Nutrispace: A novel color space to enhance deep learning based early detection of cucurbits nutritional deficiency

Reference: Orka, N.A., Haque, E., Uddin, M.N. and Ahamed, T., 2024. Nutrispace: A novel colour space to enhance deep learning based early detection of cucurbits nutritional deficiency. *Computers and Electronics in Agriculture*, 225, p.109296.

Link: Link to paper

Methods Used:

- Nutrispace colour space was introduced to improve identification of nutritional deficiencies in cucurbit plants.
- Compared Nutrispace to RGB, HSV, and CIELAB colour spaces.
- Used three lightweight deep learning classifiers: EfficientNetB0, MobileNetV2, and DenseNet121.
- Tested with four image resolutions: 32x32, 64x64, 128x128, and 256x256 pixels.
- Dataset consisted of ash gourd, bitter gourd, and snake gourd leaves showing early nitrogen and potassium deficiencies, along with healthy samples.

Results:

- Nutrispace improved accuracy by 1% to over 8% compared to RGB across all test instances.
- Achieved a maximum test accuracy of 90.62% on 256x256 pixel images.
- Performance enhancement observed in higher-resolution images, demonstrating Nutrispace's effectiveness regardless of classifier or input size.

Deep Learning Based Disease, Pest Pattern and Nutritional Deficiency Detection System for "Zingiberaceae" Crop

Reference: Waheed, H., Zafar, N., Akram, W., Manzoor, A., Gani, A., and Islam, S.U., 2022. Deep learning-based disease, pest pattern and nutritional deficiency detection system for "Zingiberaceae" crop. *Agriculture*, 12(6), p.742.

Link: Link to paper

Methods Used:

- Employed deep learning techniques, including CNN and ANN, for detecting diseases, pest patterns, and nutritional deficiencies in ginger plants.
- Used a dataset of healthy and diseased ginger plant leaves, including pest-affected leaves and leaves with nutritional deficiencies.
- Tested with Convolutional Neural Network (CNN) for disease rhizome detection, VGG-16 model for pest pattern leaves, and Artificial Neural Network (ANN) for nutritional deficiency detection.

Results:

- CNN achieved the highest accuracy of 99% for detecting disease in ginger rhizomes.
- VGG-16 attained a maximum accuracy of 96% for pest pattern detection in leaves.
- ANN achieved 96% accuracy for identifying leaves with nutritional deficiencies.
- The suggested detection methods may aid in increasing ginger production by enabling early intervention, although results may vary with different datasets.

Image-Based Automatic Diagnostic System for Tomato Plants Using Deep Learning

Reference: Khatoon, S., Hasan, M.M., Asif, A., Alshmari, M., and Yap, Y.K., 2021. Image-Based Automatic Diagnostic System for Tomato Plants Using Deep Learning. *Computers, Materials & Continua*, 67(1).

Link: link to paper

Methods Used:

- The study leverages advancements in AI and computer vision to create an image-based diagnostic system for identifying and predicting diseases, pest patterns, and nutritional deficiencies in tomato plants.
- Multiple CNN models were trained on a large dataset of tomato leaves and fruits.
- Compared the performance of ShallowNet (a new shallow network) with DenseNet, a more complex state-of-the-art deep learning model fine-tuned via transfer learning.

Results:

- DenseNet achieved an accuracy of 95.31% on the test dataset, indicating strong performance for disease and deficiency detection.
- The study demonstrated that deep learning models with optimized parameters, suitable complexity, and adequate depth yielded the best results.
- All experiments were conducted in Python using Keras and TensorFlow.

Enhancing Plant Nutritional Deficiency Analysis: A Multi-Attention Convolutional Neural Network Approach

Reference: Nikitha, S., Prabhanjan, S., Rupa, T.R., and Dinesh, R., 2024. Enhancing Plant Nutritional Deficiency Analysis: A Multi-Attention Convolutional Neural Network Approach. *Multimedia Tools and Applications*, pp.1-23.

Link: Link to paper

Methods Used:

- Developed a Multi-Attention Convolutional Neural Network (MACNN) for detecting deficiencies of Nitrogen, Phosphorus, Potassium, Sulphur, and Iron in Mulberry plants.

- Utilizes channel attention, customized spatial attention, enhanced self-attention mechanisms, and spatial pyramid pooling to capture detailed information about nutritional deficiencies.
- Compared the MACNN with a Multilayer Perceptron (MLP) model trained on handcrafted features and with other state-of-the-art pre-trained deep learning models.
- Model tested on Mulberry, Rice, Maize, and Wheat datasets, demonstrating versatility across plant types.

