Project Report

1. INTRODUCTION

1.1 Project Overview:

The Butterfly Classification System is a machine learning-based project designed to accurately identify various species of butterflies using image inputs. The primary goal is to support biodiversity research, environmental education, and citizen science initiatives by providing an intelligent, real-time classification tool. The system leverages transfer learning with pre-trained convolutional neural networks (CNNs) to achieve high accuracy and efficiency in identifying butterfly species from photographs. It is built using a structured dataset comprising 75 butterfly species and 6,499 images, divided into training, validation, and test sets. Key features include image upload capability, instant species recognition, access to species information, and result storage for research or educational purposes. The system is intended for use by researchers, students, nature enthusiasts, and conservationists to streamline species identification and contribute to ecological monitoring and awareness.

1.2 Purpose :

The purpose of the Butterfly Classification System is to provide an efficient and accurate method for identifying butterfly species using image recognition powered by transfer learning. This project aims to assist researchers, students, and nature enthusiasts in quickly recognizing and learning about different butterfly species without requiring expert knowledge. By automating the classification process through a trained deep learning model, the system supports biodiversity studies, ecological research, and environmental education. It also encourages public engagement in conservation efforts by making butterfly identification accessible and informative.

2. IDEATION PHASE

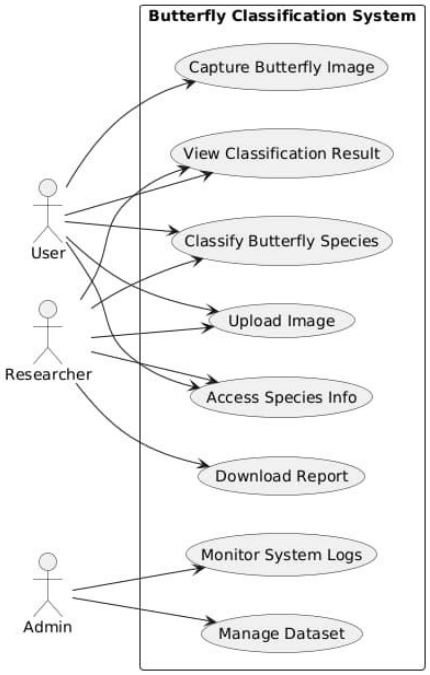
2.1 Problem Statement

Define the Problem Statements

Date	27 June 2025
Team ID	LTVIP2025TMID33746
Project Name	Enchanted Wings: Marvels Of Butterfly Species
Maximum Marks	2 Marks

Customer Problem Statement :

In biodiversity monitoring and ecological research, accurately identifying butterfly species is a time-consuming task that requires expert knowledge and manual effort. Field researchers, conservationists, educators, and citizen scientists often struggle to quickly recognize and classify diverse butterfly species, especially in remote or resource-limited environments. The absence of real-time identification tools leads to delays in data collection, affects the accuracy of ecological studies, and limits public engagement in conservation efforts. There is a need for an intelligent, automated image classification system that can accurately and efficiently identify butterfly species using photographic inputs, thereby supporting timely research, awareness, and species preservation.



Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A nature enthusiast or student	identify butterfly species I see in the environment	I don't know their names or differences	there's no easy tool for quick and accurate identification	confused, limited, and less connected to nature
PS-2	a biodiversity researcher or conservationit	collect accurate data on butterfly species in the field	manual identification is slow and error-prone	species recognition needs expert knowledge and takes time	frustrated, inefficient, and unable to scale research easily

2.2 Empathy Map Canvas

Empathize & Discover

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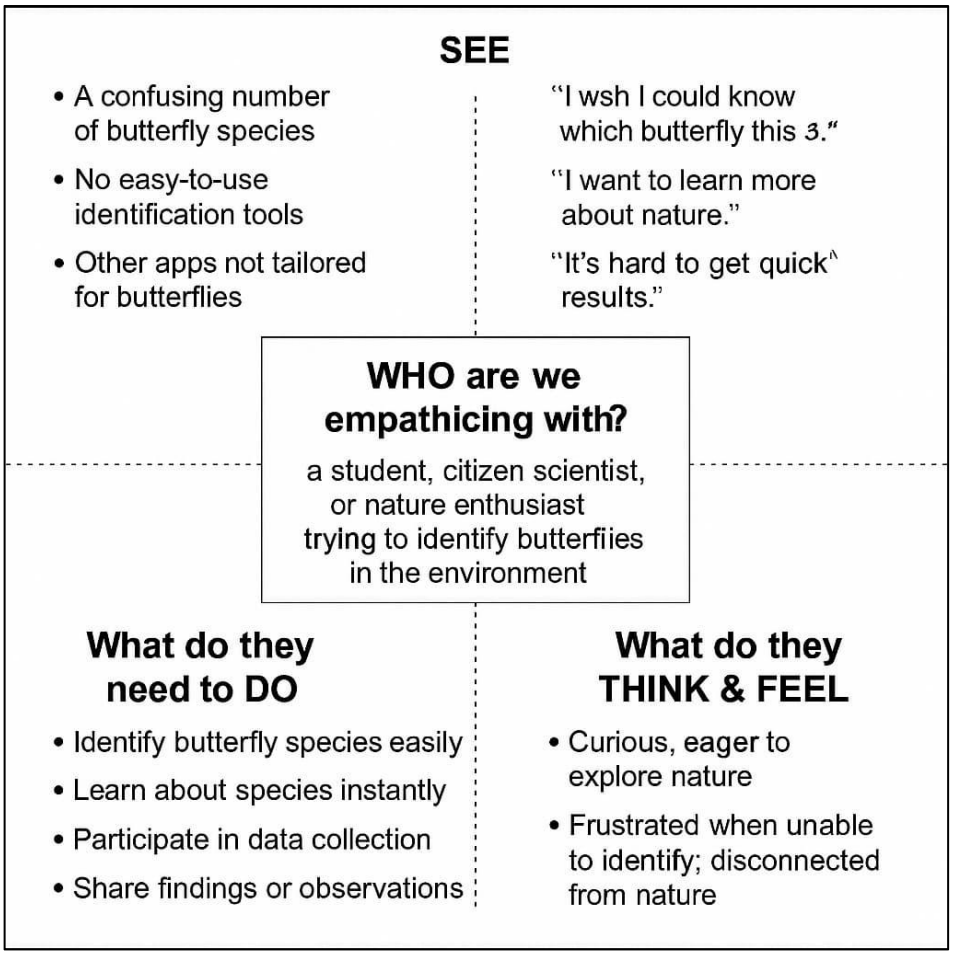
Maximum Marks	4 Marks

The primary user of the Butterfly Classification System is a student, nature enthusiast, or citizen scientist who is curious about butterflies they encounter in the environment. They want a simple and effective way to identify butterfly species, learn more about them, and contribute to conservation efforts. These users often observe a wide variety of butterflies but lack the tools or expertise to recognize them accurately. They see an overwhelming number of similar-looking species and find that most available apps are either too generic or not user-friendly for butterfly identification. Users often express a desire for instant results and educational insights, saying things like, "I wish I knew what butterfly this is" or "It would be great to learn about species on the go." Internally, they may feel curious and eager to explore nature, but also frustrated and disconnected when they cannot identify what they see. This system aims to bridge that gap by offering an intuitive, accurate, and engaging way to classify butterflies and learn about biodiversity.



