# Paddy Disease Classification in Tamil Nadu Crops utilizing Image Analysis Using Deep Learning Techniques

**C. Jayasundari[1], Prof. Dr. P. Arumugam [2], Nayan[3]**

[1] Research Scholar, Department of Statistics, Manonmaniam Sundaranar University, Thirunelveli, India
[2] Head of Department, Department of Statistics, Manonmaniam Sundaranar University, Thirunelveli, India
[3] Department Of Data Science, Loyola College, Chennai, Tamilnadu, India

**How to cite this article:** C. Jayasundari, P. Arumugam , Nayan (2024) Paddy Disease Classification in Tamil Nadu Crops utilizing Image Analysis Using Deep Learning Techniques. *Library Progress International,* 44(3), 7744-7750.

**ABSTRACT**

Paddy is one of the staple food crops in Tamil Nadu, which ensures enough food availability to several million farmers and provides socio-economic prosperity; however, it has been found immensely susceptible to various types of diseases like bacterial leaf blight, blast, and brown spot which may cause a severe reduction in yield and quality. Early detection and accurate diagnosis of these diseases are important for a timely intervention and management, since the traditional ways of identifying these diseases are very laborious, time-consuming, and prone to human errors.

This project puts forward a novel classification of paddy diseases using image analysis and deep learning techniques based on state-of-the-art advancements in artificial intelligence to develop an efficient, effective, and scalable solution. The major aim of the present project is to design a strong automatic classification system for diseases in the paddy through leaf images. This will comprise collecting comprehensive data sets of paddy leaf images affected by various diseases, preprocessing these images to enhance their quality, and designing convolutional neural networks able to classify these diseases.

With this trained model, farmers will be able to conduct real-time diagnosis of paddy diseases using deep learning and image analysis of the affected area. The farmers will receive all the details of the disease and some suitable treatment options; therefore, they will make quick and correct decisions. This project will mean a lot to agricultural technology; that simply means deep learning can be harnessed in the light of imperative issues in agriculture, such as managing diseases. This again shows how AI-driven technology does not necessarily require a web-based application to support better agricultural practices

**Keywords:** Paddy Disease Classification, Tamil Nadu Crops, Image Analysis, Agricultural Technology, Real-time Diagnosis, Disease Management, Bacterial Leaf Blight, Blast Disease, Brown Spot, AI in Agriculture, Crop Yield and Quality, Paddy Leaf Images, Automatic Classification System.

## Introduction

Paddy is one of the principal crops in Tamil Nadu and forms the main food of the area. It is also an important means of livelihood of farmers. The climatic conditions and the nature of the soil are highly suited to paddy culture in the state, but at the same time, these factors favour the incidence of various diseases widely. Bacterial leaf blight, bacterial leaf streak, bacterial panicle blight, blast, brown spot, dead heart, downy mildew, hispa, and tungro virus are some of the serious diseases of paddy, which cause maximum reduction in both crop yield and grain quality, resulting in huge economic losses to farmers. Conventional disease diagnoses depend on human interpretation, expert judgment, and often time-consuming procedures.

**Common Paddy Diseases:**

- **Bacterial Leaf Blight:** Causing the disease, Xanthomonas oryzae is the causative bacterium, which occurs as a result of the yellowing and wilting of the leaves, with consequent suppression of photosynthesis and growth.
- **Bacterial Leaf Streak**: This disease is also caused by Xanthomonas oryzae, which produces narrow, water-soaked streaks that later turn yellowish-white on the leaves and reduce the ability to photosynthesize in the plant.
- **Bacterial Panicle Blight:** This is caused by Burkholderia glumae. This destroys the panicles, causing the grains to discolor and appear empty, ultimately affecting the yield to a greater extent.
- **Blast:** A blast is a fungal disease caused by Magnaporthe oryzae. It causes lesions on leaves, collars, necks, and panicles, significantly losing the crop.
- **Brown Spot-Brown:** spot is caused by the fungus Cochliobolus miyabeanus, which causes brownish lesions on the leaves. These may later coalesce leading to widespread injury on the leaf.
- **Dead Heart:** Commonly by the stem borers, leading to the death of central leaf whorl, which turns brown and dries.
- **Downy Mildew:** A fungal disease is caused by Sclerophthora macrospora, with stunted growth, chlorosis, and downy growth on the underside of leaves.
- **Hispa:** Dicladispa armigera is an insect pest that scrapes the leaf surface, which leads to white streaks and a reduced photosynthetic area.
- **Normal:** Healthy paddy leaves without any disease symptom.
- **Tungro:** Viral disease caused by Rice Tungro Spherical Virus (RTSV) and Rice Tungro Bacilliform Virus (RTBV), stunted growth, leaf yellow to orange discoloration, with less tillering.

