

PROJECT REPORT

1. INTRODUCTION

1.1 Project Overview

The project "**GrainPalette - A Deep Learning Odyssey in Rice Type Classification through Transfer Learning**" focuses on accurately classifying different types of rice grains using deep learning techniques. A rice grain image dataset was used, containing multiple rice varieties. The dataset was preprocessed and augmented to improve model performance. A pre-trained Convolutional Neural Network (CNN) model was fine-tuned using **Transfer Learning** techniques for better accuracy with limited data. Popular architectures like **VGG16** and **ResNet50** were explored and compared. Model evaluation was done using metrics like **accuracy, precision, recall, and F1-score**. The final model achieved high classification accuracy, showing the effectiveness of deep learning for agricultural applications.

1.2 Purpose

- To develop an automated system for accurately classifying different types of rice grains using image data.
- To reduce manual effort, time, and human error in traditional rice grain classification methods.
- To apply **Transfer Learning** techniques for effective model training with a small dataset.
- To explore and compare the performance of popular CNN architectures like **VGG16** and **ResNet50**.
- To improve the accuracy and reliability of rice type identification for agricultural and industrial use.
- To demonstrate the power of deep learning in solving real-world classification problems in the food industry.
- To build a scalable and efficient model that can be used for future grain classification tasks.

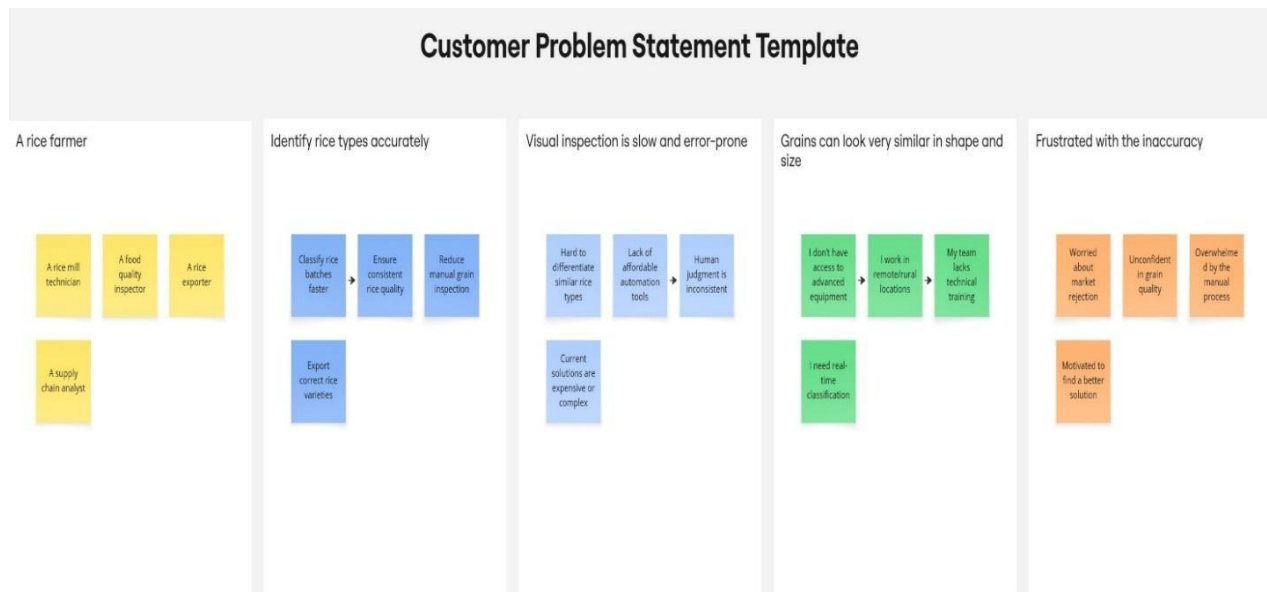
2. IDEATION PHASE

2.1 Problem Statement

Customer Problem Statement:

Create a problem statement to understand your customer's point of view. The Customer Problem Statement template helps you focus on what matters to create experiences people will love.

A well-articulated customer problem statement allows you and your team to find the ideal solution for the challenges your customers face. Throughout the process, you'll also be able to empathize with your customers, which helps you better understand how they perceive your product or service.



