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Automatic Mapping of Urban Area in High Resolution with ASTER Satellite Images

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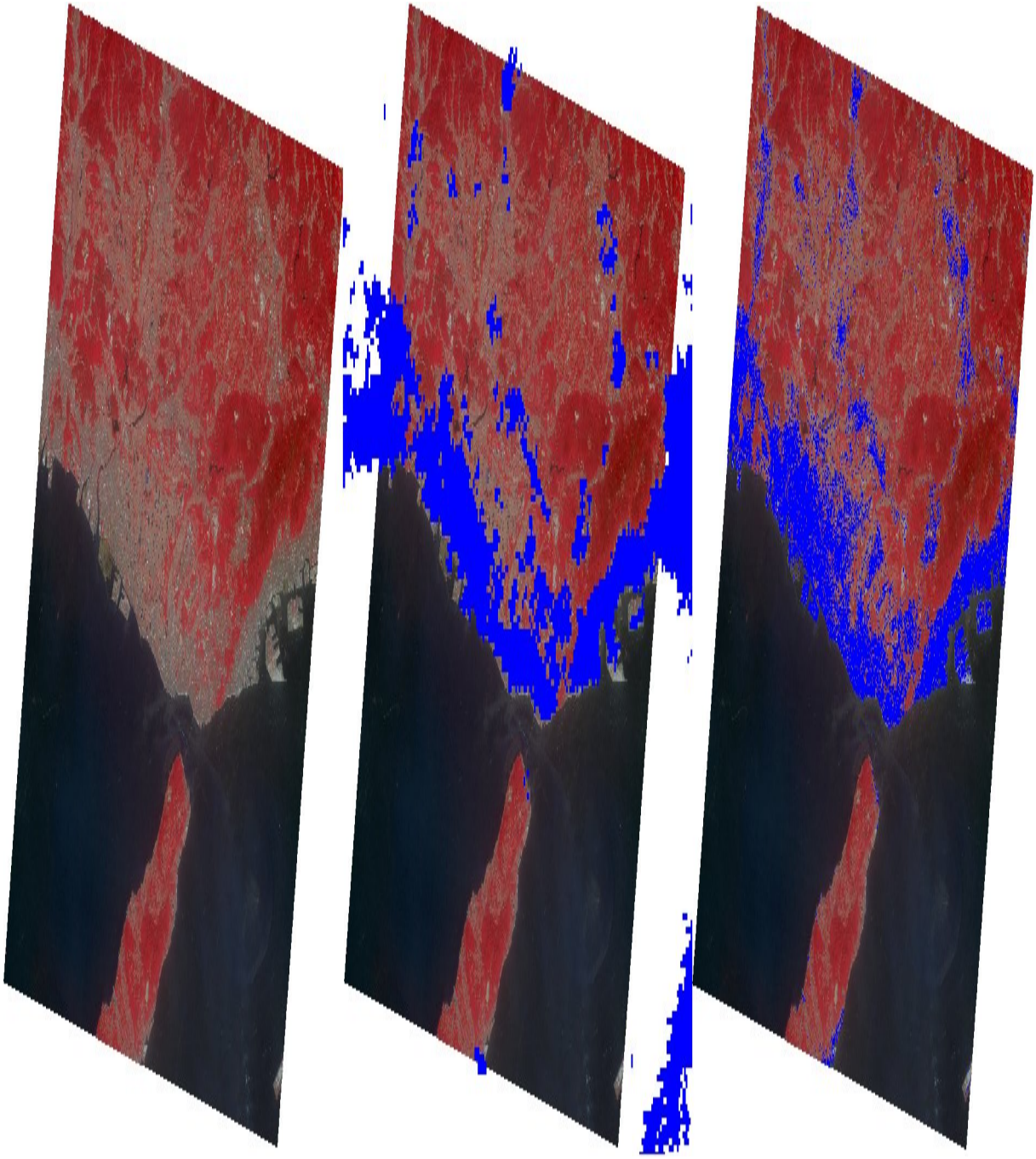

Global urban map in high resolution is urgently needed for further insights on urbanization, especially for developing countries which have been less documented. To address the issue, we present automatic algorithm for developing global urban area map from high-resolution satellite images using Learning with Local and Global Consistency (LLGC) technique and integration with existing urban area maps using logistic regression.
For global urban area mapping in high resolution, automatic processing on high-resolution satellite images is essential. Previous studies applied unsupervised clustering method to high-resolution satellite images; however identifying 'urban' or 'non-urban' for each cluster with human visual interpretation is needed because the clusters in satellite images does not have any information for classifying the clusters into 'urban' or 'non-urban'. To solve the obstacle for automation, we employed existing urban area map of coarse resolution to assign 'urban' or 'non-urban' to each cluster. However, the gap in spatial resolution between high-resolution satellite image and existing urban area map induces inconsistency in pixel values of cluster and assigned classes. In order to reduce the inconsistency cause by the gap, we applied Leaning with Local and Global Consistency (LLGC) technique for classifying the clusters into 'urban' or 'non-urban'. LLGC is a technique to correct roughly labeled classification into smoothly classified result. The technique is very appropriate for our case, in which roughly labeled clusters in coarse resolution should be corrected based on high-resolution satellite images.
Though LLGC would provide successful classification, the result could include misclassifications due to similarity in surface reflectance of urban area and the other non-vegetated land cover (e.g. bare land and sand). To correct the misclassification, we integrated the LLGC-derived map with existing urban area map and miscellaneous data by employing logistic regression. In existing urban area map, 'urban' is more probable around urban centre than around urban fringe, thus we introduced distance from boundary of urban area of existing urban area map as variable of the regression. We also introduced slope derived from DEM to the regression considering significant relationship between urbanization and terrain, which indicates that hilly terrain likely to prevent urbanization.
According to the consideration mentioned above, we implemented a series of procedure automated with LLGC and logistic regression using ASTER satellite images, MCD12Q1, MOD12Q1, GRUMP/Urban Extent Grid and DEM derived from ASTER satellite images. We had experiment against 340 scenes of ASTER satellite images and acquired estimated urban area in 15m resolution for the scenes. Accuracy assessment against the result showed that the accuracies were 78% for user's accuracy, 57% for producer's accuracy, 91% for overall accuracy and 0.92 for kappa coefficient. Overall accuracies and kappa coefficients of our estimation were higher than LLGC-derived maps and existing urban area maps, indicating that the classification accuracy was improved by the integration.
The figure shows the result around Kobe, Japan, comparing false color composite of ASTER satellite image (left), 'urban and build-up area' class of MCD12Q1 (middle) and estimated urban area with our method (right). The estimated urban area with our method represents spatial structure of urban area in 15m resolution much finer than MCD12Q1 of 500m resolution, with which the spatial structure was filled with a few number of pixels.
The proposed method will be practically useful for improving accuracy and spatial resolution of global urban area maps. The high-resolution global urban area map developed with the method will encourage providing deeper insights on urbanization not only for developed countries but also for developing countries through regionally and internationally comparative studies.

Keywords: ASTER, urban area, high-resolution mapping, logistic regression, LLGC