Unified fusion of satellite imagery for seasonal terrestrial habitat mapping in Hong Kong

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ABSTRACT

Current satellite sensor systems have two major technical limitations: (1) the incoming radiation energy to the sensor, and (2) the data volume collected by the sensor [1]. These lead to the dilemma that improving a satellite sensor's spatial resolution may only be achieved at the cost of losing some other advantages of satellite instruments, such as spectral resolution, temporal resolution, and radiometric resolution. Consider the Landsat 7 ETM+ sensor and the MODIS (Moderate-resolution Imaging Spectroradiometer) sensor as an example. The ETM+ data possess high spatial resolution (30 meters), low temporal resolution (16-day revisit cycle), and low spectral resolution (bandwidth of approximately 70-200 nm in visible and infrared (VIR) bands). By contrast, the MODIS data possess low spatial resolution (250/500/1000 meters), high temporal resolution (daily revisit cycle), and high spectral resolution (bandwidth of approximately 10-50 nm in VNIR bands). However, the remote sensing data that are available to researchers may not be the data they actually need [2].

One possible solution to this problem is data fusion. Since the 1980s, numerous spatio-spectral fusion methods have combined multispectral (MS) bands with a panchromatic (PAN) band image to produce MS images with the spatial resolution of PAN. Reviews of these pan-sharpening methods can be found in [5]-[9]. These methods have also been extended to merge hyperspectral images with a PAN band [10]. Similarly, to obtain images with both high spatial and temporal resolution, many spatio-temporal fusion methods applied to different

sensors have been developed since the 1990s [11]-[13]. However, little work has so far been done to explore a unified fusion of satellite images to generate high spatio-temporal-spectral resolution simultaneously.

By formulating the spatio-temporal fusion and spatio-spectral fusion into one general problem, i.e. super resolving a low spatial resolution image with a high spatial resolution image acquired under different conditions (e.g. at different times or in different acquisition bands), we propose a notion of unified fusion that can accomplish both spatio-temporal fusion and spatio-spectral fusion in one process. An image super-resolution method is, thus, developed to perform both spatio-temporal fusion and spatio-spectral fusion in a similar manner.

The proposed method has been applied to generate Landsat 8 – like satellite images with the temporal resolution and spectral resolution of MODIS. These images were then used to produce seasonal habitat maps in Hong Kong [14]. Twenty five habitat categories were defined; they are Fung Shui Forest, Montane Forest, Lowland Forest, Mixed Shrubland, Freshwater/Brackish Wetland, Natural Watercourse, Mangrove, Seagrass Bed, Intertidal Mudflat, Shrubby Grassland, Baeckea Shrubland, Plantation or Plantation/Mixed Forest, Fishpond/Gei Wai, Sandy Shore, Rocky Shore, Cultivation, Bare Rock or Soil, Grassland, Modified Watercourse, Artificial Rocky/Hard Shoreline, Golf Course/Urban Park, Quarry, Rural Industrial Storage/Containers, Landfill, and Other. To produce the habitat maps with twenty five categories, the PAN band (15 meter spatial resolution) of Landsat was fused with the multi-spectral bands of Landsat, and so the satellite images used for classification had the spatial resolution of 15 meters. Such images were also fused with MODIS images so that the images at four dates in 2013 representing the four seasons were generated with the fine spectral resolution of MODIS to improve the habitat classification accuracy. In the afore-mentioned way, the seasonal habitat maps can then be generated and their associated habitat quality evaluated. Given the seasonal maps, the change of habitat quality over different seasons can be viewed. In the presentation, we will report to you the process and methods of generating the seasonal habitat maps and the accuracy associated with the maps. We will elaborate the impossibility without the use of unified fusion. In other words, the advantages of the unified fusion will be demonstrated and highlighted.

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