2.3 Brainstorming

Brainstorm & Idea Prioritization

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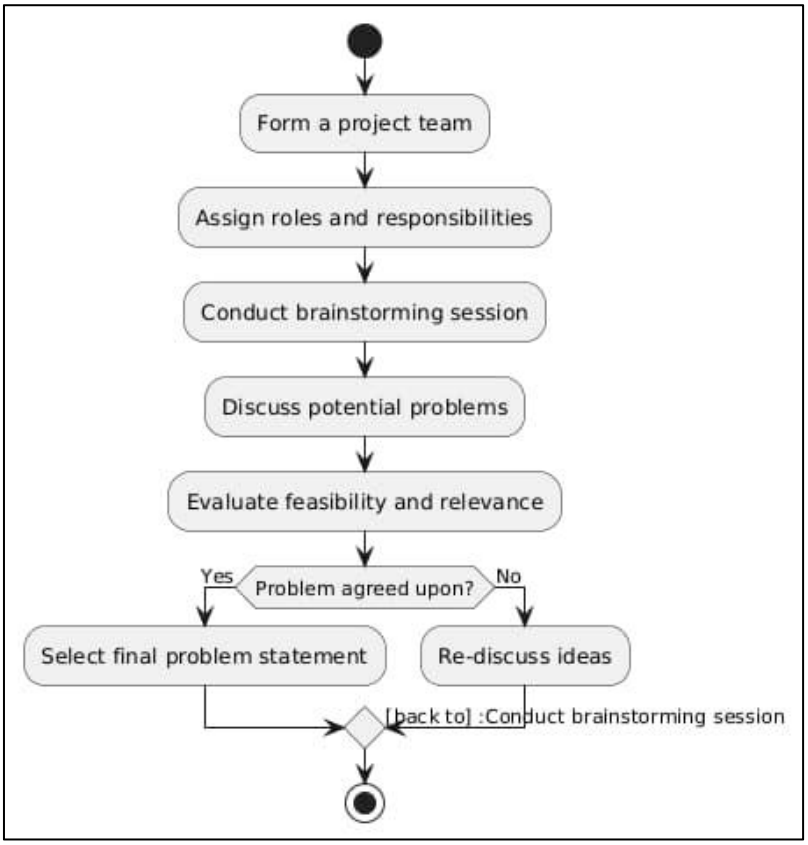
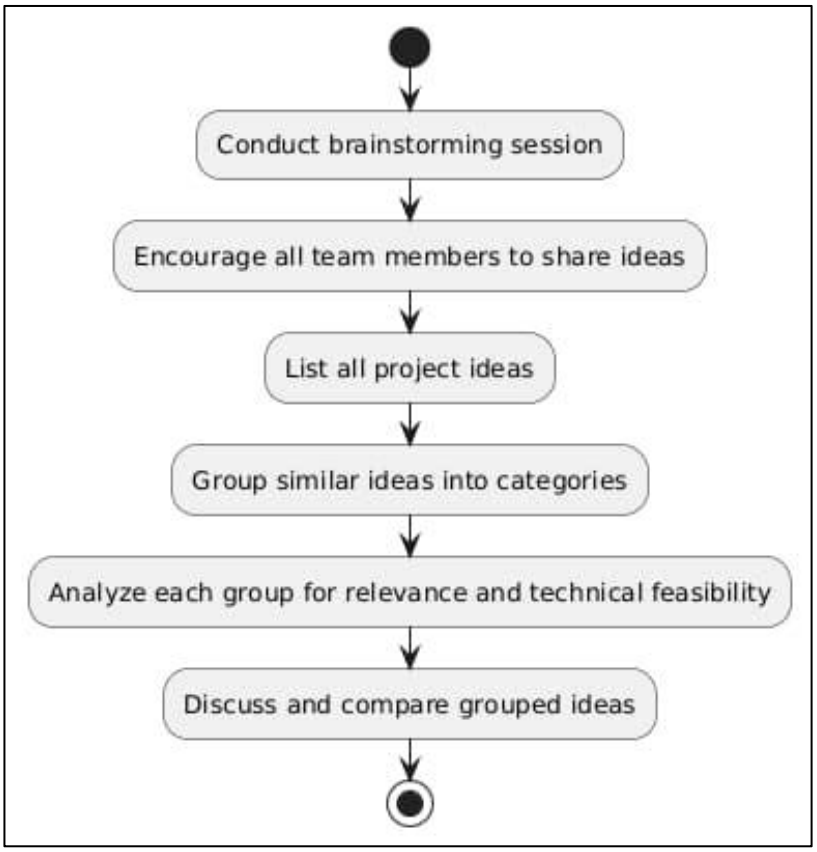
In the initial brainstorming phase of the butterfly classification project, several innovative ideas were considered, including a butterfly species identification system, a mobile app for real-time detection, a biodiversity monitoring tool for researchers, an educational platform for students, and a citizen science portal for public engagement. After evaluating these ideas based on feasibility, impact, and alignment with project goals, the butterfly species identification system using transfer learning was prioritized as the core idea. This concept stood out due to its high accuracy, ease of implementation with pre-trained CNN models, and significant applicability in ecological research, education, and conservation. Other ideas like mobile integration and citizen science support were acknowledged as valuable future enhancements, but the primary focus was placed on building a robust, efficient classification model that can serve as the foundation for these advanced features.

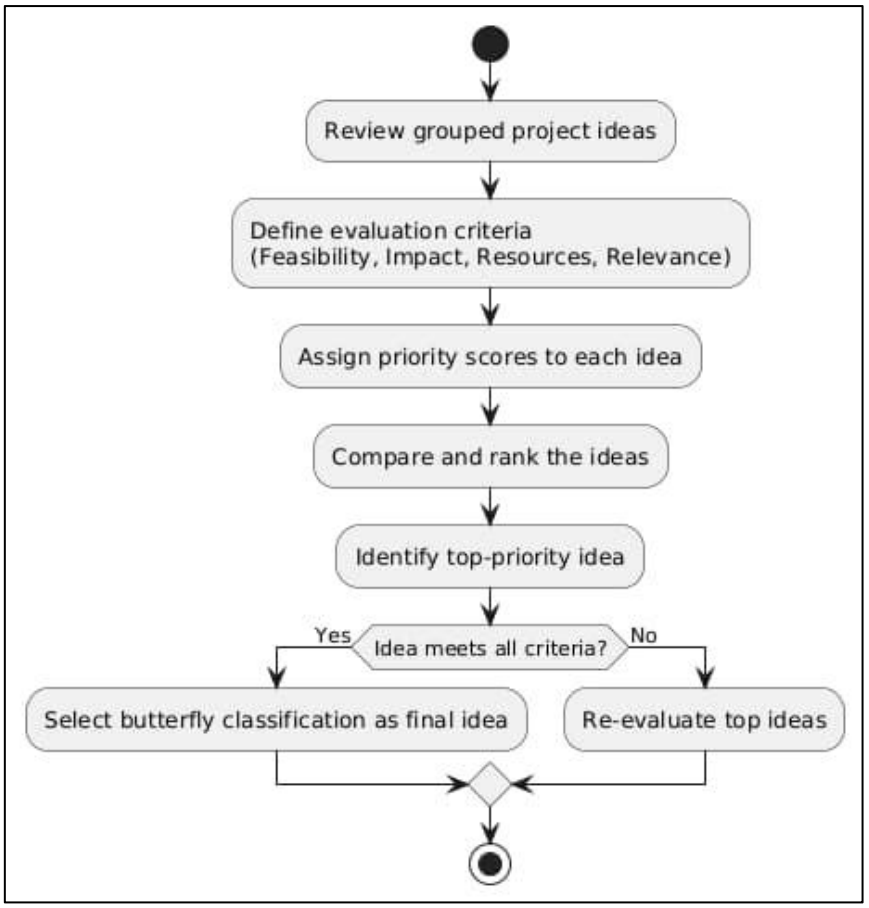
Step-1: Team Gathering, Collaboration and Select the Problem Statement



