; it seems impossible to meaningfully visualize the actual classification result for the complete area under investigation.

Therefore, aggregation is needed in order to explore spatial patterns and thus to gain geospatial knowledge. Ca. 42-ha-sized hexagons were chosen as reference unit for aggregation, covering the area under investigation with in total 1,324 polygons. Based on the classification result, a DEM, as well as additional data retrieved through visual interpretation (i.e. schools and roads), for each individual hexagon parameters of land use (6), landscape structures (4), and accessibility (3) have been derived. Through hierarchical cluster analysis based on Ward's method three typology maps have been created, one for each topic [4]. A fourth synoptic map summarizes all 13 parameters and results in 10 distinct farmland types. The maps created allow the identifying of areas of similar characteristics and thus reveal distinct spatial patterns. From these findings local planning could benefit by adjusting planning activities to the specific needs and problems of people living in similar settings.

As another application of the classification result, scenarios of rural livelihoods have been modelled, again with hexagons as the reference unit. In eight scenarios different developments in crop yields and prices were assumed for four time steps (2005-2020). Here, projections on population growth, an assumed decrease of household sizes, as well as additional area needed due to dividing farms have been accounted for. The modelling output has been summarized for seven map topics, among them household production of important crops and household earnings through the sale of crops, these being the basis for possible 175 distinct thematic maps.

Even though the data is aggregated, simple map print-out and a one-by-one comparison would not be the solution for a comprehensive exploration of the results. In order to identify cause-and-effect chains and to retrieve additional geospatial knowledge, interactive and/or dynamic visualization techniques are required. Therefore, a browser-based tool is implemented that allows for an explorative data analysis through interactive and dynamic cartographic visualizations emphasising on user friendliness. Also this tool can be useful for local planning, especially when linked with the farmland types described above. It could further be used for making the local people aware of upcoming problems they are likely to face under certain circumstances. As many people in East Africa lack experience in map reading [5] the very abstract presentation at hexagon level and the actual 'topographic' situation on the ground is linked through additional large-scale visualizations of present and future land use/cover situations of selected subsets that are integrated into the tool.

We can conclude that the vast amount of geospatial information retrieved by the classification of in particular VHR satellite imagery and the modelling outcomes do on their own not guarantee the exploration of spatial patterns and the gaining of geospatial knowledge. In order to make the information more usable, detailed and aggregated as well as the combined display of cartographic and statistical methods is needed, the latter as discussed in the field of geo-visualization [6]. Here, cluster analysis subsequent to data aggregation and resulting in synthetic maps [7] can be used for identifying regions of similar characteristics within the farmland. Interactive and dynamic visualizations can help to explore relationships especially between different scenarios. Only this way, local planning can fully benefit from such numerous versatile cartographic depictions.

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