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Deep Learning for Qualitative and Quantitative Grain Quality Analysis Using Hyperspectral Imaging

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Abstract : Grain quality analysis is a multi-parameterized problem that includes a variety of qualitative and quantitative parameters such as grain type classification, damage type classification, and nutrient regression. Currently, these parameters require human inspection, a multitude of instruments employing a variety of sensor technologies, and predictive model types or destructive and slow chemical analysis. This paper investigates the feasibility of applying near-infrared hyperspectral imaging (NIR-HSI) to grain quality analysis. For this study two datasets of NIR hyperspectral images in the wavelength range of 900 nm - 1700 nm have been used. Both datasets contain images of sparsely and densely packed grain kernels. The first dataset contains ~87,000 image crops of bulk wheat samples from 63 harvests where protein value has been determined by the FOSS Infratec NOVA which is the golden industry standard for protein content estimation in bulk samples of cereal grain. The second dataset consists of ~28,000 image crops of bulk grain kernels from seven different wheat varieties and a single rye variety. In the first dataset, protein regression analysis is the problem to solve while variety classification analysis is the problem to solve in the second dataset. Deep convolutional neural networks (CNNs) have the potential to utilize spatio-spectral correlations within a hyperspectral image to simultaneously estimate the qualitative and quantitative parameters. CNNs can autonomously derive meaningful representations of the input data reducing the need for advanced preprocessing techniques required for classical chemometric model types such as artificial neural networks (ANNs) and partial least-squares regression (PLS-R). A comparison between different CNN architectures utilizing 2D and 3D convolution is conducted. These results are compared to the performance of ANNs and PLS-R. Additionally, a variety of preprocessing techniques from image analysis and chemometrics are tested. These include centering, scaling, standard normal variate (SNV), Savitzky-Golay (SG) filtering, and detrending. The results indicate that the combination of NIR-HSI and CNNs has the potential to be the foundation for an automatic system unifying qualitative and quantitative grain quality analysis within a single sensor technology and predictive model type.

Keywords : deep learning, grain analysis, hyperspectral imaging, preprocessing techniques
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