**Developing an Intelligent Real-Time Monitoring Platform for Rapid Diagnosis of Soybean Diseases**

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**Annual Report (2024-2025)**

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**RATIONALE/JUSTIFICATION FOR RESEARCH:**

**Soybean is a major crop with global importance. The United States is one of the world’s top soybean producers. Soybean production is highly vulnerable to diseases, pests, and other environmental factors such as temperature and drought. It is estimated that the average annual economic losses due to soybean diseases in the U.S. reached nearly $4.55 billion. A significantly greater mean loss (51%) was observed after the discovery of soybean rust (2004 to 2016) compared to the pre-discovery (1996 to 2003) although these losses have not been specifically associated with soybean rust, especially in Mississippi (Tom Allen, Extension/Research Professor of row crop plant pathology, MSU, personal communication). Recently, an increased amount of time has been devoted to the foliar diseases, which impact soybean production significantly in the southern U.S. Due to the lack of genetic resources for resistance breeding and the rapidly evolving nature of pathogens, accurate and timely diagnosis and treatment of diseases play an essential role in reducing crop losses. If we can develop a real-time crop growth monitoring system and couple it with an AI technology-assisted sensitive and reliable disease classification system, we will be able to detect the diseases at the earliest possible time, leading to rapid treatments and substantial reduction in crop loss.**

**Neural networks are developed by mimicking the structure and operation model of the neurons in the human brain. CNN (Convolutional Neural Network) is a popular DNN that has demonstrated high generalization performance in many image-analyzing studies. The CNN models are commonly used to analyze visual imagery and to work behind the scenes in image classification. It represents a huge breakthrough in image recognition and classification research. Their applications in face recognition and human disease detection, such as early detection of cancer, have been well reported and commercialized in many cases due to their sensitivity, accuracy, and robustness. However, AI technology application in crop disease and pest detection is still in the infancy stage. A few available related publications are mainly from other countries and most of the reported models are not mobile device compatible, limiting the application potential to small crop consultants/farmers.**

**To achieve AI-assisted rapid and accurate disease detection and classification, we developed an attention-based depth wise separable neural network with Bayesian optimization (ADSNN-BO) model based on MobileNet structure and augmented attention mechanism ADSNN-BO model achieved a test accuracy of 94.65% in rice disease classification, which outperformed the other six tested State-of-the-art deep learning classification models (Figure 1). More importantly, interpretability was achieved via feature analysis including activation map and filters visualization approach. Although various disease classification deep learning models have reported in crop studies, interpretability issue is barely addressed in other reports. In addition, ADSNN-BO model is mobile compatible, making it more accessible to crop consultants/farmers. Our article has been cited over 120 times within two years.**

**Objective 1: Train our mobile compatible algorithm (ADSNN-BO) for accurate diagnosis of the major soybean foliar diseases that occur in the MS soybean production system.**

**Activities completed**

1. We have completed training our original mobile compatible algorithm (ADSNN-BO) for major soybean foliar diseases diagnosis. Meanwhile, we have completed testing all 18 available mobile compatible AI models for disease diagnosis in soybean. **Finally, we have developed a soybean specific AI mode, named “SoyNASNet”, for soybean diseases diagnosis.** After testing with over 9000 images of common soybean diseases, **SoyNASNet outperformed all 18 available AI models with over 98% accuracy in all five assessed parameters.** Our results have been selected for presentation in an international AI conference. In addition, the graduate student Mr. Manideep Kolla has passed the Masters’ degree thesis defense with this work.

2. A new manuscript is in preparation, one manuscript is under review, two accepted conference papers, and one maters’ degree thesis.

**Objective 2: Develop an automated image capture system coupled with soybean disease diagnostic analyses.**

**Activities completed**

**This objective was mainly proposed for year 2 (2025-2026) in our original proposal. However, we realized that most farmlands are in semi-remote regions without access to electric power and WiFi signals, which we failed paying attention in the original proposal. Therefore, we started searching for cameras which can operate without electric power supply and communicate without WiFi signals. We have successfully identified the camera good for field applications. The camera is solar powered and can communicate with G4 signals in addition to Wi-Fi signals, which overcome the problems in most farmlands. We also noticed that satellite signal can be used for communication but more expensive. We will continue working on this objective in this coming year (Year 2).**