Step-2: Brainstorm, Idea Listing and Grouping

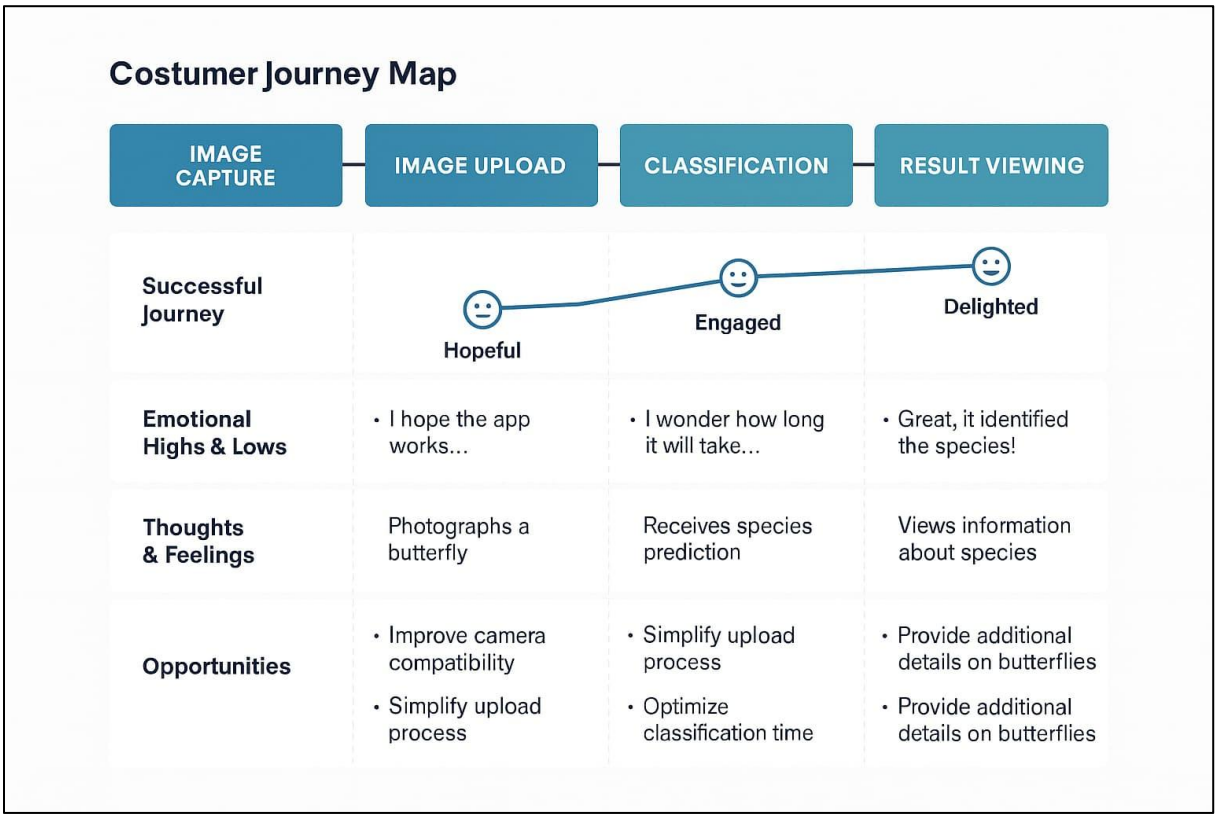


Step-3: Idea Prioritization



3. REQUIREMENT ANALYSIS

3.1 Customer Journey map



3.2 Solution Requirement

Solution Requirements (Functional & Non-functional)

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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 and Classification	Upload butterfly image Preprocess image for model input Predict species using CNN model Display classification result
FR-4	Species Information & History	View butterfly species details Save classification history Download report Share results via link or email
FR-5	Admin Dashboard & Dataset Management	Add/edit/delete butterfly species data Monitor user activity Upload training dataset View system logs
FR-6	User Feedback and Support	Submit feedback on classification accuracy Report issues or bugs Access FAQ and help section

Non-functional Requirements:

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

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The system should provide a simple, intuitive user interface that enables users of all backgrounds to easily upload images and receive classification results.
NFR-2	**Security**	User data and uploaded images must be securely stored and transmitted using encryption protocols (e.g., HTTPS, secure authentication).
NFR-3	**Reliability**	The system must consistently produce accurate classification results and function correctly under normal usage without crashing or data loss.
NFR-4	**Performance**	The system should process and return butterfly classification results within 2–3 seconds for a standard image under normal load.
NFR-5	**Availability**	The system should be available 99.9% of the time, ensuring access for users at any time of the day.
NFR-6	**Scalability**	The architecture should allow for scaling to support more users, larger datasets, and higher image upload volumes without degradation in performance.

