Assignment 2

Due on November 15, 2023 (23:59:59)

PART I: Theory Questions

Maximum Likelihood Estimate (MLE)

1. You have a coin that you think is biased, you flip it 5 times and get the sequence $HTHTH$. What is the maximum likelihood estimate for the probability of getting heads?

2. You know that candy prices are normally distributed with mean μ and standard deviation σ. You have three candy pricing 2, 3, 5 lira. What is the maximum likelihood for μ?

3. Suppose that X is a discrete random variable with the following probability mass function: where $0 \leq \theta \leq 1$ is a parameter. The following 10 independent observations

X	0	1	2	3
P(X)	$2\theta/3$	$\theta/3$	$2(1-\theta)/3$	$(1-\theta)/3$

   were taken from such a distribution: $(3, 0, 2, 1, 3, 2, 1, 0, 2, 1)$. What is the maximum likelihood estimate of θ.

4. Suppose that $X_1, ..., X_n$ form a random sample from a uniform distribution on the interval $(0, \theta)$, where of the parameter $\theta > 0$ but is unknown. Please find MLE of θ.

Naive Bayes

1. The bank uses the information of its customers to give credits. The attributes used are sex, education, age , income and credit (it can be yes or no).

   Can a male 23-year-old university graduate working class customer get a credit?

Ex	Sex	Education	Age	Income	Credit
1	female	high school	16-25	poverty class	no
2	female	none	16-25	poverty class	no
3	female	high school	26-39	upper class	yes
4	male	high school	40-64	poverty class	no
5	male	university	26-39	upper class	yes
6	female	university	16-25	working class	no
7	male	none	26-39	working class	yes
8	male	university	40-64	upper class	yes
9	female	university	26-39	working class	no
10	female	high school	40-64	upper class	yes

PART II: Semantic Segmentation of Multispectral Images

In this section of the assignment, you will be implementing the Naive Bayes classifier for the semantic segmentation of multispectral images. The dataset comprises six spectral VNIR bands and features ten object classes, with a notably unbalanced class distribution.

Gaussian Naive Bayes

Naive Bayes is a classification algorithm based on Bayes' theorem, a probabilistic approach to prediction. Naive Bayes employs the likelihood of features given a class to make predictions. The likelihood signifies the probability of observing a specific feature or a combination of features for a particular class.

Gaussian Naive Bayes is employed when features are continuous and are assumed to adhere to a Gaussian (normal) distribution. It estimates the mean and variance of each feature for every class and utilizes the probability density function of the normal distribution to compute the likelihood.

Multispectral Images

Multispectral images are a form of imagery that capture data from multiple bands or distinct segments of the electromagnetic spectrum. Unlike conventional RGB (Red, Green, Blue) images, which consist of three color channels, multispectral images can contain more than three channels, with each one representing a different wavelength range. This capability enables multispectral imaging to collect a broader spectrum of information about the objects or scenes being photographed.

Semantic Segmentation

Semantic segmentation is a computer vision technique that involves assigning a class label to each pixel in an image, effectively dividing the image into regions that correspond to different object categories or semantic concepts. Unlike image classification, where an entire image is assigned a single label, semantic segmentation provides a fine-grained understanding of the content of an image by segmenting it into meaningful regions.

RIT-18 Dataset [1]

The RIT-18 dataset was created for semantic segmentation of remote sensing imagery.

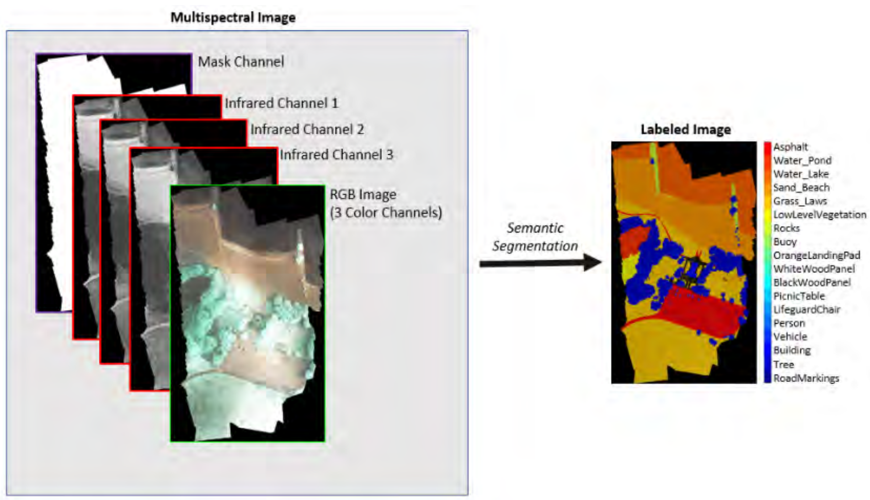

Figure 1: Example of a multispectral image and ground truth information as a labeled image.

