ROBUST IMAGE CLASSIFICATION ALGORITHMS FOR MULTISPECTRAL AND HYPERSPECTRAL DATA IN REAL-TIME ENVIRONMENTS

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by

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ABSTRACT

Image classification is one of the most prominent techniques of analysis for image interpretation and information mining tasks. It has been applied in a wide variety of remote sensing image-driven applications. The quality and operational-level utility of information from remote sensing imagery is primarily influenced by the adaptability of classification methods for information mining from imagery in a time-critical manner and with minimal human expert's involvement. The development of efficient image classification algorithms is essential to cope-up with the ever-changing and ongoing requirements of real-world applications. As a concrete example, advances in remote sensing such as very high-resolution multispectral images (MSIs) and hyperspectral images (HSIs) have opened up and fostered new opportunities in expanding the horizons of mapping applications using remotely-sensed imagery. In recent years, the increasing availability of high spatial-spectral resolution imaging has been evolving as the viable and cost-effective remotely sensed data source in various high precision and high accuracy remote sensing applications from the land surface and industrial perspectives. The bulk of classification approaches available offer good performance for the ideal scenario of having priori comprehensive ground truth information on the type, number, and spatial distribution of information classes in the imagery. In a realistic environment of imagery acquisition, these requirements are rarely met and there is always a demand for more ground truth information and hence better training of the classification model. As a result, most of the existing techniques are not efficient for the classification tasks under uncertainties such as *unseen*, *unknown*, and *dynamic environments* in terms of accuracy, training information dependencies, and minimizing computation times in a firm or near real-time environment, especially for high dimensionality data like HSIs.

The aim of this thesis is the development of efficient and robust image classification algorithms based on supervised learning approaches that are suitable for both static and dynamic real-time operational environments. To realize this aim, four different strategies,

aka objectives, are considered in this study using various MSIs and HSIs of different spatial and spectral resolutions to realize the intended objective. First, a field-programmable gate array (FPGA) based real-time decision intelligence system architecture is designed using low-complexity rapid prototyping tools. Second, a novel classifier is developed that maintains stable classification performance in both static and dynamic environments. Third, a new category of shadow and illumination invariant image classification algorithms is proposed. Besides, a novel mechanism to determine the optimal threshold for the proposed version of spectral similarity matching methods (SMMs) is also proposed. Finally, a new category of open-set classifiers that combine the advantages of a hardware accelerator, i.e., FPGA-based real-time processing and open-set classification is proposed. A new classification model architecture is also presented to get the time-critical computational benefit of the proposed open-set classifier. A thorough experimental evaluation using different MSIs and HSIs, captured from multi-sensor and multi-platform modalities, demonstrates the proposed algorithms' practical and robust classification performance. The contributions of this thesis, methods, and algorithms for remote sensing imagery classification in real-time or near real-time perspective are vital in helping realize automatic image analytic workflows in operational stream imagery analyses application.