Hierarchical image analysis of Phoenix’s urban forest structure

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Abstract
This is an object-based, methodology design for analyzing urban structure, specifically vegetation, using remote sensing techniques on high-resolution (Cirrus) airborne photography, utilizing a hybrid of image segmentation and spectral classification. Color imagery can be analyzed and classified spectrally, albeit limited in relation to midinfrared imagery. The advantage of analyzing color imagery is that it is typically collected at a higher resolution than multispectral imagery and is commercially available for many urban and suburban regions. Objects within the urban environment are typically related to specific scales. Therefore, it becomes necessary to be able to analyze objects at their respective scales. For example, vegetation is controlled at the local scale within the urban environment and is best analyzed with high-resolution data, whereas it is inappropriate to analyze broad-scale structure at a higher resolution. Data synthesis among objects of the same scale is problematic for many pixel-based, remote-sensing techniques as all objects are classified at the same scale, the resolution of the pixel. A hierarchically motivated, object-oriented approach takes into account within-pixel spectral values as well as neighborhood characteristics, making possible the extraction of non-leaf objects, improper in shape, as the basis for analysis and can be synthesized across scales. This is achieved through a combination of data-driven (bottom-up) methodologies and knowledge-based (top-down) classification. This technique is in the process of being studied for accuracy to allow for regular monitoring of vegetation change at broad scale with the resolution in the Phoenix basin.

Figure 1. Hierarchical classification scheme for image analysis of Central Arizona-Phoenix. Initially a knowledge-based, top-down approach is used to classify broad land use classes identified by the Maricopa Association of Government. This allows the data-driven, bottom-up approach to be utilized more accurately by applying localized knowledge which is adhered to the specific land use class. For example, the likelihood that any given object in the desert is a building is very low. However, in residential neighborhoods the ability to recognize and classify buildings is mandatory. Therefore, parent classes are able to pass down class descriptors to their respective child classes, allowing for more precise classification.

Figure 2. Image segmentation at varying scales. By analyzing spectral characteristics in concert with neighborhood dynamics, this process subdivides the image into discrete polygonal units at a user-defined scale. Classification is not done at this step. However, once a classification is completed, it is possible to analyze objects of interest at their appropriate resolution, while simultaneously analyzing objects of other scales at their specific resolution.