

# SEED QUALITY CLASSIFICATION SYSTEM

Automated Pumpkin Seed Classification Using Machine Learning & Flask Web Application

## 1. PROJECT OVERVIEW

The Seed Quality Classification System is a machine learning-based web application designed to classify pumpkin seeds into predefined quality categories based on their physical and morphological characteristics. The system leverages supervised learning algorithms trained on a structured dataset containing seed attributes such as area, perimeter, axis lengths, solidity, roundness, and compactness.

The project integrates a trained ML model with a Flask-based web interface, allowing users to input seed parameters and instantly receive a prediction regarding the seed class. This automated approach assists agricultural analysts, researchers, and seed quality inspectors in making faster and more accurate classification decisions.

**Project Member :**

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## **2. OBJECTIVES**

- To develop an accurate machine learning model for pumpkin seed classification.
- To analyze and preprocess seed morphology data for effective training.
- To compare multiple supervised learning algorithms and select the best-performing model.
- To deploy the trained model using a Flask web framework.
- To design a clean, user-friendly web interface for data input and result visualization.
- To enable real-time prediction of seed class based on user inputs.

### **3. KEY FEATURES**

- User-Friendly Web Interface: Simple and intuitive UI for entering seed parameters.
- Machine Learning–Based Prediction: Accurate classification using a trained ML model.
- Multiple Feature Inputs: Supports morphological attributes such as area, perimeter, eccentricity, and compactness.
- Real-Time Prediction: Instant classification results upon form submission.
- Model Persistence: Pre-trained model loaded using pickle for efficient inference.
- Clean UI Flow: Home page → Prediction page → Result display.

## **4. USE CASE SCENARIOS**

### **Scenario 1: Agricultural Research**

Researchers can input measured parameters of pumpkin seeds obtained from imaging systems. The system classifies the seeds into predefined categories, assisting in seed quality analysis and crop research.

### **Scenario 2: Seed Quality Inspection**

Seed processing units can use the application to quickly verify the quality category of seeds before packaging and distribution, ensuring consistency and quality assurance.

### **Scenario 3: Educational Demonstration**

Students and learners can use the project to understand how machine learning models are trained, evaluated, and deployed in real-world agricultural applications.

## 5. TECHNICAL APPROACH

### Frontend: Flask + HTML/CSS

- **Framework:** Flask (Python)
- **Technologies:** HTML5, CSS3
- **Features:** Form-based input, responsive layout, conditional result rendering

### Backend: Machine Learning Model

- **Algorithms Used:** Logistic Regression, Support Vector Machine, Random Forest (during experimentation)
- **Final Model:** Best-performing algorithm selected based on evaluation metrics •
- **Libraries:** NumPy, Pandas, Scikit-learn

### Data Processing

- Data cleaning and preprocessing
- Feature scaling using StandardScaler
- Label encoding for class labels

### System Architecture

- **Presentation Layer:** HTML/CSS templates
- **Application Layer:** Flask routes and request handling
- **Model Layer:** Pre-trained ML model loaded via pickle

## 6. IMPLEMENTATION PLAN

| Phase                | Activities                               | Timeline |
|----------------------|--|----------|
| Requirement Analysis | Dataset understanding, feature selection | 2 Days   |
| Data Preprocessing   | Cleaning, scaling, encoding              | 3 Days   |
| EDA                  | Statistical & visual analysis            | 3 Days   |
| Model Training       | Train multiple ML models                 | 3 Days   |
| Model Evaluation     | Accuracy comparison & tuning             | 3 Days   |
| Deployment           | Flask integration                        | 3 Days   |
| Testing              | UI & prediction testing                  | 3 Days   |

## **7. BENEFITS**

### **For Agriculture Sector**

- Faster and more consistent seed classification
- Reduced manual inspection effort
- Improved decision-making accuracy

### **For Researchers & Students**

- Practical exposure to ML model deployment
- Understanding end-to-end ML workflow
- Real-world dataset usage

## 8. PROJECT FLOW

- User Input: User enters seed parameters through the web interface.
- Data Handling: Inputs are collected and formatted by Flask backend.
- Preprocessing: Input data is scaled using the same scaler used during training.
- Prediction: The ML model predicts the seed class.
- Result Display: Predicted seed category is shown on the prediction page.

## 9. REQUIREMENTS SPECIFICATION

### System Requirements

- Python 3.8 or above
- Windows / Linux / macOS
- Web browser (Chrome, Edge, Firefox)

### Python Packages

- flask
- numpy
- pandas
- scikit-learn
- pickle-mixin

### Hardware Requirements

- Minimum 4 GB RAM
- Standard processor

## 10. RISKS AND MITIGATIONS

| Risk                  | Impact              | Mitigation                              |
|-----------------------|---------------------|---|
| Incorrect Inputs      | Wrong prediction    | Display expected ranges in input fields |
| Model Overfitting     | Poor generalization | Cross-validation & tuning               |
| Deployment Errors     | App failure         | Modular code & testing                  |
| User Misunderstanding | Invalid data entry  | Clear UI hints and placeholders         |

## **11. FUTURE ENHANCEMENTS**

- Integration with image-based seed detection
- Support for multiple seed types
- Advanced visualization of prediction confidence
- Database storage for historical predictions
- REST API for third-party integration

## 12. CONCLUSION

The Seed Quality Classification System successfully demonstrates the application of machine learning in agricultural quality analysis. By combining data preprocessing, model training, and Flask-based deployment, the project delivers a complete end-to-end solution for real-time seed classification. The system is scalable, educational, and practical, making it suitable for academic, research, and industry-level use.

## REFERENCES

1. Scikit-learn Documentation – <https://scikit-learn.org/>
2. Flask Documentation – <https://flask.palletsprojects.com/>
3. UCI Machine Learning Repository – Pumpkin Seeds Dataset
4. Python Official Documentation – <https://www.python.org/>