



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
PhD-17 SHORT ABSTRACT OF THESIS

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**SHORT ABSTRACT**

Climate changes and nutrient deprivation severely impact crop production by increasing heat and water deficit stress, altering soil nutrient availability, and reducing the nutritional content of crops, leading to lower yields. Traditional stress monitoring approaches rely heavily on manual scouting or complex laboratory analyses, which limit scalability in real-world agricultural settings. This thesis establishes a suite of explainable, lightweight deep learning frameworks tailored for field-based stress identification and severity assessment to address these limitations. The research proposes an explainable deep learning pipeline for UAV-acquired RGB imagery in drought stress detection. A pre-trained CNN backbone, with custom layers, is used for dimensionality reduction and improved generalization. Gradient based visualizations inspired by Grad-CAM are integrated to highlight the model's internal focus, enhancing interpretability and trust. This framework outperformed conventional CNN-based methods in natural agricultural conditions. Besides, an explainable Vision Transformer (ViT) framework is introduced, leveraging both an end-to-end ViT architecture and a hybrid ViT-SVM pipeline. The attention mechanism in ViTs enables precise identification of spatial regions within field images affected by drought stress, further strengthening model transparency and classification accuracy. To refine efficiency for deployment in resource-limited agricultural environments, a novel lightweight hybrid CNN is designed, inspired by ResNet, DenseNet, and MobileNetV2. This model achieves a 15-fold reduction in trainable parameters while retaining competitive accuracy. Performance is further enhanced through a gradient-guided machine unlearning mechanism, which systematically removes non-contributive training samples based on gradient magnitudes, reducing misclassification errors and improving robustness. Beyond drought detection, the thesis addresses nitrogen stress severity under combined stressors such as drought and weed competition. Two pipelines were developed using multimodal imaging datasets (RGB, multispectral, and infrared): a MobileNetV2-based spatial classifier and a MobileNetV2-LSTM hybrid for spatio-temporal modeling. The CNN-LSTM pipeline captured complex interactions

between nutrient deficiency and other stresses, demonstrating superior accuracy in severity classification. Overall, this thesis contributes lightweight, interpretable, and scalable AI frameworks for stress monitoring, offering actionable insights for precision agriculture and supporting resilient, sustainable crop production.