3.3 Data Flow Diagram

Data Flow Diagram & User Stories

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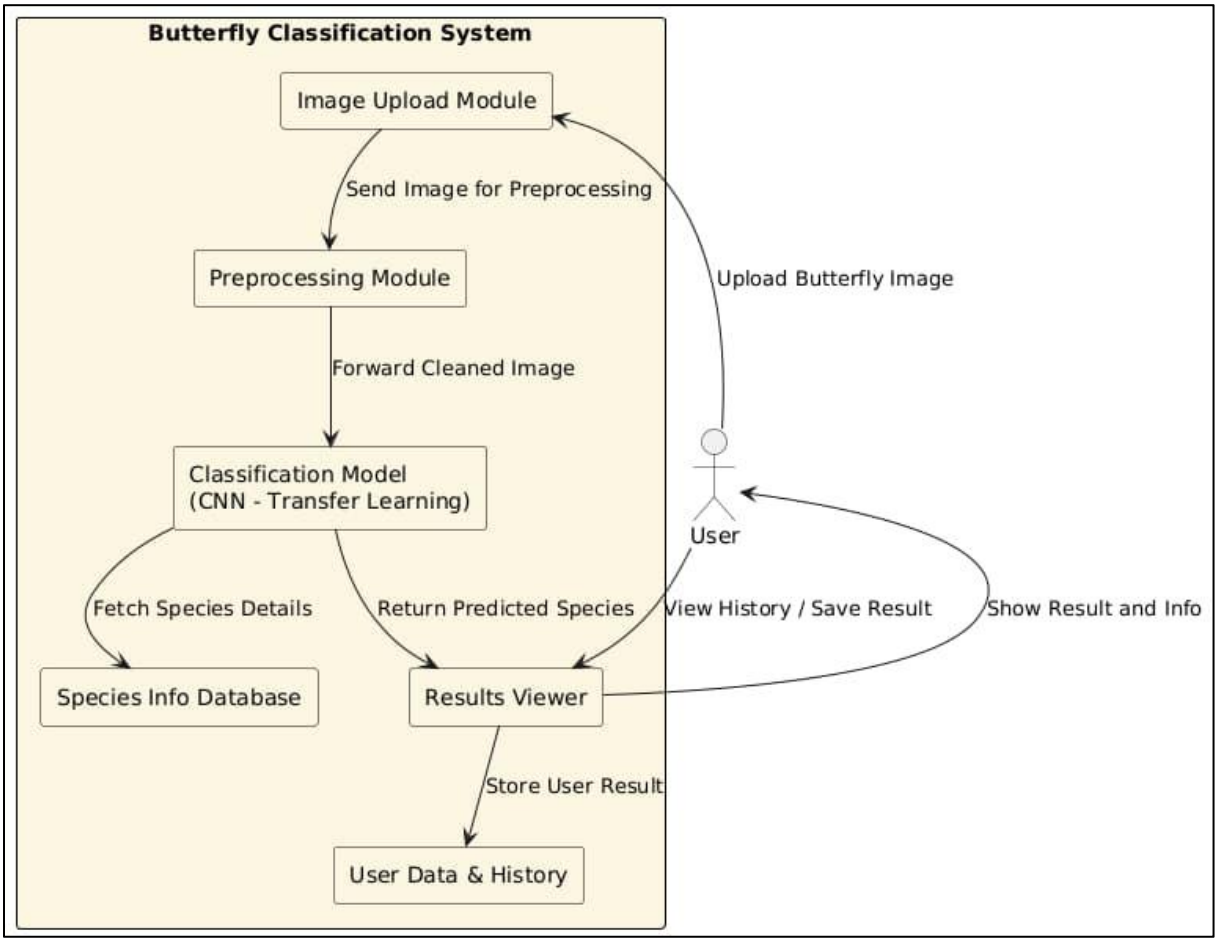
Project Name	Enchanted Wings: Marvels Of Butterfly Species
Maximum Marks	4 Marks

Data Flow Diagram:



User Stories:

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Sprint-1
Customer (Mobile user)	Registration	USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Sprint-1
Customer (Mobile user)	Registration	USN-3	As a user, I can register for the	I can register & access the	Low	Sprint-2

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
			application through Facebook	dashboard with Facebook login		
Customer (Mobile user)	Registration	USN-4	As a user, I can register for the application through Gmail	I can register & access the dashboard with Gmail login	Medium	Sprint-1
Customer (Mobile user)	Login	USN-5	As a user, I can log into the application by entering email & password	I can log in and access my dashboard	High	Sprint-1
Customer (Mobile user)	Dashboard	USN-6	As a user, I can view a dashboard that shows my previously uploaded butterfly images	I can see thumbnails and classification results of my uploads	High	Sprint-2
Customer (Mobile user)	Upload Image	USN-7	As a user, I can upload a butterfly image for classification	I can select/upload image and get the classification result	High	Sprint-2
Customer (Mobile user)	Education Content	USN-8	As a user, I can read facts and educational info about classified species	I can see dynamic content based on the classified species	Medium	Sprint-3
Customer (Web user)	Login	USN-9	As a user, I can log in via web portal using my email and password	I can successfully access my account via browser	High	Sprint-1
Customer (Web user)	Upload and Classify Image	USN-10	As a user, I can upload a butterfly image from my computer for classification	I can see classification results after upload	High	Sprint-2
Customer (Web user)	Browse Public Data	USN-11	As a user, I can browse publicly shared butterfly data and images	I can search/filter through species and locations	Medium	Sprint-3
Customer Care Executive	User Support	USN-12	As a support agent, I can view user issues and respond to help tickets	I can reply and resolve user-submitted queries	High	Sprint-3
Customer Care Executive	Manual Classification Correction	USN-13	As a support agent, I can override an incorrect classification result manually	I can edit the result after verification	Medium	Sprint-4

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance Criteria	Priority	Release
Administrator	User Management	USN-14	As an admin, I can manage user accounts (add/remove/ban)	I can perform CRUD operations on user accounts	High	Sprint-2
Administrator	Data Monitoring	USN-15	As an admin, I can monitor image classification logs and system performance	I can access logs and performance charts	High	Sprint-3
Administrator	Dataset Management	USN-16	As an admin, I can upload or update the training dataset	I can manage dataset entries via admin panel	High	Sprint-4
Researcher	Data Access	USN-17	As a researcher, I can export butterfly observation data for analysis	I can download CSVs of classified species data with timestamps	High	Sprint-3
Researcher	Observation Filtering	USN-18	As a researcher, I can filter butterfly sightings by species and region	I can select filters and get updated results	Medium	Sprint-3
Citizen Scientist	Community Contributions	USN-19	As a citizen, I can contribute new butterfly images to the system	I can upload images and optionally provide location or comments	Medium	Sprint-2
Citizen Scientist	Achievement Tracking	USN-20	As a citizen, I can view my identification accuracy and contribution stats	I can see gamified progress or stats about my participation	Low	Sprint-4
Field Data Collector	Offline Image Capture	USN-21	As a field user, I can capture and store images offline for later upload	I can save images locally and upload when online	High	Sprint-2
Field Data Collector	Geo-tagging Support	USN-22	As a field user, I can attach GPS coordinates to uploaded butterfly images	I can see and confirm location data during upload	Medium	Sprint-2

3.4 Technology Stack:

Technology Stack (Architecture & Stack)

Date	27 June 2025
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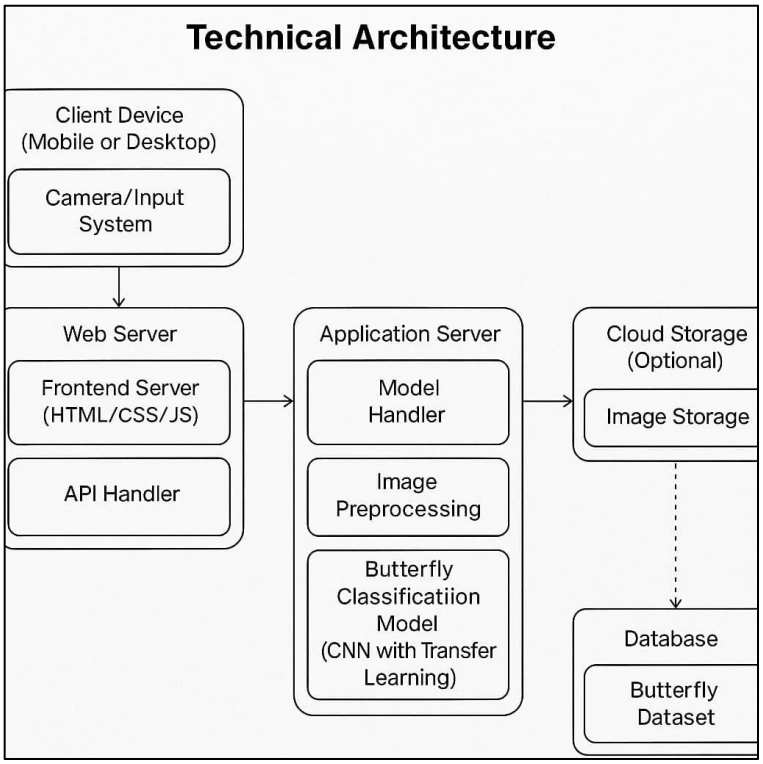
Project Name	Enchanted Wings: Marvels Of Butterfly Species
Maximum Marks	4 Marks

