Anomaly Detection and Image Classification for Multispectral and Hyperspectral Images

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This research initiative looks to develop a framework for the application of statistics and machine learning to the classification of multispectral and hyperspectral aerial images. In the envisioned scenario, an unmanned aerial vehicle (UAV) is flown over an area of interest with an attached camera taking regular images of the ground below. Often, these images are to be stitched together to create a spectral map of the monitored area, which can then be used for a variety of applications. This image stitching is done automatically by dedicated programs. However, due to instability and inconsistencies inherent in light aircrafts, the camera may not always be pointed normally at the ground. In extreme cases, the UAV may tilt or bank to a point where certain images are irreconcilable with the surrounding images. In these situations, the anomalous images may cause the image stitching process to fail or perform poorly. The goal of this research project is primarily to develop a system for identifying such anomalous images in pseudo-real time, thereby allowing them to be retaken and improving the performance and output of the subsequent image stitching process. An underlying assumption in this study is that, under normal operating conditions, there is significant geographical overlap between consecutive images, making their empirical pixel distributions statistically correlated. Our current imaging setup targets an overlap of 0.75 between consecutive images, meaning that 75% of the content of one image should be present in adjacent images. Leveraging this redundancy attribute, we apply several statistical techniques from image processing, as well as from machine learning, to identify images which do not contain an acceptable level of overlap with their spatiotemporal neighbors. Such images are immediately flagged, and the flight path of the UAV can be altered to retake pictures at invalidated locations.

Texas A&M University features an extensive precision agriculture program, which incorporates information from multispectral and hyperspectral images acquired via aerial vehicles. For training and validation, we employ multiple data sets composed of flight images from various aerial vehicles and monitored areas. As an initial step, experts conduct a visual inspection of individual images and classify them as successes or failures. The lableled data is then partitioned into training and cross-validation sets, and fed into our detection algorithms. A secondary, related theme of this research initiative is the clustering and segmentation of multispectral or hyperspectral images in the context of precision agriculture. Due to the nature of spectral signatures, hyperspectral images possess structure in both the spatial and frequency domains. This allows for another dimension of analysis with regards to image processing; these images are readily amenable to sparsity analysis. Harnessing emerging techniques for statistical problems with sparse structures is an ongoing initiative within the context of this research project, along with optimizing the acquisition process in term of altitude, filtering and lens selection. The ultimate goal of the project is to enable the autonomous collection of pertinent agricultural data that can translate into rapid research cycle and enhanced field production.