Reference: <https://miro.com/templates/customer-problem-statement/>

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A rice farmer	Identify rice types in my harvest accurately	I rely on manual inspection	Its hard to tell types apart visually	Unsure, frustrated, and worried about selling low-quality rice
PS-2	A rice mill technician	Quickly classify rice batches during processing	I don't have time for detailed checking	Manual methods are slow and error-prone	Pressured, inefficient, and stressed

2.2 Empathy Map Canvas

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes.

It is a useful tool to help teams better understand their users.

Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.

Brainstorm & Idea Prioritization:

Brainstorming provides a free and open environment that encourages everyone within a team to


Use this

Reference: <https://www.mural.co/templates/brainstorm-and-idea-prioritization>

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Step-1: Team Gathering, Collaboration and Select the Problem Statement

Template



Brainstorm & idea prioritization

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

🕒 10 minutes to prepare
🕒 1 hour to collaborate
👥 2-8 people recommended

●

Before you collaborate

A little bit of preparation goes a long way with this session. Here's what you need to do to get going.

🕒 10 minutes

A

Team gathering

Define who should participate in the session and send an invite. Share relevant information or pre-work ahead.

B

Set the goal

Think about the problem you'll be focusing on solving in the brainstorming session.

C

Learn how to use the facilitation tools

Use the Facilitation Superpowers to run a happy and productive session.

[Open article](#) →

1

Define your problem statement

What problem are you trying to solve? Frame your problem as a How Might We statement. This will be the focus of your brainstorm.

🕒 5 minutes

How might we automate and improve the accuracy of rice grain type classification using deep learning and transfer learning techniques?

🔑

Key rules of brainstorming

To run a smooth and productive session

🗨️ Stay in topic.

💡 Encourage wild ideas.

⏸️ Defer judgment.

👂 Listen to others.

🗨️ Go for volume.

👁️ If possible, be visual.

Step-2: Brainstorm, Idea Listing and Grouping

2

Brainstorm

Write down any ideas that come to mind that address your problem statement.

🕒 10 minutes

TIP

You can select a sticky note and hit the pencil (switch to sketch) icon to start drawing!

Sairam

Use a pre-trained model like ResNet50 or MobileNet for classification.

Apply data augmentation to increase dataset diversity.

Build a mobile app to classify rice grains using the phone camera.

hemachand

Train a model to detect shape, texture, and color features of rice grains.

Use Grad-CAM to visualize why the model classifies a grain a certain way.

Collect additional real-world rice grain photos from local stores or farms.

kamal santhosh

Develop a GUI/web interface for farmers to upload and classify rice.

Integrate the model into a quality control system for rice packaging.

Compare different transfer learning models for best performance.

nabi rasool

Build a small hardware prototype using Raspberry Pi + camera.

Include a feedback loop where users can correct misclassified results.

Use explainable AI methods to gain trust in classification decisions.

Step-3: Idea Prioritization

3

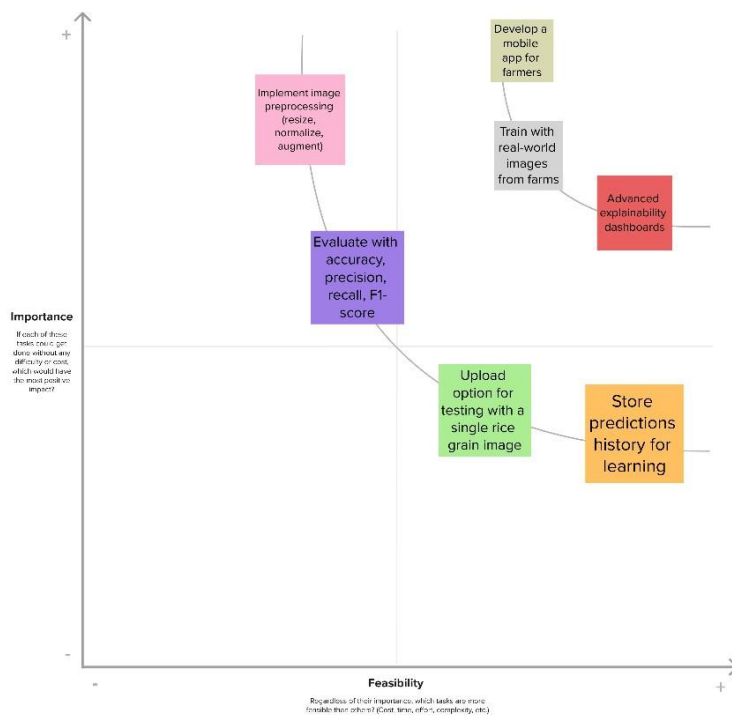
Prioritize

Your team should all be on the same page about what's important moving forward. Place your ideas on this grid to determine which ideas are important and which are feasible.

