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Geovisualisation for Defense Based on a Deep Learning Monocular Depth Reconstruction Approach

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Abstract : The military commanders increasingly dependent on spatial awareness, as knowing where enemy are, understanding how war battle scenarios change over time, and visualizing these trends in ways that offer insights for decision-making. Thanks to advancements in geospatial technologies and artificial intelligence algorithms, the commanders are now able to modernize military operations on a universal scale. Thus, geovisualisation has become an essential asset in the defense sector. It has become indispensable for better decisionmaking in dynamic/temporal scenarios, operation planning and management for the war field, situational awareness, effective planning, monitoring, and others. For example, a 3D visualization of war field data contributes to intelligence analysis, evaluation of postmission outcomes, and creation of predictive models to enhance decision-making and strategic planning capabilities. However, old-school visualization methods are slow, expensive, and unscalable. Despite modern technologies in generating 3D point clouds, such as LIDAR and stereo sensors, monocular depth values based on deep learning can offer a faster and more detailed view of the environment, transforming single images into visual information for valuable insights. We propose a dedicated monocular depth reconstruction approach via deep learning techniques for 3D geovisualisation of satellite images. It introduces scalability in terrain reconstruction and data visualization. First, a dataset with more than 7,000 satellite images and associated digital elevation model (DEM) is created. It is based on high resolution optical and radar imageries collected from Planet and Copernicus, on which we fuse highresolution topographic data obtained using technologies such as LiDAR and the associated geographic coordinates. Second, we developed an imagery-DEM fusion strategy that combine feature maps from two encoder-decoder networks. One network is trained with radar and optical bands, while the other is trained with DEM features to compute dense 3D depth. Finally, we constructed a benchmark with sparse depth annotations to facilitate future research. To demonstrate the proposed method's versatility, we evaluated its performance on no annotated satellite images and implemented an enclosed environment useful for Geovisualisation applications. The algorithms were developed in Python 3.0, employing open-source computing libraries, i.e., Open3D, TensorFlow, and Pythorch3D. The proposed method provides fast and accurate decision-making with GIS for localization of troops, position of the enemy, terrain and climate conditions. This analysis enhances situational consciousness, enabling commanders to fine-tune the strategies and distribute the resources proficiently.

Keywords : depth, deep learning, geovisualisation, satellite images
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