New hopes for addressing agronomic challenges have appeared in recent years with the progress of technology in image analysis and deep learning. Because deep learning is one of the branches of artificial intelligence, it exhibits a significantly higher success ratio than conventional image classification. Now, automation, using these technologies, makes possible the development of systems for the rapid and correct diagnosis of diseases in paddy to provide timely information to farmers to manage the disease effectively.

The current project is aimed at deploying the powerful paradigms of deep learning in the field of image analysis for developing a robust, user-friendly system that would classify diseases on paddy. This would involve the acquisition of a varied dataset of paddy leaf images, designing convolutional neural networks, and mobilizing the trained model for application.

The purpose here is to revolutionize the practices of disease management in paddy for the state of Tamil Nadu. This innovative approach will not only enhance crop health and yields but also improve the overall livelihood of the farmers with respect to increased food security and economic stability in the region. In this project, we would like to demonstrate the potential of AI transformation into agriculture, toward more sustainable and technology-advanced farming practices.

**Literature Review**

During the last years, image analysis along with deep learning techniques contributed too much in agricultural disease detection. Indeed, recent methods focused on the classification and diagnosis of paddy crop diseases in Tamil Nadu. Several works used both machine learning techniques and more recent deep learning approaches for this task.

The review of Kannan et al. presents the work done using deep learning techniques for the detection of common paddy diseases of Tamil Nadu. The work was based on a dataset of infected crop images collected from agricultural fields in that region and used various CNN-based architectures to classify diseases. It was observed that the integration of those deep learning models developed considerable improvement in the accuracy of disease detection, hence providing a pragmatic approach for real-time diagnosis in the agricultural sector.

Ravi and Natarajan 2019 discussed various image processing methods for the detection of paddy diseases, such as bacterial blight and blast diseases, commonly occurring in Tamil Nadu. They emphasized the preprocessing steps: filtering, segmentation, and feature extraction, which are the steps that need to be taken to strengthen the machine learning models. But their study was more focused on classical image processing techniques, while this has set the ground to merge these techniques with deep learning models and present better results.

Muthusamy et al. studied CNNs as a suitable tool for classifying paddy disease in Tamil Nadu. This work was based on training CNNs by means of images to find out whether the crops were in good health or diseased. They proved that CNNs have great potential to automate the process of classification through complex feature processing of images that would not be feasible with traditional techniques.

Similarly, Kumar and Suresh (2018) investigated machine learning techniques applied to image datasets from different districts of Tamil Nadu to detect and classify paddy diseases. Their work aimed at integrating the machine learning methods like a support vector machine into systems that can recognize images. Though that was much of a contribution, results obtained were limited by the complexity of the features involved; hence, it recommended the application of deep learning methods instead.

These studies together reflect the growing interest in image analysis and deep learning methods for paddy disease classification. The collective insights and methodologies provide a good foundation for future research on more advanced deep learning models like generative adversarial networks and transfer learning, which may further improve accuracy and scalability.

**Objective and Methodology**

The main objective of the project is to develop a system that is comprehensive and automated for the classification and diagnosis of paddy diseases using image analysis techniques and deep learning. The developed system is expected to provide farmers with timely, accurate, and actionable information in disease management for improved crop yield. The detailed methodology to achieve these specific objectives is given below:

**Data Collection and Dataset Creation**

**Objective**

- Engage with research institutions in agriculture, local agricultural extension offices, and farmers to collect high-resolution images of paddy leaves with different diseases such as bacterial leaf blight, bacterial leaf streak, bacterial panicle blight, blast, brown spot, dead heart, downy mildew, hispa, and tungro.
- The dataset shall ensure images with respect to varying stages of diseases, environmental conditions, and different geographical locations within the state of Tamil Nadu to increase the generalizability of the model.
- The dataset will be augmented by images that could be sourced from online databases and images published in research articles to ensure that all the disease symptoms are portrayed in the dataset.

**Methodology:**

- Engage stakeholders for image collection and take diverse images through the application of sophisticated imaging tools such as drones.
- Dataset diversity: Images included from various growth stages, environments, and regions
- The dataset has been supplemented by adding other pictures from online sources and research projects

**Image Preprocessing and Enhancement**

**Objective:**

- Use this to improve the capability of the deep learning model: Preprocessing techniques like resizing, normalization, and augmentation.
- Utilize advanced methods of image enhancement, such as histogram equalization, contrast adjustment, and noise reduction, to enhance the quality and clarity of images—this consequently aids the model's better extraction of features.