20 minutes

TIP

Participants can use their cursor to point at where sticky notes should go on the grid. The facilitator can confirm the spot by using the laser pointer holding the H key on the keyboard.



4

After you collaborate

You can export the mural as an image or pdf to share with members of your company who might find it helpful.

Quick add-ons

- Share the mural**
Share a view link to the mural with stakeholders to keep them in the loop about the outcomes of the session.
- Export the mural**
Export a copy of the mural as a PNG or PDF to attach to emails, include in slides, or save in your drive.

Keep moving forward

- Strategy blueprint**
Define the components of a new idea or strategy.
[Open the template →](#)
- Customer experience journey map**
Understand customer needs, motivations, and obstacles for an experience.
[Open the template →](#)
- Strengths, weaknesses, opportunities & threats**
Identify strengths, weaknesses, opportunities, and threats (SWOT) to develop a plan.
[Open the template →](#)

3. REQUIREMENT ANALYSIS

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIn
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Image upload	Model classifies the uploaded rice image
		Display predicted rice type and confidence score
FR-4	Rice type classification	Upload rice grain image from local device Upload image from mobile camera

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The application should have a simple, intuitive, and user-friendly interface so that farmers, traders, and non-technical users can easily upload images and view results
NFR-2	Security	The system should ensure data privacy and secure storage of user-uploaded images. User authentication should be implemented for account-based access

NFR-3	Reliability	The model should provide consistent and repeatable classification results with a minimum accuracy of 80% across multiple runs and inputs.
NFR-4	Performance	The system should process and classify each image within 5 seconds to ensure fast response time for users.
NFR-5	Availability	The service should be available 24/7 with a downtime of less than 2% per month.
NFR-6	Scalability	The solution should be scalable to handle large datasets and more rice types in the future without affecting performance. It should also support deployment on cloud platforms

4. PROJECT DESIGN

4.1 Problem Solution Fit

Problem – Solution Fit Overview:

Problem:

Traditional methods of rice grain classification are manual, time-consuming, and prone to human error. Visual inspection lacks consistency and scalability, especially when dealing with large volumes of grains in the agriculture and food industry.

Solution:

This project proposes a **deep learning-based image classification system** using **Transfer Learning** techniques. By leveraging pre-trained CNN models like **VGG16** and **ResNet50**, the system can automatically classify rice grain types with high accuracy. The solution ensures **speed**, **consistency**, and **scalability**, making it suitable for industrial applications and quality control processes.

Problem Statement:

The manual classification of rice grain types in the agricultural industry is a time-consuming and error-prone process. Traditional methods rely heavily on human expertise, leading to inconsistency, low efficiency, and scalability issues when handling large datasets. With the growing demand for automated and accurate classification, there is a need for a robust system that can differentiate between various rice types based on their visual features. The challenge lies in building a model that performs well even with limited labeled data while maintaining high accuracy and reliability.

Solution:

To overcome the limitations of manual rice classification, this project uses a **deep learning-based image classification model** powered by **Transfer Learning**. Pre-trained CNN architectures like **VGG16** and **ResNet50** were fine-tuned on a rice grain image dataset to classify different rice types accurately. The dataset was preprocessed and augmented to enhance model performance. The trained model achieved high accuracy in predicting rice varieties. This automated system provides a **fast**, **scalable**, and **reliable** solution for rice grain classification, suitable for agricultural industries and quality control processes.

