**Project Report:**

**Enchanted Wings – Marvels of Butterfly Species**

**Team ID: LTVIP2025TMID33527**

**Team Size: 3**

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**1. INTRODUCTION**

Butterflies are one of the most stunning and ecologically valuable insect species on Earth. With their delicate wings and vibrant patterns, they not only enrich the environment visually but also play a vital role as pollinators and biodiversity indicators. The goal of this project is to explore butterfly diversity using technology — enabling identification and awareness through automation. This report outlines the design and development of a smart image-based butterfly species classifier supported by machine learning.

**2. PHASE 1: BRAINSTORMING & IDEATION**

**Problem Identification:**

Identifying butterfly species is usually limited to experts or field researchers. General users and students often struggle to identify even common species due to the variety in colors, wing shapes, and regional differences.

**Proposed Idea:**

Build a lightweight, AI-powered tool that can accurately classify butterfly species using uploaded images. It can serve educational, research, and citizen science goals — making butterfly identification accessible to all.

**Innovation Element:**

* Uses **pre-trained deep learning models** for species prediction.
* Supports **real-time image classification**.
* Provides **visual and scientific information** about each predicted species.

**3. PHASE 2: REQUIREMENT ANALYSIS**

**Functional Requirements:**

* Upload butterfly images from any device.
* Run classification and display species name.
* Show related data like scientific name, range, and habitat.

**Technical Requirements:**

* Programming Language: Python 3.10+
* ML Framework: TensorFlow / Keras
* Deployment: Flask or Streamlit (local/web)
* Dataset: Butterfly Image Dataset with 70+ species

**Tools Used:**

* **TensorFlow**: For deep learning model training
* **Matplotlib & Seaborn**: For visual analysis
* **LabelEncoder**: To map class names to numeric labels
* **OpenCV**: For image preprocessing

**4. PHASE 3: PROJECT DESIGN**

**System Overview:**

The system consists of three major components:

1. **Frontend** – A simple interface to upload images
2. **Backend** – Model processing engine
3. **Database/Storage** – Contains species info & images

**Data Flow:**

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User Uploads Image → Preprocess → Predict Using CNN Model → Output Species Info

**User Journey:**

* Step 1: Open the web app
* Step 2: Upload butterfly image
* Step 3: Get instant prediction & butterfly info
* Step 4: Optionally save or share result

**5. PHASE 4: PROJECT PLANNING**

**Timeline:**

| **Week** | **Activity** |
| --- | --- |
| 1 | Dataset collection and cleaning |
| 2 | Model selection & architecture |
| 3 | Training & tuning |
| 4 | Interface design & backend link |
| 5 | Testing and bug fixing |
| 6 | Final report & deployment |

**Team Roles:**

* **Data Handler**: Cleans and manages dataset
* **ML Engineer**: Builds and trains model
* **UI Developer**: Designs and codes interface
* **Tester/QA**: Validates outputs and performance

**6. PHASE 5: DEVELOPMENT**

**Model Architecture:**

The system uses **EfficientNetB0** for feature extraction, with a final classification layer trained on butterfly classes. The model accepts input images of size 224x224 and outputs class probabilities.

**Preprocessing:**

* Resize to 224x224
* Normalize pixel values
* One-hot encode class labels

**Training Summary:**

* Accuracy: ~88% (on validation data)
* Loss: Low after 20 epochs
* Augmentation: Applied rotation, zoom, flipping

**7. PHASE 6: TESTING**

**Types of Testing Conducted:**

* **Functional Testing**: Correct output for valid images
* **Negative Testing**: Error for invalid/non-butterfly inputs
* **Performance Testing**: Response time under 5 seconds
* **Cross-browser Testing**: App tested on Chrome, Edge

**Testing Results:**

| **Test Case** | **Status** |
| --- | --- |
| Image upload & preview | Pass |
| Correct class prediction | Pass |
| Interface responsiveness | Pass |
| Handling invalid inputs | Pass |

**8. RESULTS & BENEFITS**

* Enables **quick species identification**.
* Helps in **spreading ecological knowledge**.
* Can be integrated with **mobile apps or museum displays**.
* Acts as a **digital field guide** for butterfly lovers.

**9. CONCLUSION**

"Enchanted Wings" combines biology and artificial intelligence to promote butterfly awareness and education. It shows how even small-scale technology can have a big impact in citizen science and conservation. With further refinement, this tool could be scaled to work offline in field conditions and support more insect families.

**10. FUTURE SCOPE**

* Expand to 200+ butterfly species across continents.
* Add real-time location tagging and maps.
* Build a community image gallery for collaborative learning.
* Add support for other insect types (e.g., moths, beetles).

**11. REFERENCES**

* Kaggle Butterfly Dataset
* TensorFlow Documentation
* National Butterfly Research Centre India
* iNaturalist API Documentation