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Coupling deep learning and GIS for forest damage assessment based on high-resolution remote sensing data

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Due to global warming, natural disasters such as thunderstorms are becoming more frequent. Such events have a strong impact on forest health and wildlife habitat, inflicting economic losses. Methods to quickly assess damage and to manage disaster in the aftermath of storm events are of high importance for the management. Due to the large areas affected by storms, assessing the damage in a forest is time consuming, if done manually using aerial imagery and GIS tools. As time is a crucial factor in disaster management, integrating deep learning with remote sensing data into a GIS environment holds a high potential for accelerating and improving damage assessment. Convolutional neural network (CNN), a supervised learning architecture, is extensively used in many areas (e.g. interpretation of medical images, 3D reconstructions, objects detection and classification in self-driving cars). They are efficient in finding patterns within a large amount of data and are widely used in computer vision and recognition in images. We develop an algorithm based on CNNs that are trained on labeled damaged areas visible in after-storm aerial orthophotos (RGB and NIR, 0.2 m spatial resolution) of a large forest area in Bavaria (~109 square km). Integration into ArcGIS was achieved with the Python API and Jupyter Notebooks. We investigate two CNN architectures: considering the four bands (RGB + NIR) as independent and trying to find features in each band independently (2-dimensional convolution); and looking for patterns in of the image space of all four bands (3-dimensional convolution). In preliminary results, the CNN trained using only 100 000 pixels of labeled data could perform, within seconds (depending on the size of the input raster), a detection with a score of over 90% based on the intersection over union metric. These results are promising, considering the complexity of detecting areas of fallen trees. A next step will be to use a second CNN architecture to quantify timber losses due to the storm in terms of volume in addition to a real damage. We will also consider further optimization of the algorithm by assessing the optimal ratio of true positives to false negatives, based on a decision analysis. Overall, our results highlight the potential of deep learning on high resolution imagery for damage assessment following disasters.

Biography

Zayd Mahmoud Hamdi studies Environmental Engineering at the Technical University of Munich focusing on Remote Sensing. As a part of his Master thesis, he is investigating in collaboration with ESRI Germany and the Bavarian Forestry Ministerium, the coupling of deep learning and GIS, using high-resolution remote sensing data to assess storm damages in forests.

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