A GIS-based Approach for Segmenting the Northern Border of the United States into Monitoring Zones

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Extended Abstract

The border between the United States and Canada is one of the longest borders in the world, spanning approximately 7500 kilometers. The United States Customs and Border Protection Agency is responsible for securing and guarding the nation's borders, safeguarding the American homeland against terrorism, and enforcing the laws of the United States. The Border Patrol currently utilizes several technologies to assist them in their mission, including camera surveillance, night vision, thermal imaging, ground-based sensors, and geographic information systems (GIS). However, it is not practical to closely monitor the entire border using these techniques alone. The remote sensing approach offers the potential to efficiently monitor such expansive areas within the border region by providing information on illegal activities. Still, it is not practical to regularly monitor all of the US – Canada border. Therefore, it is necessary to divide the border into monitoring regions, or segments, to prioritize monitoring activities according to the area's potential for illegal activities. Further, segments to be monitored may have unique remote sensing requirements based upon terrain and land cover conditions that affect the choice of remote sensing platform, sensor, and/or image analysis methods.

The objective of the research was to demonstrate the utility of a fuzzy K-means clustering approach using nationwide land cover and terrain datasets to divide the northern border of the contiguous United States into segments with unique potential for illegal immigration/smuggling and unique remote sensing requirements. Terrain and elevation data utilized for the analysis were the 2001 National Land Cover Dataset and US Geological Survey National Elevation Dataset, respectively. Six variables were extracted from these datasets that relate to illegal immigration/smuggling potential and remote sensing requirements. These were land cover, elevation, slope, aspect, road presence, and road density.

The fuzzy K-means clustering method grouped pixels with similar characteristics together which eventually resulted in individual segments that are similar in land cover, terrain, and road presence/density conditions. Conversely, these conditions are different between segments. Four products were generated with this process using different combinations of input variables in order to indicate the effect of the derived road presence and road density variables on the segmentation results. Input variables and the resulting number of classes vary between the four products but the land cover types that cover the majority of the segments for all four products are the same. In addition, a general pattern is visible throughout the border strip for all four segmentation results. The key differences in the segmentation results were the number of distinct classes and the location and length of the actual segments.

The segmentation product that utilized all six input variables is considered to be the most robust because it utilized both road variables, in addition to the land cover and terrain data. The segmentation procedures implemented here demonstrate that the U.S.-Canada border may be divided into segments for monitoring, based upon nationwide terrain and land cover data sets. Because it is not practical to regularly monitor the nation's border in its entirety, these segments may assist in developing and prioritizing monitoring methods according to unique remote sensing requirements as well as potential for illegal immigration and smuggling for individual segments.