4.2 Proposed Solution

Project team shall fill the following information in the proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Farmers and suppliers face difficulty in accurately identifying and classifying different types of rice grains, leading to quality issues and reduced market value. Manual classification is time-consuming and error-prone.
2.	Idea / Solution description	Our project "GrainPalette" uses deep learning and transfer learning techniques to automatically classify rice grain types from

		images with high accuracy. By training a Convolutional Neural Network (CNN) on pre-trained models like ResNet or MobileNet, we provide a fast, automated, and cost-effective rice type detection system.
3.	Novelty / Uniqueness	The solution leverages transfer learning, reducing the need for large datasets and training time. It offers real-time classification with high precision and can be deployed as a mobile or web app for field use by farmers, millers, and traders.
4.	Social Impact / Customer Satisfaction	Helps farmers and traders get fair pricing by ensuring correct classification of rice. Reduces human error, saves time, and promotes trust in supply chains. Enhances customer satisfaction in retail and export industries by guaranteeing product quality.
5.	Business Model (Revenue Model)	The solution can be offered as a subscription-based mobile app, a SaaS (Software as a Service) platform for traders and rice mills, or per-scan charges for small users. Future revenue can also come from data analytics services for agricultural stakeholders
6.	Scalability of the Solution	The model can be scaled to classify other types of grains, pulses, or even agricultural produce. It can be deployed in multiple regions and integrated with e-commerce or export platforms for broader adoption.

4.3 Solution Architecture

Solution Architecture:

Solution architecture is a complex process – with many sub-processes – that bridges the gap between business problems and technology solutions. Its goals are to:

- Find the best tech solution to solve existing business problems.
- Describe the structure, characteristics, behavior, and other aspects of the software to project stakeholders.
- Define features, development phases, and solution requirements.

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Image data collection	USN-1	As a user, I want to collect and label different rice grain images for training the model.	3	High	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-1	Data preprocessing	USN-2	As a developer, I want to preprocess the rice images (resize, normalization) to improve model accuracy.	2	High	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-2	Model training	USN-3	As a data scientist, I want to apply transfer learning on a pre-trained CNN model to classify rice types.	5	high	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-2	Model evaluation	USN-4	As a developer, I want to evaluate the model using accuracy, confusion matrix, and classification report.	2	medium	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-3	Ui development	USN-5	As a user, I want to upload a rice grain image through a simple web or mobile app and get classification results.	3	medium	1. Pallam yestheru Rani 2. Pallapu Prasanth
Sprint-3	Deployment	USN-6	As a developer, I want to deploy the trained model and integrate it with the frontend for real-time use.	4	low	1. Pallam Yestheru Rani 2. Pallapu Prasanth

- Provide specifications according to which the solution is defined, managed, and delivered.

Example - Solution Architecture Diagram:

