Texture Based Identification of Informal Settlements in Curvelet and Contourlet Feature Space

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Abstract: Many cities in the developing world are facing rapid growth of dynamic informal built-up areas characterized by sub-standard housing conditions. However, detailed and up-to-date information on their locations and analysis of development dynamics is limited. Despite several studies, the task of identifying informal settlements remains a challenge. Formal settlements and other land cover classes are mapped sufficiently with distinct features, however this does not hold for informal settlements. Due to their microstructure and instability of shape, the detection of these settlements is substantially more challenging. Hence, more sophisticated multi-scale methods of image analysis are necessary, which act as a spatial basis for informal settlement identification. Multiresolution analysis (MRA) has been successfully used in texture analysis. Given that texture too occurs at multiple scales in the image, multiresolution approaches to texture analysis are more likely to perform better than other approaches. Traditionally, wavelet transforms have been very popular for MRA but they are constrained in their ability to capture directional information beyond horizontal, vertical and diagonal. The wavelet transform uses a particular set of basis functions, which are defined by roughly isotropic functions present at all scales and locations. Therefore, it is more appropriate for isotropic features or slightly anisotropic features.

This paper proposes a texture based scheme using newly developed curvelet and contourlet based multiresolution methods to capture anisotropic features for informal settlement area identification. The use of curvelets and contourlets for image segmentation by texture, particularly in the context of remotely sensed image analysis is limited, and it is the aim of this paper to explore these relatively new multiresolution techniques for this application. The proposed method consists of two steps; first textural information in terms of statistical moments are extracted at various scales and in different directions with the help of curvelet and contourlet transforms and in the second step identification is done using different classifiers.

To delineate slum areas, image segmentation is performed as pixel-level classification for three classes: informal settlements, formal built-up and non-built-up areas. For each of the three classes, image tiles are randomly selected using ground truth observations. An IRS-1C

satellite’s panchromatic sensor image and worldview-2 image of part of Mumbai city are considered. This resolution is well suited for texture analysis since it is not adequate to extract individual buildings or narrow roads but groups of them render a visible checked pattern in dense urban areas. Since every subband decomposed from the MRA is not useful for texture identification, significant features are selected using the Principal Component transform (PCT). To reduce the computational complexity and save memory the incomplete tree-structured wavelet-based MRA is also employed and compared with the method using PCT.

A comparative analysis is carried out using minimum distance to mean, support vector machines and random forest classifiers. The performance is evaluated in terms of sensitivity, specificity, precision and overall accuracy. It is found that the proposed method shows better class-discriminating power as compared to existing methods and overall classification accuracy of 91.4–96.8%.

Keywords: informal settlements, texture analysis, multiresolution, curvelet, contourlet