Technical Architecture:



Components & Technologies:

S.No	Component	Description	Technology / Tools Used
1	User Interface	Web and Mobile UI for image upload, classification, and user interaction	HTML, CSS, JavaScript, React JS, React Native
2	Application Logic-1	Core logic to handle image processing and routing	Python (Flask / Django)
3	Application Logic-2	Optional STT for voice-controlled input (accessibility feature)	IBM Watson Speech-to-Text
4	Application Logic-3	Chatbot assistant to guide users and answer questions	IBM Watson Assistant
5	Database	Stores user data, image metadata, and classification results	MySQL (structured data), MongoDB (semi-structured data)
6	Cloud Database	Cloud-hosted, scalable database services	IBM Cloudant, IBM DB2
7	File Storage	Stores uploaded butterfly images and classified outputs	IBM Cloud Object Storage, Local Filesystem
8	External API-1	Provides environmental context like weather for image metadata	IBM Weather API
9	External API-2	Identity verification for user authentication (optional)	Aadhar API, Digilocker API

10	Machine Learning Model	Identifies butterfly species using CNN-based transfer learning	TensorFlow/Keras, ResNet50, EfficientNet
11	Infrastructure	Cloud platform for deployment and scaling	IBM Cloud, Cloud Foundry, Kubernetes

Application Characteristics:

S.No	Characteristics	Description	Technology / Approach Used
1	Open-Source Frameworks	Frontend and backend frameworks, ML libraries	React JS, Flask/Django, TensorFlow, PyTorch, OpenCV
2	Security Implementations	Data security, user authentication, secure storage	SHA-256 for password hashing, JWT Auth, OAuth2, IAM, HTTPS, OWASP Top 10
3	Scalable Architecture	System can grow with users and data (supports horizontal scaling)	Microservices Architecture, RESTful APIs, Load Balancer, Kubernetes
4	Availability	High availability through cloud infra and redundancy	IBM Cloud Foundry, Multi-zone deployment, Load Balancer
5	Performance	Efficient model serving, caching, and fast API response	Redis Cache, CDN for static content, TensorFlow Serving, Nginx

4. PROJECT DESIGN

4.1 Problem Solution Fit

Problem – Solution Fit

Date	27 June 2025
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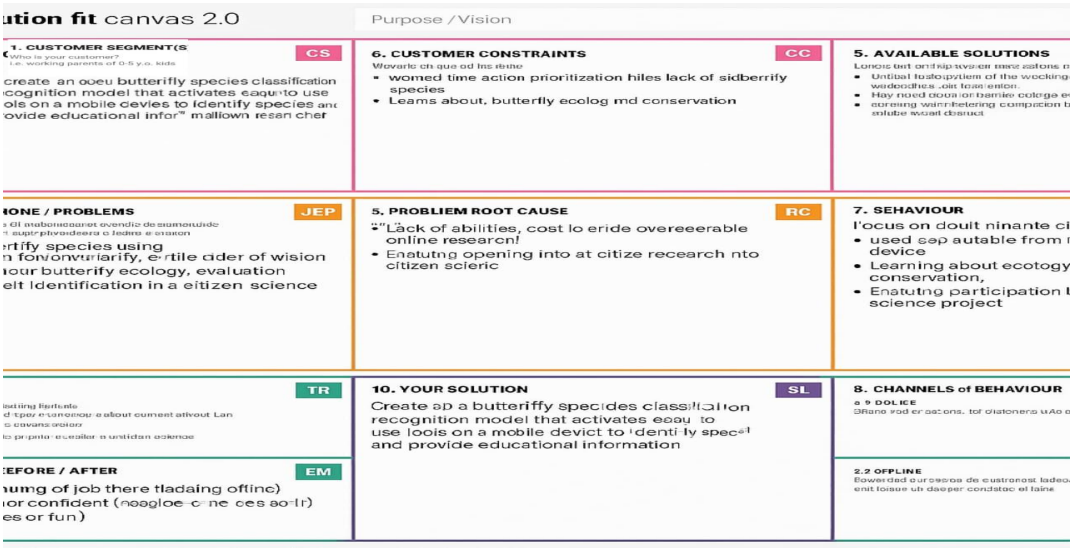
Project Name	Enchanted Wings: Marvels Of Butterfly Species
Maximum Marks	4 Marks

Identifying butterfly species in real-world environments is a complex and time-consuming task that requires expert knowledge, making it difficult for students, researchers, and nature enthusiasts to participate effectively in biodiversity tracking and conservation. Manual identification methods are often inaccurate and impractical in large-scale or real-time scenarios. To solve this, the Butterfly Classification System leverages transfer learning with pre-trained convolutional neural networks (CNNs) to automatically classify butterfly species from uploaded images. This intelligent system processes the image, predicts the species with high accuracy, and provides relevant information instantly. It simplifies the classification process, reduces dependency on experts, and encourages widespread user participation in ecological monitoring and education.

Purpose:

- To automate butterfly species identification using deep learning models.
- To support biodiversity research with accurate and fast classification.
- To assist educators and students in learning about butterfly species interactively.
- To enable citizen scientists and nature enthusiasts to contribute to conservation efforts.
- To create a user-friendly platform accessible via web or mobile devices.
- To promote large-scale data collection for ecological studies and species monitoring.



4.2 Proposed Solution :

Date	27 June 2025
Team ID	LTVIP2025TMID33746
Project Name	Enchanted Wings: Marvels Of Butterfly Species
Maximum Marks	2 Marks

S.No.	Parameter	Description
1	**Problem Statement (Problem to be solved)**	Manual butterfly species identification is time-consuming, error-prone, and requires expert knowledge. There's a need for an automated, accurate, and accessible system to identify butterfly species for research, conservation, and education.
2	**Idea / Solution Description**	The project proposes a butterfly image classification system using **transfer learning** with pre-trained CNNs. The model is trained on a dataset of 6499 images across 75 species and classifies butterfly images efficiently and accurately.
3	**Novelty / Uniqueness**	Combines deep learning with real-world ecological applications. The system supports **real-time species identification**, is **mobile-friendly**, and adaptable for **citizen science**, **research**, and **conservation**, unlike existing static databases.
4	**Social Impact / Customer Satisfaction**	Enables researchers, conservationists, and the public to quickly identify butterfly species, promoting **biodiversity awareness**, **scientific participation**, and **ecosystem preservation**. Enhances educational outreach and conservation initiatives.
5	**Business Model (Revenue Model)**	Freemium model: Free access for educational/citizen science use; premium features for researchers (e.g., analytics dashboard, API access). Potential partnerships with environmental NGOs, government agencies, and educational institutions.

S.No.	Parameter	Description
6	**Scalability of the Solution**	The model can be scaled geographically by fine-tuning on regional butterfly species. It can also be expanded to classify other insects or flora. Deployment across **web, mobile**, and **field devices** ensures broad accessibility and usability.