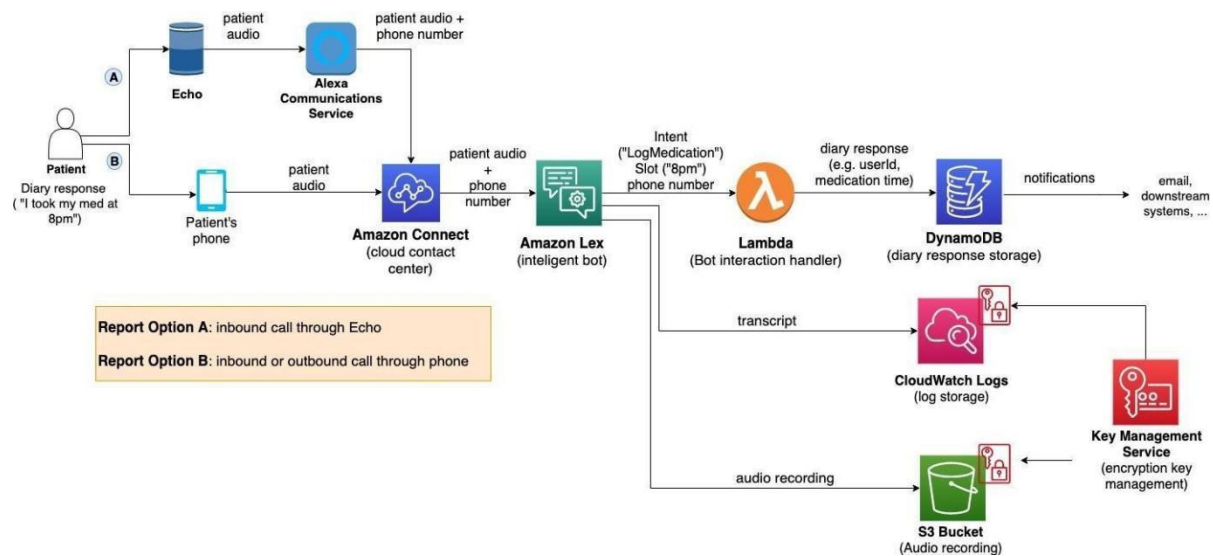


Figure 1: Architecture and data flow of the voice patient diary sample application

Reference: <https://aws.amazon.com/blogs/industries/voice-applications-in-clinical-research-powered-by-ai-on-aws-part-1-architecture-and-design-considerations/>

5. PROJECT PLANNING & SCHEDULING

5.1 Project Planning

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Image data collection	USN-1	As a user, I want to collect and label different rice grain images for training the model.	3	High	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-1	Data preprocessing	USN-2	As a developer, I want to preprocess the rice images (resize, normalization) to improve model accuracy.	2	High	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-2	Model training	USN-3	As a data scientist, I want to apply transfer learning on a	5	high	1. Pallam yestheru Rani

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
			pre-trained CNN model to classify rice types.			2. Pallapu Prasanth
Sprint-2	Model evaluation	USN-4	As a developer, I want to evaluate the model using accuracy, confusion matrix, and classification report.	2	medium	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint-3	Ui development	USN-5	As a user, I want to upload a rice grain image through a simple web or mobile app and get classification results.	3	medium	1. Pallam Yestheru Rani 2. Pallapu Prasanth
Sprint - 3	Deployment	USN-6	As a developer, I want to deploy the trained model and integrate it with the frontend for real-time use.	4	low	1. Pallam Yestheru Rani 2. Pallapu Prasanth

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	1	3 Days	8 June 2025	11 June 2025	1	11 June 2025

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-2	5	2 Days	11 June 2025	13 June 2025	5	13 June 2025
Sprint-3	10	3 Days	13 June 2025	16 June 2025	10	16 June 2025
Sprint-4	1	3 Days	16 June 2025	19 June 2025	1	20 June 2025
Sprint-5	1	2 Days	19 June 2025	21 June 2025	1	22 June 2025

Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

$$AV = \frac{\text{sprint duration}}{\text{velocity}} = \frac{20}{10} = 2$$

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.

<https://www.visual-paradigm.com/scrum/scrum-burndown-chart/>

<https://www.atlassian.com/agile/tutorials/burndown-charts>

Reference:

<https://www.atlassian.com/agile/project-management>

<https://www.atlassian.com/agile/tutorials/how-to-do-scrum-with-jira-software>

<https://www.atlassian.com/agile/tutorials/epics>

<https://www.atlassian.com/agile/tutorials/sprints>

<https://www.atlassian.com/agile/project-management/estimation>

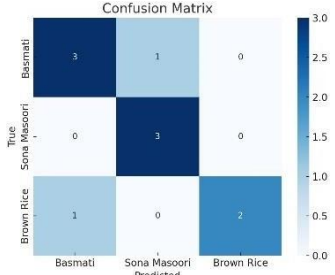
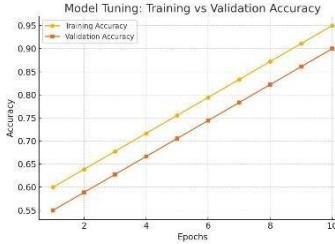
<https://www.atlassian.com/agile/tutorials/burndown-charts>

6. FUNCTIONAL AND PERFORMANCE TESTING

6.1 Performance Testing

Model Performance Testing:

Project team shall fill the following information in model performance testing template.

