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Crop Field Boundary Delineation using Historical Crop Rotation Pattern

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Abstract— GIS data layer on crop field boundary has many applications in agricultural research, ecosystem study, crop monitoring, and land management. Crop field boundary mapping through field survey is not time and cost effective for vast agriculture areas. Onscreen digitization on fine-resolution satellite image is also labor-intensive and error-prone. The recent development in image segmentation based on their spectral characteristics is promising for cropland boundary detection. However, processing of large volume multi-band satellite images often required high-performance computation systems. This study utilized crop rotation information for the delineation of field boundaries. In this study, crop field boundaries of Iowa in the United States are extracted using multi-year (2007-2018) CDL data. The process is simple compared to boundary extraction from multi-date remote sensing data. Although this process was unable to distinguish some adjacent fields, the overall accuracy is promising. Utilization of advanced geoprocessing algorithms and tools on polygon correction may improve the result significantly. Extracted field boundaries are validated by superimposing on fine resolution Google Earth images. The result shows that crop field boundaries can easily be extracted with reasonable accuracy using crop rotation information.

Keywords— Crop Rotation, Crop Field, Agriculture, CDL, Field Boundary

I. INTRODUCTION

The size, shape, pattern, and spatial distribution of crop field represent the cadastral system, land tenure, agriculture practice, landscape, and topographic setting of an area [1]. Land fragmentation is also related to several environmental factors such as biodiversity, ecosystem, and diversity of cropland species [2]. Accurate information on agricultural field boundaries is precious to many aspects in agriculture management including but not limited to land demarcation, land utilization, resource allocation, and economic planning [3]. Crop field boundary information is important to study of crops by remote sensing [4]. The extent of agricultural field is also important for field-level crop yield prediction, crop condition monitoring [5], and crop loss assessment [6]–[9]. Field boundary also useful for the post-processing of image classification for remote sensing-based crop-type identification [10].

Crop field boundaries have been drawn in the cadastral map through land surveying for many centuries. Mapping of field boundaries is improved by the recent development of survey instruments such as Global Positioning System (GPS) devices, theodolites, and total stations. However, survey-based crop field boundary mapping is not time and cost-effective for the vast agricultural area. Field boundary delineation through manual digitization on fine-resolution images is also a very common approach in recent decades. Manual digitization is also very time consuming, labor-intensive, and error-prone processes for large areas. There is a number of studies focusing on automatic field boundary extraction using machine learning approaches on satellite images. In remote sensing images, a boundary is locally connected pixels characterized by their abrupt spectral intensity variation around an area of a set of homogenous pixels. Thus, the spectral variation between crop fields and boundaries is the key to the utilization of remote sensing images for boundary delineation. A deep feature learning approach based on the Fully Convolution Networks (FCNs) is utilized on fine spatial resolution Wordview3 images for the automatic delineation of crop field boundaries in Nigeria [3]. Similarly, Alemu implemented line segment detection algorithm on the Gray Level Co-occurrence Matrix (GLCM) extracted from Wordview2 images for field boundary detection. Ji [4] used the wavelet transformation technique on moderate spatial resolution single-date Landsat near-infrared band for crop field boundary detection. He concluded that a single-date image fails to determine boundaries of fallow land and boundaries between adjacent crop fields with the same crops. Thus, the utilization of multi-temporal images may help to improve the result. Yan and Roy [11] extracted crop field boundary for US croplands using image segmentation approach on multi-temporal Landsat data to extract crop field boundary. They utilized the watershed algorithm and geometric algorithm to decompose segments into a field boundary.

Most of the above-mentioned studies utilized complex algorithms and multi-band images which is computationally intensive for vast agricultural land. It is also hard to delineate boundaries between two fields with same crops using single date images. Crop rotation is usual practice in most of the crop fields in US. All pixels in a crop field is spectrally homogenous because of having the same crop in a season and all these pixels have same crop rotation in another year. Two adjacent fields may not have same crop rotation pattern in past years. Therefore, the combination of multi-year data provides better contrast among crop fields. Multi-band remote sensing data for many years is not only

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