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Damage Assessment for Disaster Relief Efforts in Urban Areas Using Optical Imagery and LiDAR Data

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Imagery combined with LiDAR data and LiDAR-derived products provides a significant source of geospatial data which is of use in disaster mitigation planning. Feature rich building inventories can be constructed from tools with 3D rooftop extraction capabilities, and two dimensional outputs such as DSMs and DTMs can be used to generate layers to support routing efforts in Spatial Analyst and Network Analyst workflows. This allows us to leverage imagery and LiDAR tools for disaster mitigation or other scenarios.

Software such as ENVI, ENVI LiDAR, and ArcGIS® Spatial and Network Analyst can therefore be used in conjunction to help emergency responders route ground teams in support of disaster relief efforts.

This is exemplified by a case study against the background of the magnitude 7.0 earthquake that struck Haiti's capital city of Port-au-Prince on January 12, 2010. Soon after, both LiDAR data and an 8-band WorldView-2 scene were collected to map the disaster zone. The WorldView-2 scene was orthorectified and atmospherically corrected in ENVI prior to use.

ENVI LiDAR was used to extract the DSM, DTM, buildings, and debris from the LiDAR data point cloud. These datasets provide a foundation for the 2D portion of the analysis. As the data was acquired over an area of dense urbanization, the majority of ground surfaces are roads, and standing buildings and debris are actually largely separable on the basis of elevation classes.

To extract the road network of Port-au-Prince, the LiDAR-based feature height information was fused with the WorldView-2 scene, using ENVI's object-based feature extraction approach. This road network was converted to a network dataset for further analysis by the ArcGIS Network Analyst.

For the specific case of Haiti, the distribution of blue tarps, used as accommodations for refugees, provided a spectrally distinct target. Pure blue tarp pixel spectra were selected from the WorldView-2 scene and input as a reference into ENVI's Spectral Angle Mapper (SAM) classification routine, together with a water-shadow mask to prevent false positives.

The resulting blue tarp shape file was input into the ArcGIS Point Density tool, a feature of the Spatial Analyst toolbox. The final distribution map shows the density of blue tarps in Port-au-Prince and can be used to roughly delineate camps of refugees.

Analogous, a debris density map was generated after separating the debris elevation class. The combination of this debris density map with the road network allowed to construct an intact road network of Port-au-Prince within the ArcGIS Network Analyst. Moderate density debris was used as a cost-increase barrier feature of the network dataset, and high density debris was used as a total obstruction barrier feature.

Based on this information, two hypothetical routing scenarios were analyzed. One involved routing a ground team between two different refugee concentration zones. For the other, potential helicopter landing zones were computed from the LiDAR-derived products and added as facility features to the Network Analyst. Routes from the helicopter landing zones to refugee concentration access points were solved using closest facility logic, again making use of the obstructed network.