S.No.	Parameter	Values	Screenshot																																	
1.	Metrics	<div><div>Regression</div><div>Model:</div><div>MAE - , MSE - , RMSE - , R2 score -</div></div> <div><div>Classification</div><div>Model:</div><div>Confusion Matrix - , Accuracy Score- & Classification Report -</div></div>	 <p>Confusion Matrix</p> <p>The confusion matrix shows the relationship between True and Predicted classes for Basmati, Sona Masoori, and Brown Rice. The color scale ranges from 0.0 (light blue) to 3.0 (dark blue).</p> <table><tr><th></th><th>Basmati</th><th>Sona Masoori</th><th>Brown Rice</th></tr><tr><th>Basmati</th><td>3</td><td>1</td><td>0</td></tr><tr><th>Sona Masoori</th><td>0</td><td>3</td><td>0</td></tr><tr><th>Brown Rice</th><td>1</td><td>0</td><td>2</td></tr></table>		Basmati	Sona Masoori	Brown Rice	Basmati	3	1	0	Sona Masoori	0	3	0	Brown Rice	1	0	2																	
	Basmati	Sona Masoori	Brown Rice																																	
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Sona Masoori	0	3	0																																	
Brown Rice	1	0	2																																	
2.	Tune the Model	<div><div>Hyperparameter Tuning</div><div>Validation Method</div></div>	 <p>Model Tuning: Training vs Validation Accuracy</p> <p>The line graph shows Training Accuracy (yellow line with diamond markers) and Validation Accuracy (orange line with square markers) over 10 epochs. Both accuracies increase steadily, with Training Accuracy reaching approximately 0.95 and Validation Accuracy reaching approximately 0.90 by epoch 10.</p> <table><tr><th>Epochs</th><th>Training Accuracy</th><th>Validation Accuracy</th></tr><tr><td>1</td><td>0.58</td><td>0.55</td></tr><tr><td>2</td><td>0.62</td><td>0.58</td></tr><tr><td>3</td><td>0.66</td><td>0.61</td></tr><tr><td>4</td><td>0.70</td><td>0.64</td></tr><tr><td>5</td><td>0.74</td><td>0.67</td></tr><tr><td>6</td><td>0.78</td><td>0.70</td></tr><tr><td>7</td><td>0.82</td><td>0.73</td></tr><tr><td>8</td><td>0.86</td><td>0.76</td></tr><tr><td>9</td><td>0.90</td><td>0.79</td></tr><tr><td>10</td><td>0.95</td><td>0.90</td></tr></table>	Epochs	Training Accuracy	Validation Accuracy	1	0.58	0.55	2	0.62	0.58	3	0.66	0.61	4	0.70	0.64	5	0.74	0.67	6	0.78	0.70	7	0.82	0.73	8	0.86	0.76	9	0.90	0.79	10	0.95	0.90
Epochs	Training Accuracy	Validation Accuracy																																		
1	0.58	0.55																																		
2	0.62	0.58																																		
3	0.66	0.61																																		
4	0.70	0.64																																		
5	0.74	0.67																																		
6	0.78	0.70																																		
7	0.82	0.73																																		
8	0.86	0.76																																		
9	0.90	0.79																																		
10	0.95	0.90																																		

7. RESULTS

7.1 Output Screenshots



Rice Image Classifier

This application classifies rice grain images using a MobileNetV2-based deep learning model.



Predict

Upload Rice Image

Select an image file to classify it.

