Corn crop density assessment using texture analysis on visible imagery collected using unmanned aerial vehicles

Introduction

Determining corn crop density on a large field is of tremendous value to monitor plant health and damages caused by hogs and deer. Texture modelling techniques are investigated to map three different densities (Low, Medium and High) on a corn field by using visible imagery collected using an Unmanned Aerial Vehicle (UAV).

Texture Modeling Techniques

Gray Level Co-Occurrence Matrix (GLCM)

GLCM is a statistical method of examining texture that considers the spatial relationship of pixels. This also known as the gray-level spatial dependence matrix. The GLCM characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

Segmentation – based Fractal Texture Analysis (SFTA)

The SFTA extraction algorithm consists in decomposing the input image into a set of binary images from which the fractal dimensions of the resulting regions are computed in order to describe segmented texture patterns. In the past, SFTA successfully used for the tasks of content-based image retrieval (CBIR) and image classification, comparing its performance to that of other widely employed feature extraction methods such as Haralick and Gabor filter banks. SFTA achieved higher precision and accuracy for CBIR and image classification. Additionally, SFTA was at least 3.7 times faster than Gabor and 1.6 times faster than Haralick with respect to feature extraction time.

Wavelet Texture Analysis

Wavelet texture analysis is based on the application of a 2D wavelet transform to each raw sub-image, which essentially consists of transforming a matrix of numbers (pixel intensities, as we are analyzing single-channel or grey-level images) into another, with the same size (same overall number of wavelet coefficients), containing blocks of coefficients regarding details for different scales (from the finest to the coarsest scale, which is known as the decomposition depth) and along three different directions (horizontal, vertical and diagonal).

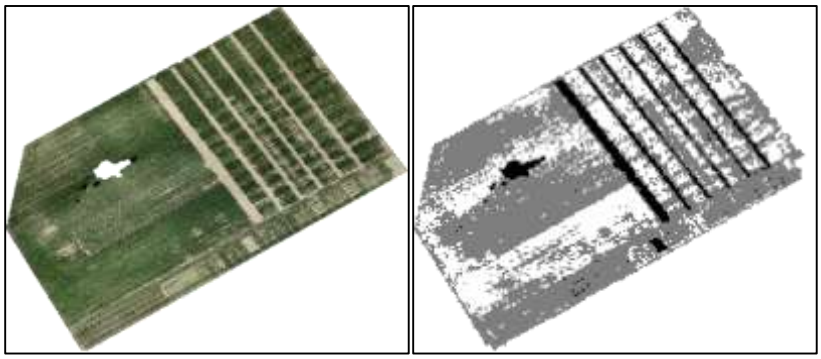
Texture Analysis based on Gabor Filters

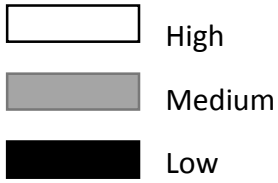
In image processing, a Gabor filter, named after Dennis Gabor, is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture

representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave.
Simple cells in the visual cortex of mammalian brains can be modeled by Gabor functions. Thus, image analysis with Gabor filters is thought to be similar to perception in the human visual system.

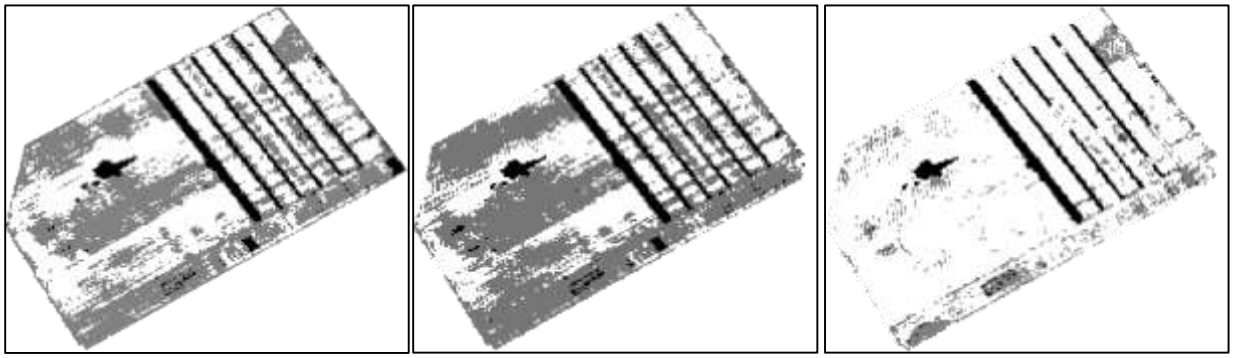
Usually, a filter bank consisting of Gabor filters with various scales and rotations is created. The filters are convolved with the signal (image), resulting in a so-called Gabor space. This process is closely related to processes in the primary visual cortex.

Results





Original GLCM



SFTA Wavelets Gabor Filters

Run time performance of the algorithms

On a field of 20 acres, the run time of each algorithm does not take more than 30 mins. For larger fields this is expected to grow linearly with size.

Conclusion

Texture analysis is proving to be a very useful technique to map densities of large corn fields.