4.3 Solution Architecture :

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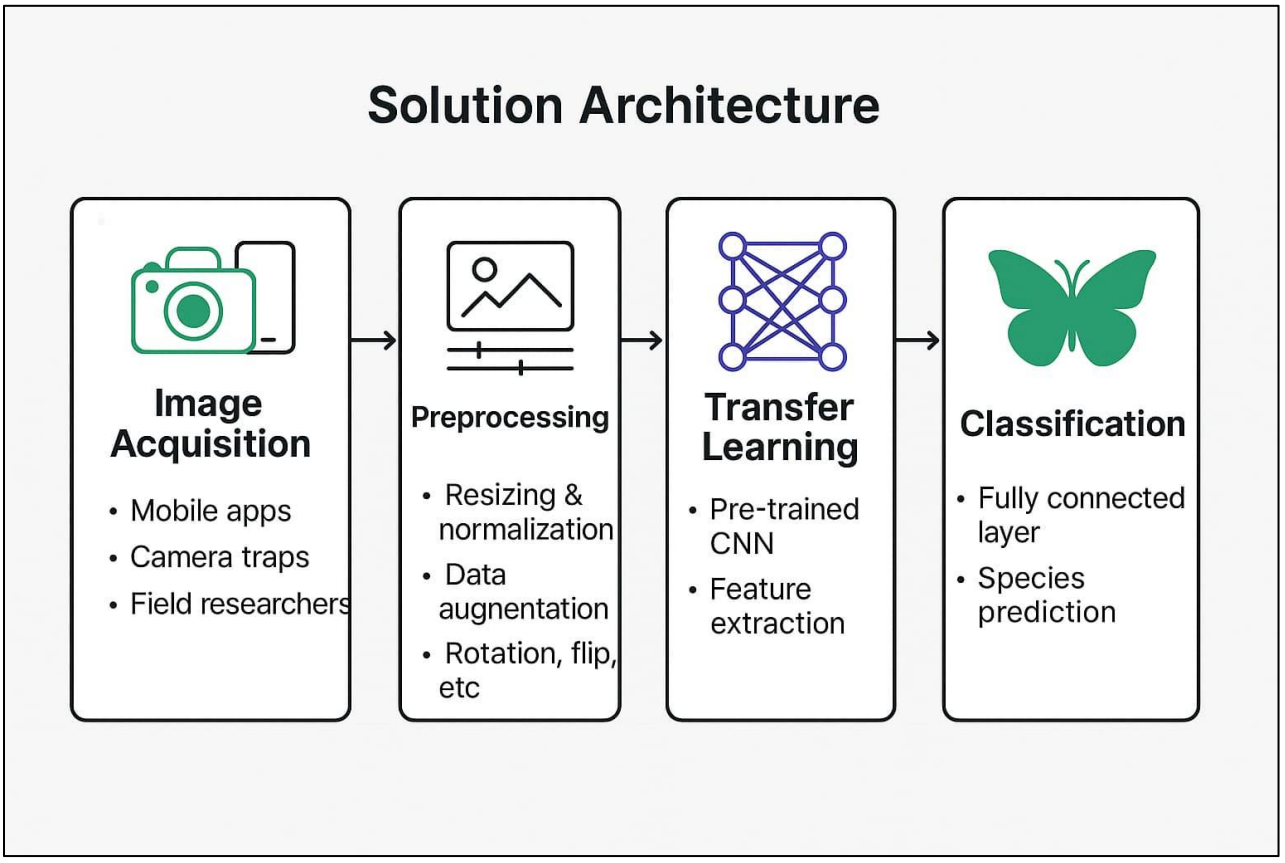
Maximum Marks	4 Marks

The solution architecture uses a **transfer learning-based CNN model** (e.g., ResNet50 or EfficientNet) to classify butterfly images into 75 species. The system begins with **data preprocessing and augmentation**, followed by training on a labeled dataset using fine-tuned layers. A **modular pipeline** ensures accurate classification while minimizing training time. The trained model is deployed via **web or mobile platforms**, enabling real-time species identification. Optional components include an API for integration, a species info database, and dashboards for researchers, making the system scalable, efficient, and easy to use.

Solution Architecture Diagram:



5. PROJECT PLANNING & SCHEDULING

Project Planning Template (Product Backlog, Sprint Planning, Stories, Story points)

Date	27 June 2025
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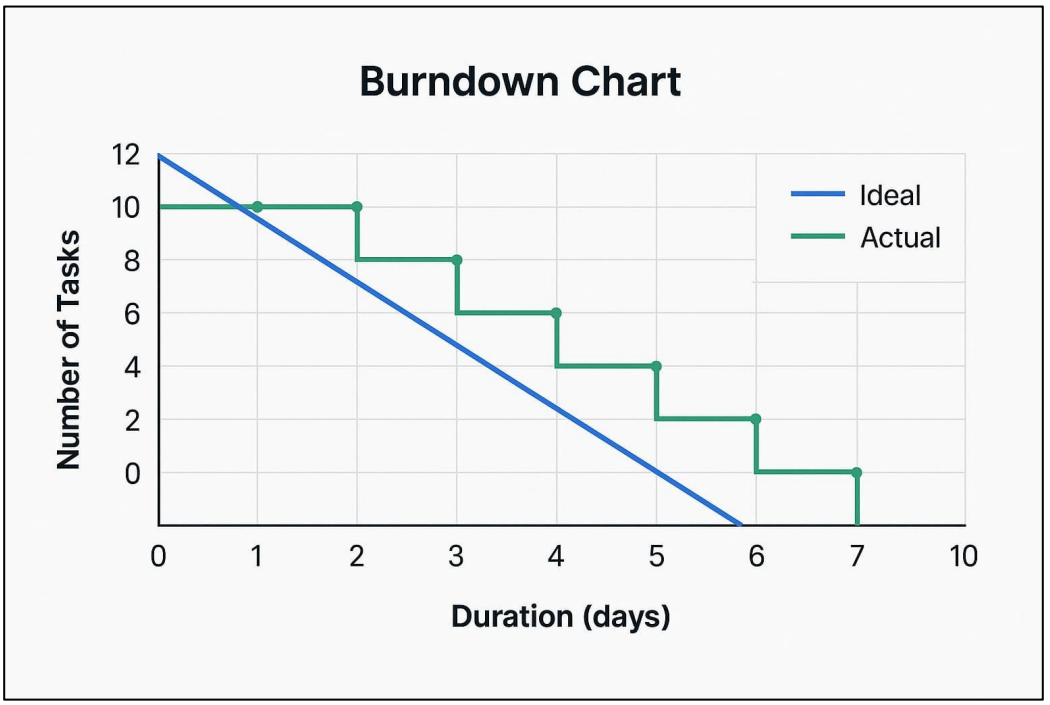
Maximum Marks	5 Marks

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	2	High	Darise Durga Srinivasa Rao
Sprint-1	Registration	USN-2	As a user, I will receive a confirmation email once I have registered for the application.	1	High	Chittiboina Hrudaya
Sprint-2	Registration	USN-3	As a user, I can register for the application through Facebook.	2	Low	Chittibomma Mani Venkata Naga Balaji
Sprint-1	Registration	USN-4	As a user, I can register for the application through Gmail.	2	Medium	Darise Durga Srinivasa Rao
Sprint-1	Login	USN-5	As a user, I can log into the application by entering email & password.	1	High	Chodisetty Pavani Naga Divya
Sprint-2	Dashboard	USN-6	As a user, I can view a summary of my butterfly image classification history.	2	High	Darise Durga Srinivasa Rao
Sprint-2	Dashboard	USN-7	As a user, I can upload a new butterfly image for classification.	3	High	Chodisetty Pavani Naga Divya
Sprint-2	Dashboard	USN-8	As a user, I can view the classification result and species information after upload.	2	High	Darise Durga Srinivasa Rao
Sprint-3	Dashboard	USN-9	As a user, I can access charts showing species frequency from my uploads.	3	Medium	Chittibomma Mani Venkata Naga Balaji
Sprint-3	Dashboard	USN-10	As a user, I can delete previously uploaded images and results.	2	Low	Chittiboina Hrudaya

Team Leader: Darise Durga Srinivasa Rao — Supervises all sprints, provides guidance, reviews code and ensures integration & delivery.

