Mapping Green Areas and Shadow Inside Cities

-utilizing high spatial resolution orthophotos-

For every aerial imaging service provider, detailed city mapping based on high-resolution imagery may become a very tedious task if image analytics are not highly automated. In such cases, the sheer number of visible objects to be mapped may become enormous. This is especially true for green areas in a city, including parks, gardens and green space along roads. Also, in most circumstances cities show a large and fragmented amount of shadows, coming from man-made structures as well as trees and mobile objects like cars.

The Tama Group now offers a structured methodology for aerial imagery service providers to increase the level of automation for city mapping projects. The methodology centers on automated extraction of green areas and shadowed areas. The effectiveness of the methodology is introduced by COWI orthophotos (30cm), acquired within COWI's HxIP program.

Objects of interest

Green areas and shadowed regions are important spaces, significantly influencing the well-being of citizens. The amount of vegetation describes the suitability of areas for recreational purposes and serves as major carbon sink. Areas covered by shadow can particularly contribute to light deficiency. Especially shadows being cast from tall buildings in narrow urban canyons can create regions without direct sunlight throughout the year. Thus, both features affect the health -positively and negatively- of people in urban environments. Corresponding statistics acquired by the usage of remote sensing data are relevant for city planners as well as retailers and other stake holders.

In this study, high resolution airborne orthophotos (30cm, 16bit) and a digital surface model (derived from orthophotos, 80 cm spatial resolution) are utilized to extract green areas and shadowed regions in combination with a building mask for a part of the city of Bremen, Germany.

For green area and shadow detection, we concentrate on three different study sites, urban, industrial, and rural, characterized by dissimilar amounts of vegetation and impervious surfaces as well as different building types (Fig. 1).

Fig. 1: Rural, urban, and industrial areas as different study sites for green area and shadow detection.

Green areas

In order to detect green areas, especially the near infrared band of the 4-band (R, G, B, NIR) orthophotos is very valuable. The whole process chain is designed for very fast performance, making use of rather simple ruleware. First, the user is able to set a custom value as NDVI threshold. Subsequently, an NDVI image layer is calculated for the entire scene and the image is automatically classified into vegetation and non-vegetation based on the selected NDVI threshold. Furthermore, ruleware for the generalization of the results is applied. This step creates smoother object boundaries. Finally, several statistics and vector data of the resulting classification are exported and the accuracy is checked.

For 100 sample pixels, the agreement with the vegetation classification reaches 99 % and even up to 100 % within the three study sites, demonstrating the accuracy of the analysis even though making use of rather simple ruleware. Smaller classification errors result from strongly shadowed regions next to huge buildings, where the received signal of the NIR is affected significantly. Whilst vegetation cover for the selected industrial region amounts only to 13 %, urban and rural sites feature vegetation coverage of around 40 %. In addition, the mean size of green patches of the industrial area is lowest (75.84 m²). In contrast, the urban (231.98m²) and rural (275.05 m²) sites exhibit larger connected vegetated areas. Similar to this, many more statistics can be extracted automatically.

Fig. 2: Vegetation extracted by Tama ruleware on eCognition for the three different test sites.

Shadow areas

Regions covered by shadow are characterized by dark areas adjacent to elevated objects. Therefore, use is made of the elevation information stored in the DSM. In order to initially create a building mask, the values of the DSM are normalized (nDSM), representing the heights above ground. Then, all elevated objects with low NDVI values are assigned to the building class. Afterwards, a segmentation only for the still unclassified part of the image is performed and shadowed regions are assigned, based on local minima with regard to normalized brightness values. Neighbor objects with similar brightness values of the local minima are then merged to shadow objects. As a next step, the validity of shadow objects is checked. This check occurs by taking adjacent elevated objects into account. Finally, vector data as well as relevant statistics are exported.

In our setup classification accuracies for 100 sample pixels range from 92 % for the city subset, to 94 % for rural areas, and 96 % for industrial areas. Fig. 3 shows a combination of fully automatically extracted shadows, green areas, and the building mask. The highest amount of shadow was found in the selected urban area (20.1 %), whereas rural (9.6 %) and industrial areas (7 %) exhibited significantly less shadow.

Focusing on the common border of shadows and buildings, a similar structure becomes obvious, with urban areas showing the highest amount of shadows caused by buildings in contrast to other elevated objects. Challenges of shadow analysis are caused by the very demanding extraction of an accurate nDSM from a given DSM. This is especially true in industrial areas with very large buildings. And, some small but very bright objects feature high gray values, even though being covered by shadow, and are therefore ignored by the classification routine.