Results:

- The MACNN model achieved best-in-class accuracy with results of 93.27% for Mulberry, 97.19% for Rice, 96.11% for Maize, and 96.50% for Wheat.
- The study showed that attention mechanisms within CNNs can effectively detect plant nutritional deficiencies, which may benefit crop management and agricultural practices.
- The lightweight model has fewer trainable parameters and requires minimal training time, enhancing efficiency for practical applications.

Nutrition Deficiency Classification in Maize Plant Using Deep Learning Algorithms

Reference: Patel, A. and Mishra, R., 2024. Nutrition Deficiency Classification in Maize Plant Using Deep Learning Algorithms. *Nanotechnology Perceptions*, pp.1196-1216.

Link: Link to paper

Methods Used:

- Utilized deep learning techniques to identify nutritional deficiencies in maize plants through leaf images.
- Focused on four key nutritional deficiency categories: nitrogen, phosphorus, potassium, and zinc.
- Compared multiple deep learning approaches, including Convolutional Neural Networks (CNNs), pre-trained models like VGG19 and Inception, and a hybrid CNN-SVM model.

Results:

- The CNN-SVM hybrid model achieved the highest classification accuracy, reaching 98% on the test dataset.
- Demonstrated that deep learning can significantly aid in the rapid and accurate diagnosis of maize plant nutritional deficiencies.
- Concluded that automated image analysis using these methods can support farmers and agricultural professionals in managing plant nutrition, which can improve crop yield, food security, and sustainability.

Detection of Plant Leaf Nutrients Using Convolutional Neural Network Based Internet of Things Data Acquisition

Reference: Sathyavani, R., JaganMohan, K., and Kalaavathi, B., 2021. Detection of plant leaf nutrients using convolutional neural network-based internet of things data acquisition. *International Journal of Nonlinear Analysis and Applications*, 12(2), pp.1175-1186.

Link: Direct Article Link

Methods Used:

- Utilized Internet of Things (IoT) devices for capturing plant leaf images and analyzing nutrient deficiencies.
- Implemented an enhanced Convolutional Neural Network (CNN) to detect and analyze leaf nutrient levels based on color and region-specific data collected by the IoT-based nutrition analyzer.
- Data from multiple types of plants (e.g., coriander, tomato, pepper, chili) were stored and processed in the cloud, where CNNs deployed on Virtual Machines performed the nutrient analysis.
- Used 3,000 images of five plant illnesses with 5-fold cross-validation for evaluation.

Results:

- The CNN model showed superior performance compared to other deep learning models in terms of detection accuracy.
- The system was evaluated based on multiple metrics: accuracy, sensitivity, specificity, f-measure, geometric mean, and percentage error.
- Demonstrated that an IoT-CNN integrated system can effectively analyze and detect nutrient deficiencies in plant leaves, providing actionable insights for agricultural management.

Nutrient Deficiency Identification and Yield-Loss Prediction in Leaf Images of Groundnut Crop Using Transfer Learning

Reference: Venkatesh, K. and Naik, K.J., 2024. Nutrient deficiency identification and yield-loss prediction in leaf images of groundnut crop using transfer learning. *Signal, Image and Video Processing*, 18(5), pp.4553-4568.

Link: Direct Article Link

Methods Used:

- Utilized transfer learning by implementing an improved VGG16 model to identify nutrient deficiencies in groundnut crop leaves, specifically focusing on nitrogen (N), phosphorus (P), and potassium (K) deficits.
- Enhanced the VGG16 model with an additional nutritional severity diagnosis module for improved accuracy.

- Employed images of groundnut and rice plants to detect and classify nutrient deficiencies in leaf images.
- Assessed the severity of the nutrient deficiency to predict yield loss in groundnut crops, based on data on N, P, and K deficiencies.

Results:

- The proposed VGG16-based model achieved 98% classification accuracy on the groundnut dataset.
- The model showed better performance than other state-of-the-art models trained on the same dataset.
- The study demonstrated that transfer learning could effectively classify nutrient deficiencies in plant leaves and estimate potential yield loss due to nutrient shortages, providing valuable insights for crop management and productivity enhancement.

AI Based Early Identification and Severity Detection of Nutrient Deficiencies in Coconut Trees

Reference: Manoharan, S.K., Megalingam, R.K., Gopika, A., Jogesh, G., Aryan, K., and Kunnambath, A.R., 2024. AI Based Early Identification and Severity Detection of Nutrient Deficiencies in Coconut Trees. *Smart Agricultural Technology*, p.100575.