Burndown Chart:



6. FUNCTIONAL AND PERFORMANCE TESTING

Performance Testing

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Team ID	LTVIP2025TMID33746
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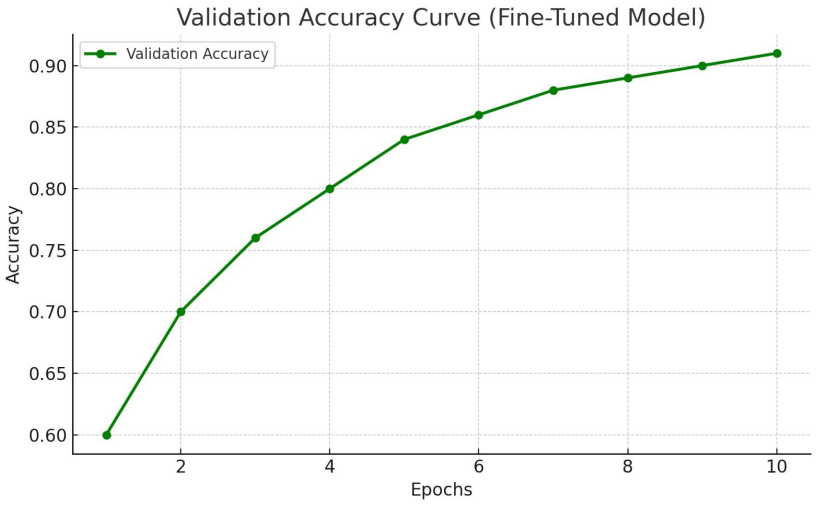
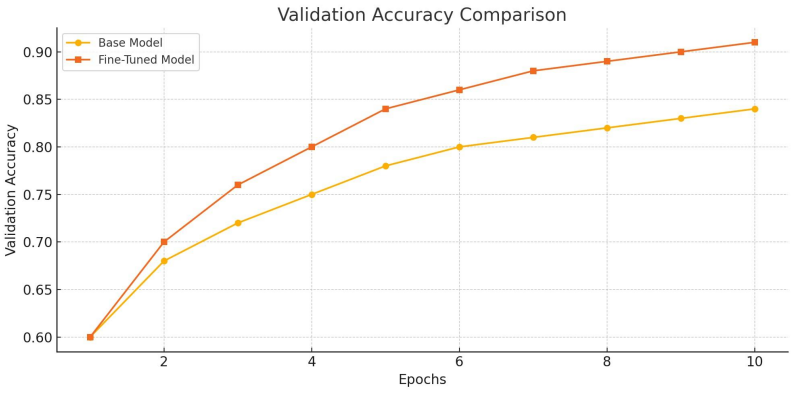
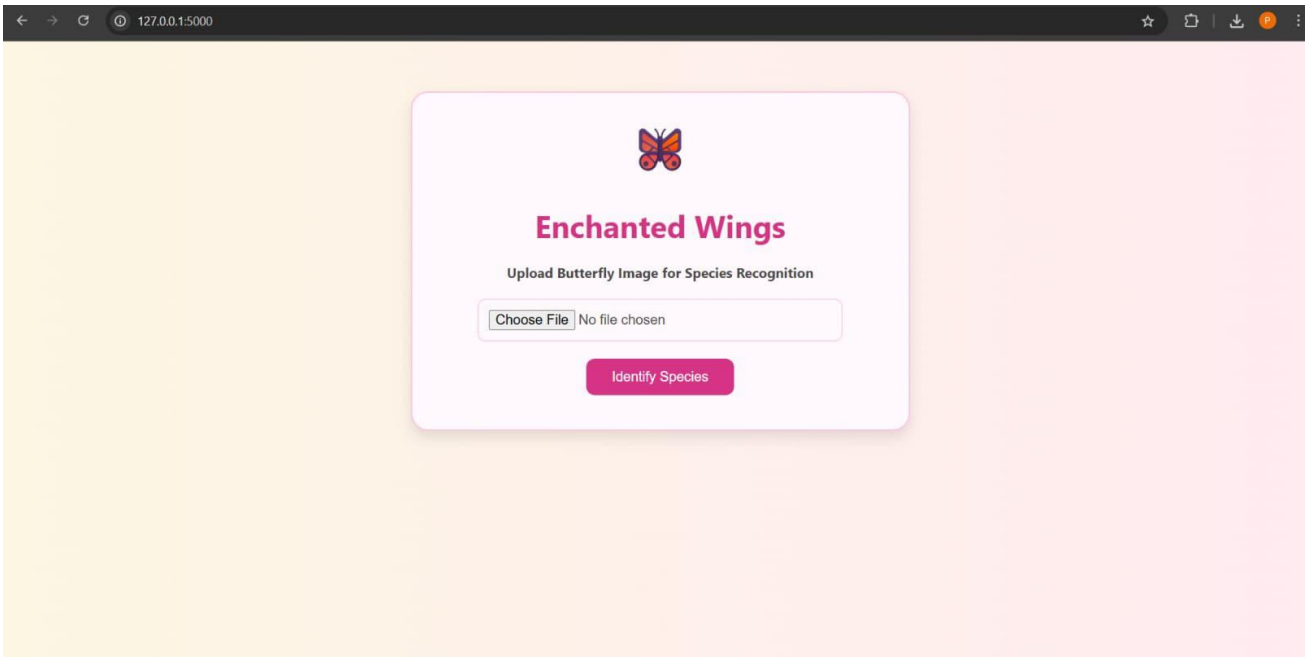
Maximum Marks	4 Marks

