GENERIC OBJECT RECOGNITION IN HIGH RESOLUTION SAR IMAGES

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Many users of Earth observation SAR images are only interested in individually selected application tasks. Thus, instead of applying universal data analysis tools, SAR users often aim at interactively controlled feature determination based on object size, object motion, double bouncing, or occultation.

In contrast to these typically geometry-driven approaches, we propose a combined radiometry/morphology-driven approach that allows us to detect, identify and classify arbitrary and unexpected objects being "machine visible" in high resolution SAR images. Thus, we can look for any kind of generic object being characterized by specific brightness and shape feature combinations. The initial object selection will be made interactively by clicking on positive and negative examples. Detected similar and dissimilar objects will then be put into categories that typically comprise two dozen cases. The advantage of this technique is that we can fully explore the data space without being limited by the capabilities of the human visual system. In particular, this becomes a clear advantage when we have to deal with speckled SAR images and their visually annoying appearance.

The proposed approach is motivated by the characteristics of typical high resolution remote sensing SAR images. On the one hand, we see extended surface areas such as forests or ocean surfaces: their main criteria are overall brightness and texture. On the other hand, we can also see an enormous number of small-scale details especially in urban areas, where three-dimensional effects and multiple scattering have to be taken into account [1]. Since typical SAR images taken from satellites often contain both large-scale and small-scale objects, we have to cover both cases. In order to solve these issues, we resort to descriptors that provide a universal and robust representation of arbitrary scene content. In particular, we have to deal with fully developed speckle of extended objects as well as with peculiar reflection effects of small-scale facets that become visible in high resolution images.

Our method starts with the ingestion of images to be analyzed. Each image will be decomposed into adjacent and partly overlapping tiles. Then feature vectors will be extracted from each tile. Each feature vector comprises several elements that describe the most important properties per image location. To reduce the data volume the selected image locations are taken from a sub-sampled pixel grid. In most cases, the sub-sampling step does not affect the description quality.

The feature vectors transform the two-dimensional information contained in the image tiles (of typically 200 * 200 pixels) to an extremely compact data structure. This highly compact set of descriptors opens the way toward efficient image comparisons. We can apply our technique both to detected SAR data as well as to complex-valued images [2]. In both cases, the descriptors can be clustered to obtain a representation amenable to classification and the definition of categories.

By combining the information derived from adjacent tiles, an entire image can be described by a so-called feature map. This feature map is independent from any user application and can be understood as an extended image annotation similar to a quick-look image.

The use and interpretation of these feature maps requires a feature browser or an attached image search engine. In our case, we use an image search engine comprising a Bayesian inference stage to learn categories together with a support vector machine classifier to assign user-defined semantics to images [3]. The resulting categories are grouping and memorizing the semantics of image structures; thus, they facilitate their recognition in various contexts. The generation of categories helps learning from a small training data set (i.e., user selected image examples). As a consequence, the method is also useful for the exploitation of very large data volumes where we search for similar scene content across many images.

One of the clear advantages of our system is its capability to handle and analyze detected as well as complex-valued SAR image data. Thus, any phase effects in the backscattered signals can be exploited. This allows the recognition of inhomogeneous or moving targets [4]. Typical examples are classical sub-band analysis goals: the detailed analysis of isolated buildings, towers, pylons, or the analysis of moving, rolling, or pitching ships. Moving trains represent an additional class of objects as their extended length can be exploited to fit motion effects over several pixels resulting in high accuracy velocity measurements.

Ongoing activities aim at assessing the impact of additional de-speckling and at understanding the physical origin of the observed phenomena. Our goal is to decompose the available image information into physical building blocks being responsible for the observed signals. This can be reached by comparing the signatures of selected objects with their physical structure. Since we can concentrate on a few established test sites with known targets, we are confident to obtain reliable results.

A point that still needs more attention is the combination of SAR and optical image data when we want to exploit their joint information. There are two points to consider. Firstly, according to our experience, we have to use different features for each kind of image data. Thus, a direct feature-to-feature comparison is not feasible. Secondly, we have to work with correctly co-aligned data. When we want to avoid phase interpolation effects in the case of single-look complex SAR data, this would necessitate a distortion of optical data to adapt them to the geometry of the SAR data acquisition.

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