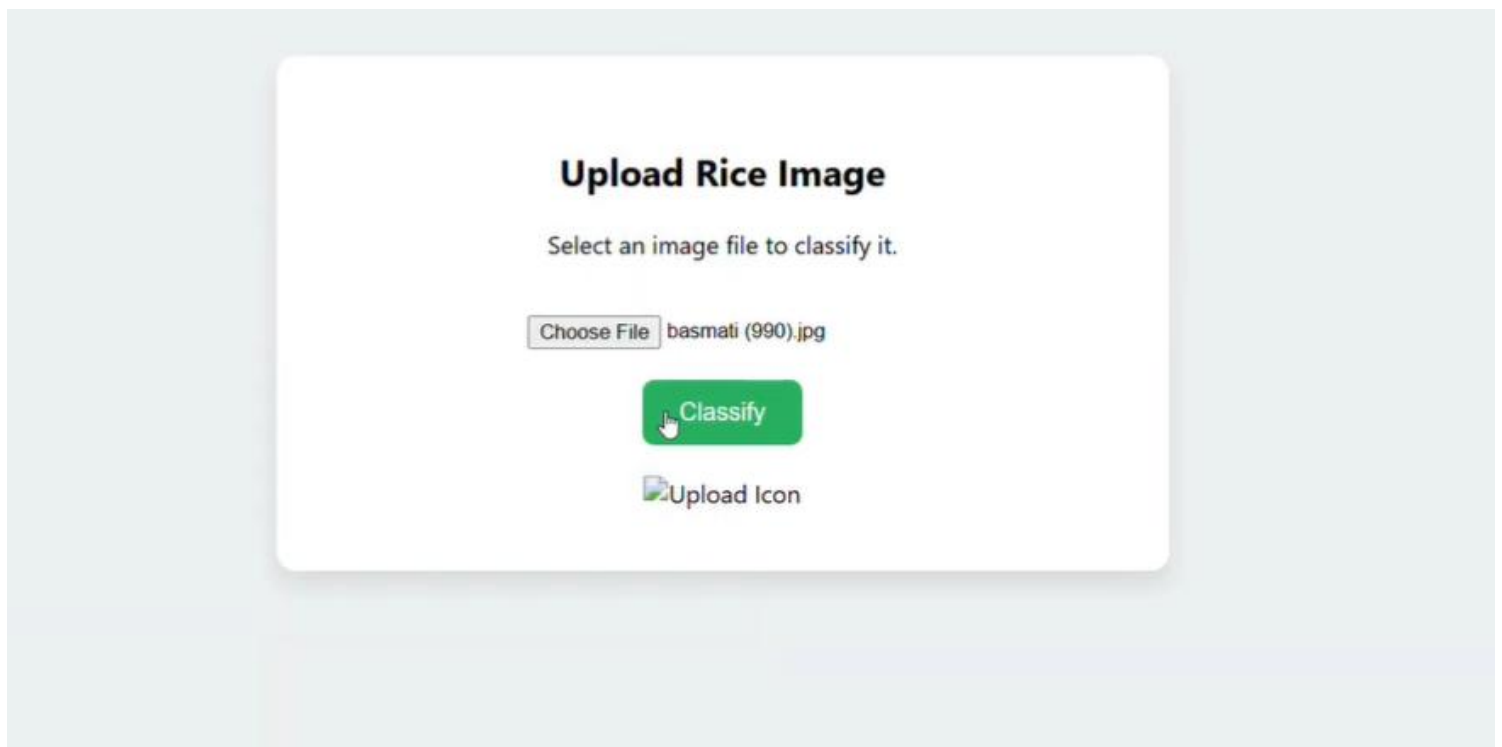
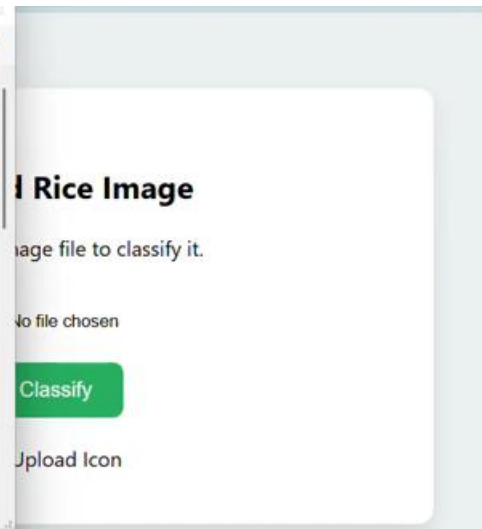
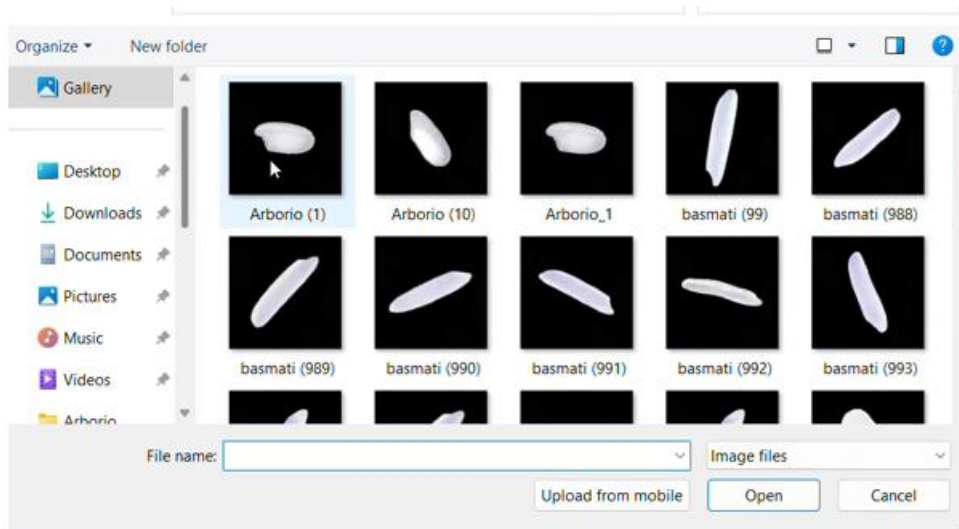
Choose File