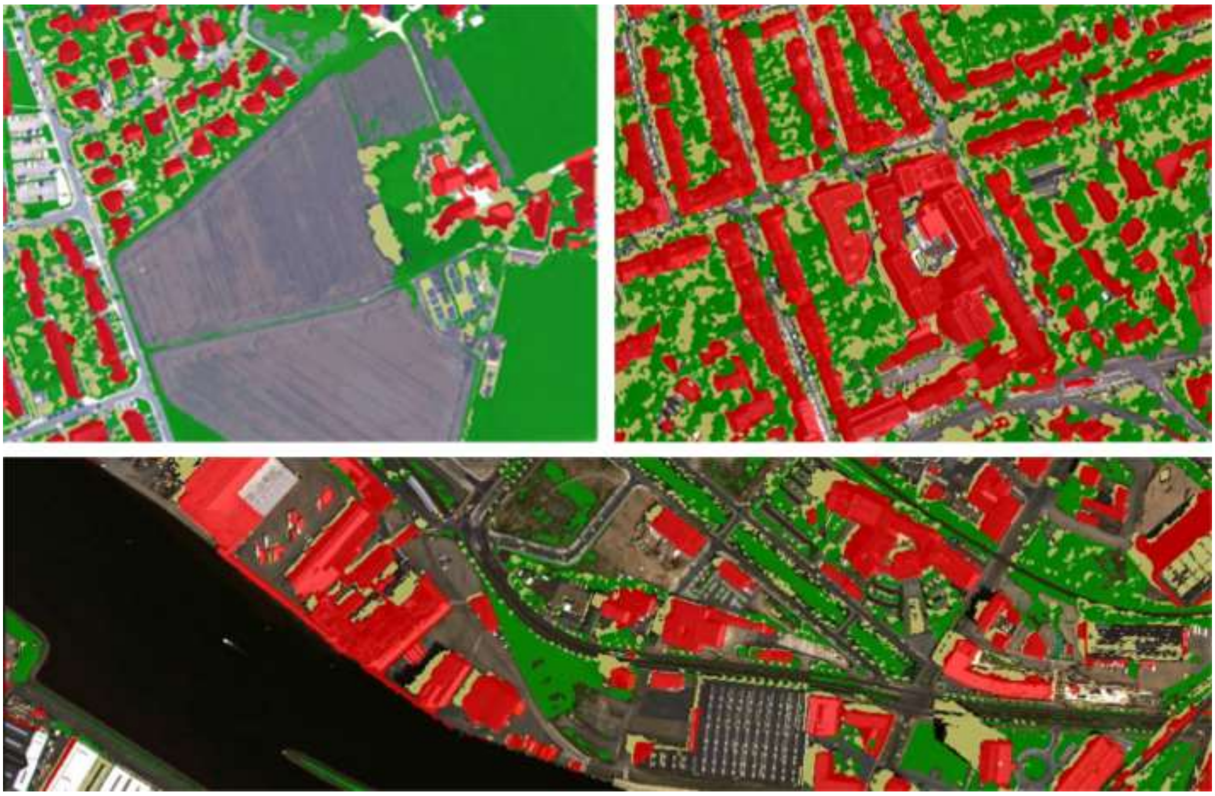

Fig. 3: Shadow (yellow), vegetation (green), and building mask (red) for the three different test sites.

Versatility

Our structured methodology for mapping green areas and shadows inside cities can be adapted and integrated in many ways. All the layers created, including NDVI, nDSM, building mask, shadows and green areas, may be mixed and matched with GIS data and other thematic layers for example.

The versatility of this methodologies allows for many different use cases, both for aerial imaging service providers as well as consumers of the information extracted. All steps introduced are fully automated and can be adapted for large scale batch processing.

Overview of the application of high-resolution RGB data for city mapping

Input data	16 bit airborne orthophotos, 30 cm spatial resolution (Red: 619-651 nm, Green: 525-585 nm, Blue: 435-495 nm, NIR: 808-882 nm) DSM, 80 cm spatial resolution
Preprocessing	Calculation of additional layers (NDVI, nDSM)
Software	eCognition Developer eCognition Server (recommended for large data sets)
Ruleware	Tama Group multistage approach: • Extraction of green areas based on NDVI • Extraction of nDSM and building mask • Calculation of normalized brightness values • Shadow classification based on local minima
Results	Output format: • Image data (JPEG/TIF/PNG) • Maps (SHP) • Statistics

Applications Aerial Imaging
Information Extraction from Orthophotos

Tama Group specializes in automated information extraction, especially in object-based image analysis with eCognition.

We analyze images from various sensors and continue to refine our methods of automating information extraction. In doing so we combine machine learning, deep learning and expert knowledge.

With our **forest portal**, we are able to offer an image-based digital twin of his forest to practically every forestry company. This allows us to provide important information about the managed forest area in a clear manner.

Our **information factories** offer solutions for specific questions in various industrial areas such as agriculture, construction, energy, transport, environmental protection and materials science.

Distribution of Trimble eCognition: We offer an extensive sales, support and training portfolio, including our 4D maintenance package.

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