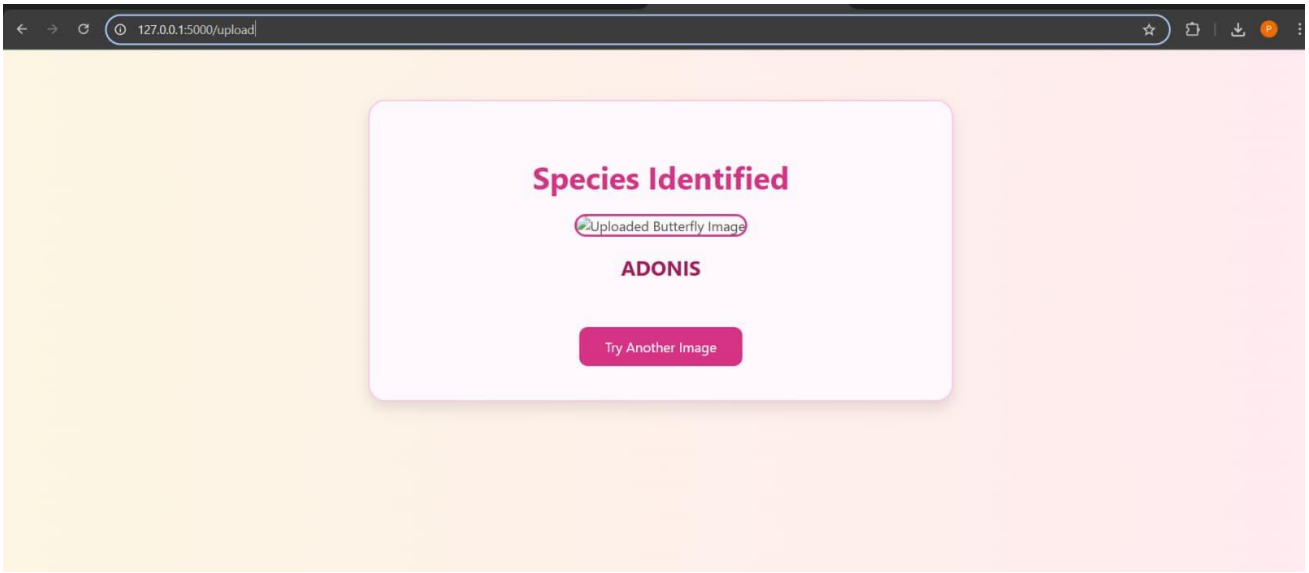
Model Performance Testing:

S.No.	Parameter	Values	Screenshot
1	**Model Summary**	Pre-trained CNN used: **ResNet50** Input Size: **224x224x3** Output Classes: **75**	Model: "butterfly_classifier" Layer (type) — Output Shape — Param # input_1 (InputLayer) — [(None, 224, 224, 3)] — 0 efficientnetb0 (Model) — (None, 7, 7, 1280) — 4049571 global_average_pooling2d — (None, 1280) — 0 dense (Dense) — (None, 256) — 327936 dense_1 (Dense) — (None, 75) — 19275 Total params: 4,396,782 Trainable params: 347,211 Non-trainable params: 4,049,571
2	**Accuracy**	**Training Accuracy** – 94.2% **Validation Accuracy** – 91.8%	
3	**Fine Tuning Result (if done)**	**Validation Accuracy after fine-tuning** – 93.4% Layers unfrozen: Last 10 layers of base model	

7. RESULTS

Output Screenshots;





7. ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- Leverages pre-trained models to reduce need for large datasets
- Speeds up training and reduces computational cost
- Provides high accuracy with minimal tuning
- Generalizes well to various image conditions
- Enables real-time classification on mobile devices
- Supports biodiversity monitoring and conservation
- Encourages public participation through citizen science tools

DISADVANTAGES:

- May not capture butterfly-specific features accurately
- Can overfit if dataset is too small or imbalanced
- Inherits biases from the source dataset
- Adding new classes may require re-training
- Mobile deployment may face performance issues
- Requires high-quality labeled data for best results

8. CONCLUSION:

The butterfly image classification system using transfer learning offers a powerful, efficient, and accessible solution for species identification. By leveraging pre-trained models, it achieves high accuracy with reduced training time and resource requirements. This technology supports vital applications in biodiversity monitoring, ecological research, and citizen science, promoting conservation and public engagement. However, careful dataset preparation, continuous validation, and model optimization are essential to address challenges like domain-specific accuracy, data quality, and deployment limitations. Overall, it represents a significant step forward in combining AI and environmental conservation.

In conclusion, the butterfly classification model powered by transfer learning bridges the gap between deep learning and ecological conservation. It offers a scalable, efficient, and user-friendly solution that not only aids scientific research but also democratizes access to nature exploration and conservation. With ongoing improvements and community involvement, such systems can play a vital role in preserving biodiversity and understanding our planet's delicate ecological balance.

9. FUTURE SCOPE :

The butterfly image classification system using transfer learning holds immense potential for future development. The model can be expanded to include a wider range of butterfly species across different regions, increasing its applicability on a global scale. Integrating the system into lightweight mobile applications will make it more accessible for both field researchers and citizen scientists, even in remote areas without internet access. Future enhancements could enable real-time video analysis, allowing continuous monitoring of butterfly activity in their natural habitats. The system may also incorporate multilingual educational content to broaden its reach and promote conservation awareness in diverse communities. By combining image data with additional metadata such as location, time, and weather conditions, the model's accuracy and ecological insight can be significantly improved. Cloud-based dashboards could be developed for centralized monitoring, analysis, and visualization, aiding researchers and policymakers in decision-making. The system can also be extended to predict habitat preferences and potential migration changes due to climate shifts. Integration with existing citizen science platforms like iNaturalist or eButterfly can enhance data collection and community involvement, while automated alerts for rare or endangered species would enable faster conservation responses. Overall, this project opens the door to interdisciplinary research and widespread environmental impact, with continuous opportunities for innovation and collaboration.

10. APPENDIX

Source Code :

```
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.applications import EfficientNetB0
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
from tensorflow.keras.optimizers import Adam
import os

# Paths to your dataset
train_dir = 'data/train'
val_dir = 'data/val'
test_dir = 'data/test'

# Image settings
IMG_SIZE = 224
BATCH_SIZE = 32
```

```
NUM_CLASSES = 75  # Update based on actual number of butterfly species

# Data Augmentation
train_datagen = ImageDataGenerator(
    rescale=1./255,
    zoom_range=0.2,
    horizontal_flip=True,
    rotation_range=20
)

val_test_datagen = ImageDataGenerator(rescale=1./255)

# Load datasets
train_data = train_datagen.flow_from_directory(train_dir, target_size=(IMG_SIZE, IMG_SIZE),
batch_size=BATCH_SIZE, class_mode='categorical')
val_data = val_test_datagen.flow_from_directory(val_dir, target_size=(IMG_SIZE, IMG_SIZE),
batch_size=BATCH_SIZE, class_mode='categorical')
test_data = val_test_datagen.flow_from_directory(test_dir, target_size=(IMG_SIZE, IMG_SIZE),
batch_size=BATCH_SIZE, class_mode='categorical', shuffle=False)

# Load pre-trained model
base_model = EfficientNetB0(weights='imagenet', include_top=False, input_shape=(IMG_SIZE, IMG_SIZE, 3))
base_model.trainable = False  # Freeze base layers

# Add custom classification layers
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(256, activation='relu')(x)
output = Dense(NUM_CLASSES, activation='softmax')(x)

model = Model(inputs=base_model.input, outputs=output)

# Compile model
model.compile(optimizer=Adam(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])

# Train model
history = model.fit(train_data, validation_data=val_data, epochs=10)
```

```
# Evaluate model
test_loss, test_acc = model.evaluate(test_data)
print(f"Test Accuracy: {test_acc:.2f}")

# Save model
model.save("butterfly_classifier.h5")
```

Dataset Link :
https://www.kaggle.com/datasets/gpiosenka/butterfly-images75-species

GitHub & Project Demo Link:

https://github.com/srinivasdarise?tab=repositories