Link: Direct Article Link

Methods Used:

- Developed a model using YOLOv9 to automatically detect nutrient deficiencies in coconut trees, focusing on both macro and micronutrient shortages.
- Proposed an Image Analysis-based Severity Detection (IASD) method to determine the severity of nutrient deficiencies visually.
- Introduced a Severity Index Calculation Model (SICM) to estimate the Severity Index (SI) for each identified deficiency.
- Provided specific fertilizer recommendations, including type and quantity, based on the deficiency and severity detected.
- Compared four deep learning models—RetinaNet, Faster R-CNN, YOLOv5, and YOLOv9—using a dataset of 5,720 images of nutrient-deficient coconut tree leaves.

Results:

- YOLOv9 outperformed other models, achieving 80% accuracy, 98.59% precision, and 80.37% recall.
- The study presented a precise, automated tool for early detection and severity assessment of nutrient deficiencies in coconut trees, which can help farmers and agricultural experts improve crop health and yield with targeted interventions.

- Manual validation of IASD and SICM predictions supported the model's reliability for practical applications in managing nutrient deficiencies in coconut plantations.

Evaluation of Deep Learning for Image-based Black Pepper Disease and Nutrient Deficiency Classification

Reference: Khew, C.Y., Teow, Y.Q., Lau, E.T., San Hwang, S., Bong, C.H., and Lee, N.K., 2021, September. Evaluation of Deep Learning for Image-based Black Pepper Disease and Nutrient Deficiency Classification. *In 2021 2nd International Conference on Artificial Intelligence and Data Sciences (AiDAS)* (pp. 1-6). IEEE.

Link: Direct Article Link

Methods Used:

- Developed a custom Convolutional Neural Network (CNN) model to classify black pepper leaf diseases and nutrient deficiencies based on image data.
- Conducted performance comparisons with VGG16 and Inception V3 deep learning models.
- Used a dataset of 947 images from black pepper farms in Sarawak, representing 8 classes. These images were augmented to expand the dataset to 9,532 images.

Results:

- The customized CNN achieved a sensitivity rate of 0.98, which slightly outperformed VGG16 and Inception V3.
- Image augmentation was shown to significantly enhance prediction performance across all tested deep learning models.
- The study demonstrated that deep learning models, particularly with image augmentation, can effectively classify diseases and nutrient deficiencies in black pepper leaves, highlighting the potential of AI for plant health monitoring in agriculture.

An Improved Model for Nutrient Deficiency Diagnosis of Rice Plant by Ensemble Learning

Reference: Talukder, M.S.H., Sarkar, A.K., and Nuhi-Alamin, M., 2022, December. An Improved Model for Nutrient Deficiency Diagnosis of Rice Plant by Ensemble Learning. *In 2022 4th International Conference on Sustainable Technologies for Industry 4.0 (STI)* (pp. 1-6). IEEE.

Link: Direct Article Link

Methods Used:

- The study focused on diagnosing nutrient deficiencies in rice plants using machine learning, particularly through ensemble learning.
- Used a dataset of 1,156 rice leaf images from Kaggle, enhanced with data augmentation to improve model training.

- Trained three pre-trained Convolutional Neural Network (CNN) models: MobileNet, DenseNet121, and DenseNet169, each equipped with a bottom pooling layer and dropout for regularization.
- Applied ensemble learning by averaging the predictions from the three models to boost accuracy.

Results:

- The ensemble model achieved a testing accuracy improvement, reaching 96.67% compared to the individual models.
- The model obtained a high ROC-AUC score of 99.62%, indicating excellent discriminatory power.
- This research highlights that combining data augmentation, transfer learning, and ensemble methods can significantly enhance the accuracy of nutrient deficiency diagnosis in rice plants, providing an effective solution for improving rice yield by early deficiency detection.

Feature aggregation for nutrient deficiency identification in chili based on machine learning

Reference: Rahadiyan, D., Hartati, S., & Nugroho, A.P. (2023). Feature aggregation for nutrient deficiency identification in chili based on machine learning. *Artificial Intelligence in Agriculture*, 8, 77-90.

Link: Feature aggregation for nutrient deficiency identification in chili based on machine learning

Methods Used

- **Data**: 5,166 augmented images representing six plant health issues.
- **Feature Extraction**:
    - Color Features: HSV (Hue, Saturation, Value) and RGB (Red, Green, Blue).
    - Texture Features: Gray Level Co-occurrence Matrix (GLCM) and Local Binary Patterns (LBP).
    - Shape Features: Hu moments and centroid distance.
- **Models Evaluated**: Multi-Layer Perceptron (MLP), Support Vector Machine (SVM), Random Forest, Naive Bayes, and Convolutional Neural Network (CNN).

Results

- **Best Performing Features**: Combination of RGB, GLCM, Hu moments, and centroid distance.
- **Model Accuracies**:
    - CNN: **97.76%**

    - SVM: **90.55%**
    - MLP: **89.70%**
- Despite MLP's lower accuracy than CNN, it remains effective for recognizing plant health issues in modest agricultural settings.