Name of Student:	James Bobby Kiawu
Submitted To:	**Ratinder Rajpal**, Lecturer.
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Intro AI	**Assignment 11 Image Classification**
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GitHub = https://github.com/jkiawu7/colab-git-V2-Jkiawu7

Image Classification Using Random Forest and SVM Models — Final Report

1. **Introduction** : Image classification is an essential task in computer vision, enabling machines to identify and categorize visual inputs. This project explores classical machine learning techniques for image classification using the CIFAR-10 dataset, a widely used benchmark dataset containing 60,000 color images belonging to ten classes, including airplane, automobile, bird, cat, deer, dog, frog, horse, ship, and truck. Each image is sized at 32×32 pixels with three color channels (RGB), resulting in 3,072 input features after flattening.

Because CIFAR-10 is typically processed using deep learning architectures, this project presents a valuable opportunity to examine the strengths and limitations of traditional models such as Random Forest and Support Vector Machine (SVM) when applied to high-dimensional image data. The analysis spans the full machine learning pipeline: data preprocessing, model training, hyperparameter tuning, evaluation, prediction on unseen images, and preparation for deployment.

2. **Methodology**

2.1 Data Loading and Preprocessing: The CIFAR-10 dataset was loaded using the built-in Keras API. To simplify computation in Google Colab, the training data was reduced from 50,000 to 5,000 images, and the test set from 10,000 to 2,000 images. Preprocessing steps included:

- Normalization: Dividing pixel values by 255 to scale them between 0 and 1.
- Resizing: Images were already 32×32, but custom images uploaded for prediction were resized accordingly.
- Flattening: Converting each image into a 3,072-element vector to meet traditional model requirements.

These steps ensured compatibility with algorithms like Random Forest and SVM, which do not operate directly on multidimensional image tensors.

2.2 Model Training and Tuning

Random Forest Classifier: A Random Forest model was trained using the reduced dataset. Hyperparameter tuning was performed using a small-scale GridSearchCV configuration to avoid exceeding Colab's memory limits. The search space included:

- Number of trees: 50, 100, 150, Max depth: None, 10, 20, Minimum samples per split: 2, 5, 10. The best model found by GridSearchCV used: n_estimators = 150, max_depth = 20,
- min_samples_split = 10, Support Vector Machine (SVM)

An SVM classifier with a linear kernel was implemented. Non-linear kernels were avoided due to their very high computational cost in high-dimensional data. The SVM was trained on the same reduced dataset and evaluated using identical test splits.

3. Model Evaluation

3.1 Random Forest Results : The tuned Random Forest model achieved an accuracy of 40.3% on the test set. While lower than deep learning models, this result is strong for a classical model trained on flattened pixel inputs. A classification report showed varying per-class precision and recall, with some classes like automobiles and trucks performing relatively better due to distinct visual features.

3.2 SVM Results : The SVM model achieved 30% accuracy, performing worse than Random Forest. This aligns with expectations, as SVM, with a linear kernel struggles in high-dimensional image spaces where relationships are nonlinear.

4. Visualizations

4.1 Model Performance Comparison (Included in my notebook). A comparison of accuracies clearly shows: Random Forest: 40.3%, SVM: 30%. This visualization highlights the advantage of Random Forest for nonlinear image datasets.

4.2 *Classification Reports* (Displayed in my notebook). Both models' classification reports were printed, showing precision, recall, and F1-Scores for each of the ten CIFAR-10 classes. These textual visualizations illustrate where each model struggles, such as confusion between cats and dogs or ships and airplanes.

4.3 Prediction on a New Image: A custom image ("s4vstarget.png") was uploaded form my machine and processed through the trained pipeline. The model predicted: Predicted Class: airplane. This confirmed that the end-to-end workflow—from image upload to preprocessing to prediction—functioned correctly.

5**. Deployment Strategy** – *to be found in the notebook due to space management.*

6. Conclusion: This project successfully demonstrated the complete workflow of image classification using classical machine learning algorithms applied to the CIFAR-10 dataset. Despite their limitations with image data, the Random Forest and SVM models provided meaningful insights into model behavior, feature handling, and the challenges of high-dimensional classification. Through this exercise, the end-to-end machine learning pipeline was implemented.