**Methodology:**

- Standardize image dimensions and pixel values for consistency across images.
- Use data augmentation techniques such as rotation, flipping, and zooming in and out to make the dataset wide enough, thereby increasing the robustness of the model.
- Perform image-enhancement processes of histogram equalization and noise reduction on images to ensure good quality.


**Development of Deep Learning Model**

**Objective:**

- Development of convolutional neural networks that are optimized for the classification of diseases in the paddy crop; extensive experiments with architectures, including ResNet, Inception, EfficientNet, to achieve the best model.
- Apply transfer learning in fine-tuning models pretrained on the collected dataset to optimize existing knowledge and to shorten the period of training.
- Hyperparameter optimization of the model includes learning rate, batch size, and number of epochs for better performance.

**Methodology:**

- Develop architectures in CNN and experiment with diverse models like ResNet, Inception, EfficientNet for classifying diseases.
- Apply transfer learning with fine-tuning of pre-trained models, for example, VGG, Inception, ResNet, on the paddy disease dataset.
- Further hyperparameter tuning for better model performance.

**Model Training and Validation**

**Objective:**

- Data division needs to ensure that a balanced representation of all disease classes in the data is not biased toward the classification of diseases.
- The models shall be trained by correct loss functions, such as categorical cross-entropy, and optimization algorithms, such as Adam, SGD, etc., to minimize errors in classification and maximize the model accuracy.

- Validation of models by performance metrics based on their accuracies, precisions, recalls, F1-scores, and AUC-ROC to ensure credible disease classification.

**Method:**

- Split the dataset into training (70%), validation (20%), and test sets (10%) while keeping the representation balanced.
- Train models in GPU-accelerated environments with appropriate loss functions and optimization algorithms.
- Validate models using performance metrics, and fine-tune hyper parameters if necessary.
- recommendation.

**Field Testing and Evaluation**

**Objective:**

- Carry out rigorous field trials with the local farmers to evaluate accuracy, reliability, and usability of the web application under real working agricultural condition.
- Consult farmers, agricultural experts and stakeholders in general about areas of the system that should be improved and refined
- Research on the impact of the designed system on disease management practices, crop yield as well farmer decision making process which important social economic benefits originated from the technology.

**Methodology**

- Actual testing of the application in the field by the use of local farmers determine accuracy reliability as well as user experience.
- Engage users and agricultural experts to provide feedback on strengths, weaknesses, and areas for further development.
- Assess the impact of the system on disease management practices, crop yields, and farmers' decision-making.

**Dissemination of Results and Knowledge Transfer**

**Objective:**

- Report the project methodology, results, and the findings through detailed reports and research projects.
- Publish dataset, trained models, and web application as open-access resources to enable further research and development work in the field of agricultural technology.
- Conduct workshops, seminars, and training sessions with the farmers, agricultural extension officers, and the researchers for adoption and utilization of the developed system.

**Methodology:**

- Document and publish the methodology used in the project, as well as results and findings.
- Make the dataset, trained models, and web application open resources.
- Organize workshops and training sessions for promoting the adoption and effective use of the developed system.

As a follow-up with this in-depth methodology, this project wishes to have an actual, practical, scalable, and impactful contribution to paddy disease management in Tamil Nadu by tapping into the magic of deep learning and image analysis toward better agricultural productivity and sustainability.

**Results**

| S.no | Model Name | Accuracy |
|---|---|---|
| 1 | ResNet50 | 76.2 % |
| 2 | Inception V3 | 93.7 % |
| 3 | EfficentNet B4 | 82.3 % |

ResNet50: At the fifth epoch, the ResNet50 had converged to a training accuracy of 93.4% and a validation accuracy of 76.26%. At this point, it had a final validation loss of 0.8487, meaning that ResNet50 could learn the training data but was low on generalizing to new images.

InceptionV3: The performance for InceptionV3 was very similar to ResNet50, standing at a training accuracy of 93.7% and a validation accuracy of 79.00%. This is indeed much better in generalization compared to ResNet50, despite fluctuation in its validation accuracy during training, as indicated by the validation loss of 0.7436.

EfficentNet B4 : It turned out that EfficientNet had a very competitive performance with 94.5% training accuracy, 82.3% validation accuracy, further showing that this performs much better in generalization compared to InceptionV3 and ResNet50. It also has fewer fluctuations of the validation accuracy during training. With a validation loss of 0.6925, the learning can be said to be more stable, hence making it a very good balance in determining both accuracy and efficiency within the model.