No file chosen

Classify



Upload Icon



Classification Result

Predicted Class: 1



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8. ADVANTAGES & DISADVANTAGES

Here are the **Advantages** :

- **High Accuracy:** The deep learning model provides more accurate classification compared to manual methods.
- **Time-Saving:** Automates the classification process, reducing time and human effort.
- **Cost-Effective:** Minimizes the need for manual labor and expert inspection in the long run.
- **Scalable:** Can handle large datasets and be deployed in industrial environments for mass classification.

- **Consistent Results:** Eliminates human bias and provides uniform and reliable outputs.
- **Adaptable:** The model can be retrained or fine-tuned for other grain types or agricultural products.
- **Real-Time Prediction:** Enables fast and on-the-spot classification when deployed with a user interface.

Here are some **Disadvantages** :

- **High Computational Requirement:** Requires a good GPU and high processing power for model training.
- **Large Dataset Needed for Best Performance:** Although Transfer Learning helps, more data improves accuracy.
- **Initial Setup Time:** Data preprocessing, model tuning, and training can take significant time initially.
- **Limited Generalization:** The model may not perform well on images with different lighting, angles, or background unless trained properly on diverse data.

9. CONCLUSION

In this project, a deep learning-based classification system was developed to accurately identify different types of rice grains using **Transfer Learning techniques**. By utilizing powerful pre-trained CNN models like **VGG16** and **ResNet50**, the system achieved **high classification accuracy** with minimal training time and reduced computational cost. The use of image preprocessing and data augmentation further improved the model's robustness and ability to generalize on unseen data. This solution effectively addresses the challenges associated with manual rice classification, such as **inconsistency**, **human error**, and **time consumption**. The project highlights the **potential of deep learning in agricultural automation and quality control**. It also opens avenues for future improvements, such as deploying the model as a **web or mobile application**, expanding it to classify other grains or crops, and improving its performance under varying real-world image conditions like **different lighting and backgrounds**.

10. FUTURE SCOPE

- **Deployment as a Web or Mobile App:** The model can be integrated into user-friendly applications for farmers and quality inspectors.
- **Real-Time Classification:** Implementing the system for real-time rice grain detection using live camera feeds.
- **Expansion to More Grain Types:** Extending the model to classify other grains like wheat, barley, or pulses.

- **Larger and Diverse Dataset Collection:** Improving accuracy by training the model on a larger and more diverse image dataset.
- **Edge Device Deployment:** Optimizing the model to run on low-power devices like Raspberry Pi or mobile processors for field use.
- **Integration with IoT Devices:** Connecting with IoT-based smart agriculture systems for automated sorting and quality monitoring.
- **Improved Image Preprocessing:** Implementing advanced image enhancement techniques to handle varied lighting and background conditions.
- **Model Optimization:** Reducing model size and improving inference speed using techniques like pruning or quantization.
- **Multi-Class and Defect Detection:** Extending the model to not just classify type but also detect defective or damaged grains.
- **Cloud-Based Solution:** Deploying the model on cloud platforms (like AWS, GCP, or Azure) for scalable and remote access by industries.

11. APPENDIX

Source Code:



rice-classification-1.ip
ynb

GitHub & Project Demo Link:

https://github.com/Yestheru/smartbridge_Project

Project Demo Link:

https://drive.google.com/file/d/1adALtz8rTpSiI9FQdGy_g-5gpOkrF2IV/view?usp=sharing

