Landscape Recognition with Bayesian Classifier

Deadline: 31 Oct 2023

MM: 100 points

This assignment is related to holistic features for context recognition discussed in module 04-03 in the class. You are required to use the landscape recognition image dataset from Kaggle, extract the GIST features for the images as described in the reference (Oliva & Torralba – see slide 14), and develop a Bayesian classifier for the different categories of the landscapes (e.g., coast, desert, forest, etc.) provided in the dataset. You shall also need to evaluate the performance of your classifier and create a report.

The project involves

1. Pre-processing of the images and and extraction of GIST features
2. Programming classifier in form of Bayesian network with suitable configuration for the stated purpose
3. Estimating the parameters of the network (priors and conditionals), as discussed in module 03-05 (you need to extend the 2 class example to multi-class scenario).
4. Testing the classifier and performance evaluation

Resources:

1. Kaggle image recognition dataset
2. Oliva & Torralba's paper on spatial envelope representation

Notes:

1. This assignment is not about programming alone, but involves self-study, understanding and mathematical formulations.
2. You may use global and local and edge histograms (slide 14) in lieu of spatial envelope features, though implementation of the latter will be better rewarded.
3. The web-page for the dataset provides pointers to a few neural network based implementations, with accuracy in the range of 90 - 92%. You may keep that as the target for your classifier. If the performance of your classifier is significantly lower, a detailed analysis of the possible reasons will be appreciated.

Part 1: Data Exploration and Preprocessing (20 points)

- Load and explore the provided dataset.
- Split the dataset into training and testing sets.
- Perform necessary preprocessing (e.g., normalization) on the images and extract the features (GIST / edge histogram) . Quantize the features to some discrete feature states.

Part 2: Bayesian Network Classifier (30 points)

- Implement a Bayesian Network Classifier from scratch.

Part 3: Training the Bayesian network - Parameter estimation (10 points)

- From the training data, estimate the parameters of the Bayesian Network following the approach discussed in module 03-05
    - Class Prior Probabilities (P(C)) : Estimate the prior probabilities of each class (landscape type).
    - Feature Likelihoods (P(X|C)): For each feature (e.g., color, texture, shape), estimate the likelihood of observing a specific value given a class.

Part 4: Evaluation and Interpretation (40 points)

A. *Performance metrics calculation and reporting (15 points):*

- Use the Bayesian Classifier on the training and test dataset to evaluate the performance of the classifier
    - Calculate and report at least three performance metrics for Bayesian Classifier on the training as well as test set with their interpretation and justification for selection for this specific problem.

B. *Analysis (20 points)*
    - Analyze the reported performance metrics and draw your own conclusions about the classifier, the dataset and the features used.

- Some recommended steps for analysis:
    - Generate the confusion matrix using the training and the test sets. Visualize it as a heatmap for better interpretation.
    - Analyze the confusion matrices to understand how well the model performs for the different classes.
    - Calculate accuracy, precision, recall, and F1-score for each individual class
    - Identify any class-specific strengths or weaknesses of the model.
    - Conduct feature importance analysis to identify which specific features contribute the most to the classification decisions.
    - Discuss any interesting findings or patterns in the feature importance analysis.

C. *Visualize Predictions (5 points):*

- Randomly select a subset of test images and visualize the model's predictions along with the ground truth labels.
- Show the posterior probability values for the class to which the image is classified, and the class and the posterior probability for which the posterior probability is the second highest.
- Discuss any instances where the model made correct or incorrect predictions and provide possible explanations

Submission:

- Jupyter notebook (only Colab file) containing the code and explanations.
- A report summarizing the approach, results, and insights gained from the assignment.

Please ensure the following points are followed:

1. Do not upload the dataset along with your report on the classroom platform.
2. Prefix all files with your roll number.
3. Only two files should be submitted: the Colab file (provide both the link and the actual file) and a PDF report. (No zip file)
4. Proper comments as well as sections in the colab file should be there for each Part.
5. Code must be in python.

6. Plagiarism will not be tolerated under any circumstances.
7. Failure to comply with any of the above mentioned guidelines will result in your work not being evaluated.
8. Delay penalty per day - 5% of marks obtained. After 5 days - 100% penalty.
9. Screenshots of code snippets in the report are not allowed. However, you may include screenshots (of results) for the analysis and visualization part along with explanation.