**Social Relevance**

The paddy disease classification project is very socially relevant, especially for the agricultural communities of Tamil Nadu and other such regions. Given here are some of the points related to the need:

1. **Increased Agricultural Productivity:** Paddy is the major crop sustaining millions of farmers in Tamil Nadu. Bacterial leaf blight, bacterial leaf streak, and blast are the major diseases causing severe losses in the productivity and quality of paddy. Therefore, this project assists the farmer in early identification of diseases and taking preventive management measures, in turn, reducing the intensity of crop loss and increasing productivity. The results of the project implementation will be an automated system that allows a farmer to diagnose diseases with improved accuracy and at a quicker rate.
2. **Improved Disease Management:** Current diagnostic methods for diagnosing paddy diseases mainly depend on manual inspection; these methods are time-consuming and tend to make mistakes. The web application, powered by deep learning, helps farmers to classify diseases quickly and accurately based on images of leaves, therefore reducing their reliance on costly external diagnostic services. It enables farmers to act timely on targeted treatments and management practices.
3. **Adoption Costs:** Farmers typically tend to suffer from a problem of paucity of resources in dealing with the issue of paddy diseases. The project will aim to do that by capitalizing on low-cost technologies and open-source tools. With the web application deployable on the mainstream smartphone models, there is minimal need for expensive diagnostic tools and laboratory testing; this in turn makes advanced disease management available to the masses.
4. **Capacity:** Building and Knowledge Transfer The project comprises training sessions and workshops for the farmers and the agricultural extension officers. These educational programs improve the technical knowledge of stakeholders in the identification and management of diseases, which will help to create a culture of informed decisions regarding the agriculture process. This capacity building will ensure the practice of farming being sustainable and resilient in the long run.
5. **Economic Impact:** The project, by reducing the losses and quality improvement in the produce, is likely to have a tremendous impact on the income derived from paddy farming. Higher productivity and less spending on disease management result in better economic conditions for the farming families. These people are better able to afford good education and health care facilities. The whole community experiences enhanced living conditions due to this economic prosperity.
6. **Environmental Good:** Effective control of diseases through early detection helps decrease the requirement of unnecessary spraying of pesticides. This not only prevents contamination and pollution

but also ensures more robust soil and water systems. By backing practices of integrated pest management, the project subscribes to sustainable agriculture concepts and ensures environmental conservation.

7. **Research and Development**: The various project deliverables and the tools developed would be shared as open access material. This is supportive to the larger community of researchers by offering relevant data and models that may be usable for future research and technology developments. It promotes agricultural technology innovation and constant research in disease management and crop protection.
8. **Community Involvement:** Farmers and agricultural experts are actively engaged in the development of the project and its evaluation, which ensures solutions are tailor-made to the needs and problems at hand. The involvement of stakeholders, right from the initiation of the project, creates relevance and effectiveness for which the technologies developed can be appropriately applied to the ground for dealing with real-life situations. In this regard, the paddy disease classification is very socially relevant as it contributes to solving some of the main challenges in paddy cultivation that impact farmer livelihood in a sustainable manner and in the process of advancement of agricultural technology.

**Conclusion:**

On the whole, these deep learning models for the classification of paddy diseases in crops in Tamil Nadu resulted in relatively different performances by different models. Among the models tested, EfficientNet B4 gave the best balanced performance.

This therefore means that EfficientNet B4 generalizes better and is more stable compared to InceptionV3 and ResNet50, hence being the best model for this task. InceptionV3 performed best with about 79.00% validation accuracy, with some oscillation of validation accuracy for some epochs. ResNet50 probably overfitted the training data, gaining as much as 93.4% in accuracy but attaining a minimum of just 76.26% validation accuracy. Therefore, considering the EfficientNet B4 network will provide the optimum balance among training accuracy, validation accuracy, and stability for the case of considering paddy diseases.

**Reference:**

1. **Kannan, A., Gomathi, S., & Chandrasekaran, R. (2020).** *Image-based detection of paddy crop diseases using deep learning techniques in Tamil Nadu.* International Journal of Agricultural Science, 58(4), 223-230.
2. **Ravi, K., & Natarajan, S. (2019).** *A survey on image processing techniques for paddy crop disease identification in Tamil Nadu.* Journal of Crop Protection, 32(3), 120-125.
3. **Muthusamy, S., Kumar, V., & Ramalingam, T. (2021).** *Application of Convolutional Neural Networks for Paddy Disease Classification in Tamil Nadu.* Agricultural Informatics Journal, 14(2), 145-150.
4. **Kumar, R., & Suresh, R. (2018).** *Image-based recognition and classification of paddy diseases using machine learning approaches in Tamil Nadu.* Journal of Plant Pathology and Protection, 26(1), 45-53.
5. **Tamil Nadu Agricultural University (2021).** *Paddy Crop Disease Management: Image-based Early Detection Methods.* Coimbatore, Tamil Nadu: TNAU Press.