Artificial Intelligence in Forage Research: A Case Study for Creating AI Standards

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Starting in 2022, computer artificial intelligence (AI) has been used in agriculture. This new technology has been widely applied to crop disease detection, pest identification, and UAV-based field monitoring. The AI model YOLOv5 and v8 became especially common for tasks such as leaf disease classification, crop counting, and segmentation, often achieving high accuracy (typically 80–95% mAP). By 2025–2026, enhanced variants—including YOLO-based attention and multi-scale feature models—were used for real time plant health diagnostics, rice and corn pest detection, and robust segmentation under field conditions, reflecting YOLO's evolution into a core tool for practical, high speed agricultural image analysis. However, there are challenges with relying on AI technology in research. Prediction models trained on limited or biased datasets not related to agricultural topics leading to misleading predictions. These predictions then do not generalize across diverse soils, climates, or management systems, potentially resulting in incorrect research interpretations or recommendations. AI systems can also act as "black boxes," making it difficult for researchers to interpret results or understand the biological mechanisms driving an output. Additionally, there is a risk of over reliance on algorithmic outputs without sufficient field validation and scientific rigor. Therefore, integrating AI tools into traditional research workflows requires specialized expertise, consistent data standards, and reliable digital infrastructure.

Plant scientists at USDA-ARS and computer science students at Minnesota State University – Mankato developed an AI workflow to meet agronomic scientific rigor. They aimed to improve the analysis of alfalfa stem digestibility by developing automated image-processing tools for microscopic stem cross-sections. Large datasets of alfalfa images—approximately 15,000 ND2 microscopy files stained for lignin or pectin—required conversion, preprocessing, and analysis to extract biologically meaningful features. A pipeline capable of converting ND2 files into accessible formats, detecting anatomical structures such as vascular bundles, and enabling consistent feature extraction to aid agronomy researchers was created. The project further expanded the scope by designing and implementing a complete workflow incorporating ND2-to-TIFF-to-JPG conversion, YOLO-based segmentation for isolating stem cross-sections, and RGB thresholding methods for quantifying lignin and pectin distribution. This pipeline successfully processed 3,006 high-resolution images, producing standardized outputs, chemical concentration metrics, scaling conversions, and graphical summaries to support biological interpretation. The methodology saved labor hours of image analysis by hand. Thus, we built a robust, scalable system capable of automated tissue classification, structural quantification, and integration into ongoing forage digestibility research. This study could be used as a frame work to create AI standards in agricultural research.