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Deep-Learning Coupled with Pragmatic Categorization Method to Classify the Urban Environment of the Developing World

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Abstract : Thomas Friedman, in his famous book, argued that the world in this 21st century is flat and will continue to be flatter. This is attributed to rapid globalization and the interdependence of humanity that engendered tremendous in-flow of human migration towards the urban spaces. In order to keep the urban environment sustainable, policy makers need to plan based on extensive analysis of the urban environment. With the advent of high definition satellite images, high resolution data, computational methods such as deep neural network analysis, and hardware capable of high-speed analysis; urban planning is seeing a paradigm shift. Legacy data on urban environments are now being complemented with high-volume, high-frequency data. However, the first step of understanding urban space lies in useful categorization of the space that is usable for data collection, analysis, and visualization. In this paper, we propose a pragmatic categorization method that is readily usable for machine analysis and show applicability of the methodology on a developing world setting. Categorization to plan sustainable urban spaces should encompass the buildings and their surroundings. However, the state-of-the-art is mostly dominated by classification of building structures, building types, etc. and largely represents the developed world. Hence, these methods and models are not sufficient for developing countries such as Bangladesh, where the surrounding environment is crucial for the categorization. Moreover, these categorizations propose small-scale classifications, which give limited information, have poor scalability and are slow to compute in real time. Our proposed method is divided into two steps-categorization and automation. We categorize the urban area in terms of informal and formal spaces and take the surrounding environment into account. 50 km × 50 km Google Earth image of Dhaka, Bangladesh was visually annotated and categorized by an expert and consequently a map was drawn. The categorization is based broadly on two dimensions-the state of urbanization and the architectural form of urban environment. Consequently, the urban space is divided into four categories: 1) highly informal area; 2) moderately informal area; 3) moderately formal area; and 4) highly formal area. In total, sixteen sub-categories were identified. For semantic segmentation and automatic categorization, Google's DeeplabV3+ model was used. The model uses Atrous convolution operation to analyze different layers of texture and shape. This allows us to enlarge the field of view of the filters to incorporate larger context. Image encompassing 70% of the urban space was used to train the model, and the remaining 30% was used for testing and validation. The model is able to segment with 75% accuracy and 60% Mean Intersection over Union (mIoU). In this paper, we propose a pragmatic categorization method that is readily applicable for automatic use in both developing and developed world context. The method can be augmented for real-time socio-economic comparative analysis among cities. It can be an essential tool for the policy makers to plan future sustainable urban spaces.

Keywords : semantic segmentation, urban environment, deep learning, urban building, classification
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