- You can download the dataset from given link.
- The dataset includes one very-high-resolution multispectral image with six VNIR (Visible and Near-Infrared) spectral bands: Red, Green, Blue, Infrared Channel 1, Infrared Channel 2, and Infrared Channel 3.
- Dataset includes 10 object classes. (Similar classes in the original dataset were merged.)
  - 0. Other Class/Image Border,
  - 1. Road Markings, Asphalt, Landing Pad,
  - 2. Water,
  - 3. Building,
  - 4. Vehicle (Car, Truck, or Bus),
  - 5. Person,
  - 6. Vegetation,
  - 7. Wood Panel,
  - 8. Rocks, Sand,
  - 9. Chair, Table

- The dataset comprises training image, mask image, label image, and class information.
  - **train_data:** (9393 x 5642 X 6) NumPy array containing six bands are the VNIR spectral bands.
  - **train_masks:** (9393 x 5642) NumPy array containing the mask of the orthomosaic.
  - **train_labels:** (9393 x 5642) NumPy array containing the training labels.
  - **classes:** List of object classes.
  - **Note:** The NumPy array is represented as (height x width x dimension) or (height x width) in this dataset.
- The dataset contains only one high-dimensional image. Therefore, you should select a portion of the image for training, while the remaining portion will be used for testing. (Figure 2)

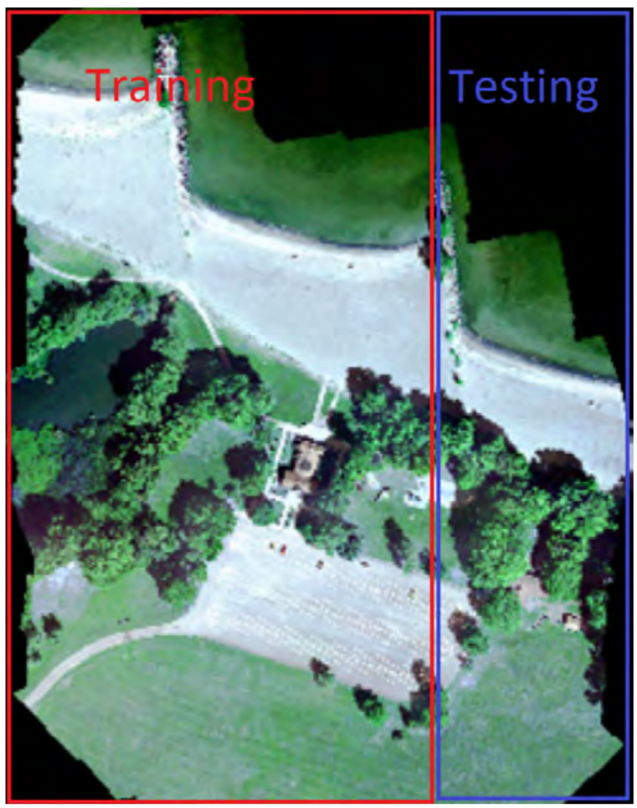

Figure 2: Example of training and testing split on the image.

Steps you need to follow:

1. Try to classify objects with Naive Bayes for each spectral image.
2. Generate the RGB image from the first 3 spectra and classify objects with Naive Bayes.

3. Generate the Infrared image from the last 3 spectra and classify objects with Naive Bayes.

4. Use all six spectra to classify objects with Naive Bayes.

5. Finally, assess your model's performance to evaluate the success of your Naive Bayes method for each configuration. The accuracy metric will be used to measure performance.

$$\textbf{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$$

6. Analyze your results and explain the reasons behind the outcomes obtained.

Submit

You are required to submit all your code in a Jupyter Notebook, along with a report in ipynb format, which should also be prepared using Jupyter Notebook. The code you submit should be thoroughly commented on. Your report should be self-contained and include a concise overview of the problem and the details of your implemented solution. Feel free to include pseudocode or figures to highlight or clarify specific aspects of your solution. Finally, prepare a ZIP file named name-surname-a2.zip containing:

- assignment_2.ipynb (including your report and code)
- assignment_2.py (py file version of your ipynb file)
- If you used pictures in Part I, please send the pictures as well.
- Do not send the dataset.

The ZIP file will be submitted via Google Classroom. Click here to accept your Assignment 2.

Grading

- Code part: Naive Bayes: 30 points, other code parts (well-written): 30 points
- Theory part: 12 points, Analysis of the results: 28 points.

Note: Preparing a good report is important as well as the correctness of your solutions! You should explain your choices and their effects on the results. You can create a table to report your results.

Late Policy

You may use up to four extension days (in total) over the course of the semester for the three problem sets you will take. Any additional unapproved late submissions will be weighted by 0.5. You have to submit your solution in (the rest of your late submission days + 4 days), otherwise, it will not be evaluated.

Academic Integrity

All work on assignments must be done individually unless stated otherwise. You are encouraged to discuss with your classmates about the given assignments, but these discussions should be carried out in an abstract way. That is, discussions related to a particular solution to a specific problem (either in actual code or in the pseudocode) will not be tolerated. In short, turning in someone else's work, in whole or in part, as your own will be considered as a violation of academic integrity. Please note that the former condition also holds for the material found on the web as everything on the web has been written by someone else.

References

[1] Kemker, R., Salvaggio, C., & Kanan, C. (2018). Algorithms for semantic segmentation of multispectral remote sensing imagery using deep learning. ISPRS journal of photogrammetry and remote sensing, 145, 60-77.