Abstract:

Recent advances in satellite and airborne cameras have made it possible to acquire new digital images with submetric resolutions for a few years. The latter give us a new insight into natural and man-made environments. In particular, urban areas' studies should really benefit from those new data, especially since one of the main features of urban areas is their 3-dimensional structure. Hence, this thesis belongs to the field of remote sensing of urban areas at a very large scale. We will especially focus on the identification of urban materials. Keeping this in mind, we decided to take advantage of the following physical properties of materials: They reflect different amount of energies depending on their relative orientation towards light sources and observation directions. The main goal of this thesis is to classify urban materials seen in aerial images, by only taking into account their reflection properties, which means by identifying their Bidirectional Reflectance Distribution Functions (BRDF).

To achieve our ends, we have overlapping, large-band, coloured aerial images, and a segmented 3D model of the urban areas of interest. A surface, like a roof, is usually seen on around 10 images, i.e. from 10 view angles. The identification of materials' BRDF essentially boils down to inverting the radiative transfer equation explaining the formation of images. Using the images, and knowledge on the shooting conditions, it means being able to evaluate the irradiances received by the observed surfaces, and the radiances measured by the camera. The material BRDFs are computed from those data, and finally a clustering of the observed materials can be done. Thus, the method basically comes in three steps: First, to understand and model the most important radiometric terms in urban areas; Second, to write a radiometric equation explaining the formation of the images and to invert it; Third, to cluster the surfaces effectively.

We first studied the physical processes explaining the irradiances received by the surfaces and the radiances measured by the digital camera. We especially set up a computer code simulating the irradiances measured in urban scenes, taking into account the shooting conditions, and in particular the atmospheric conditions. This program is all the more interesting as it enables us to correct shadows quite well in dense urban areas, validating the different irradiance terms.

Knowing the most important radiometric terms, we could write a radiometric equation linking irradiances due to the light sources, radiances measured by the camera, and materials' BRDF. After the choice of a relevant parametric BRDF model (Torrance-Sparrow-Oren-Nayar model), we could invert the radiometric equation. As a result, we obtained parameters of the BRDF model for every surface.

Finally, we clustered the different surfaces. We used a new measure of similarity between BRDF models, in order to overcome ambiguities and bad determinations of parameters during the previous inversion. Results show that using reflectance properties of materials is indeed interesting to classify them, but limitations of the method are also highlighted.