LAHORE UNIVERSITY OF MANAGEMENT SCIENCES
Department of Electrical Engineering

EE514/CS535 Machine Learning
Spring 2022

Project Description

Total Marks: 50

Contribution to Final Assessment: 20%

1 Objectives

In this course project, we will serve the following objectives:

- Learn to extract the features from audio (speech) recordings or images
- Understand the role of feature extraction in machine learning
- Learn to use the different algorithms covered in the course to the problems of

  Project 1: Synthetic Speech Detection and Attribution from the Audio Recording

  Project 2: Vehicle Detection and Classification from Images

- Learn to evaluate and compare the performance of different algorithms
- Learn to document, report and present the solution of a machine learning problem

We assume that the execution of the project will help the retention of the material and significantly enhance the depth of your understanding.

We require you to work in a group of (maximum) three students (every student in the group will receive same score).

2 Project 1 - Synthetic Speech Detection and Attribution from the Audio Recording

2.1 Motivation

These days, manipulation of audio, speech and video has become easier due to the availability of off-the-shelf softwares and mobile applications. Furthermore, the recent technological advances in the area of signal processing, machine learning and deep learning has enabled the development of tools for the generation of close to realistic synthetic audio or speech. Though these tools and softwares are extremely useful for digital artists, these can be used to generate fake audio, speech or video and therefore can be used for generating fake news.

Recently, a lot of research has been carried out to develop algorithms and systems for the classification of algorithms used to generate different synthetic audios. Most of these algorithms use characteristics (features) of the audio signal in conjunction with the sophisticated machine learning algorithms to detect the synthetic speech.

2.2 Project Overview

In this project, you will work on the development of a classifier to identify the algorithm used for the generation of a synthetic audio. You will first extract features of the given audio signal and use these features for classification.

2.3 Data Set Description

There are 5000 synthetic audio recordings generated from 5 different algorithms in the dataset provided to you. We may also provide you with the dataset of noisy synthetic speech recordings, where noise is added by means of operations like noise addition, reverberation, filtering, and lossy compression.

2.4 Feature Extraction

We require you to review the literature and identify a list of features that can be used for synthetic speech attribution. For your convenience, we have listed below the features that can be potentially used for the problem under consideration.

- Fourier transform
- Mel frequency cepstral coefficients (MFCCs): Features that describe the overall shape of a spectral envelope of the signal.
- Melspectrogram : A spectrogram where the signal frequencies are converted to Mel scale.
- Chromagram: Also known as chroma features, this is a representation for audio or speech signal in which the entire signal spectrum is projected onto 12 bins known as pitch classes.
- Bicoherence: Mean, variance, skewness and kutrosis of magnitude and phase of bicoherence.
- Spectral centroid: Location of center of mass of the spectrum.

- Spectral bandwidth: Difference between the highest and the lowest frequency in the spectrum.
- Spectral contrast: The decibel difference between peaks and valleys in the spectrum.

2.5 Classifiers

Followed by feature extraction, we require you to evaluate the performance of following different classifiers.

- K-Nearest Neighbors
- Logistic Regression
- Naive Bayes
- Support Vector Machines
- Neural Network

You are allowed to use Scikit-learn implementations of the algorithms.

3 Project 2 - Vehicle Detection and Classification from Images

3.1 Motivation

In recent years, thanks to advances in hardware technologies and the equally growing need for traffic monitoring, there is a demand for artificially intelligent solutions geared towards improving surveillance of traffic in urban areas. Vehicle detection is a crucial step in these solutions, which is what you will be exploring in this project.

Feature extraction and learning is an essential part of object detection. Although most object detection techniques out there employ self-adaptive neural networks, nevertheless, it is important to establish an acute understanding of the classical approach to isolate an object in an image or a video stream. This project will give you a hands-on comprehension of the way in which a feature identification pipeline is designed and use the features for classification tasks.

3.2 Project Overview

In this project, you will work on the development of a classifier to detect a vehicle (car or motorbike) in a video stream. This can be interpreted as a multi-class classification problem in which we have three classes: no vehicle, car and motorbike.

You will extract features of the object from the given data-set and implement a sliding window technique to use your trained classifier to search for vehicles in images.

3.3 Data Set Description

In the data-set, there are 5000 images collected from various sources. You may add your own images to the data-set should you feel the need to do so.

3.4 Feature Extraction and Object Localization

For your convenience, we have listed below the features that can be potentially used for the problem under consideration. We require you to review the literature and identify more features that can be used for object (vehicle) detection and localization.

- Colour Histogram
- Spatial Binning
- Histogram of Oriented Gradients

You will use these trained classifiers to localize objects (car or motorbike) in the sliding window.

3.5 Classifiers

Followed by feature extraction, we require you to evaluate the performance of following different classifiers.

- Support Vector Machines

- Naive Bayes
- Logistic Regression
- Neural Network

You are allowed to use Scikit-learn implementations of the algorithms.

4 Expectations and Scope of Work

4.1 Scope of Work

The scope of the project includes

Task 1: Formulation of the problem under consideration.

Task 2: Carry out literature review to identify the features that can be used for the problem under consideration.

Task 3: Apply feature extraction/engineering

Task 4: Apply dimensionality reduction (if needed or to evaluate the impact of reduction on the performance).

Task 5: Implement the different classifiers for the problem under consideration.

Task 6: Report the performance of different classifiers and presentation of analysis/findings.

4.2 Assessment

There are three components of assessment in the project:

- Project report (20 marks).
- Project code (along with code documentation) (15 marks).
- 8-10 minutes video presentation summarizing your work (10 marks).
- Submission of deliverables on time (5 marks).

Final report must be prepared using the provided template (to be uploaded on LMS). Your report is expected to have the following sections:

- Abstract (executive summary)
- Introduction
- Mathematical Formulation
- Identification and Extraction of Features
- (Optional) Feature Engineering e.g., dimensionality reduction (optional)
- Use of different classification algorithms; a subsections on each algorithm
- Performance Evaluation (plots, tables etc.), analysis and findings
- Conclusions

Note that: We encourage Masters and PhD students to use the LaTeX template for their report.

5 Timeline of Deliverables

We want you to adhere to the following time-lines.

- **Deliverable 1:** Project selection and group formation.
  - Due: Week 7, 4th March, Friday 23:55
  - The spreadsheet for groups can be found here.
- **Deliverable 2:** Submit preliminary project report with the following sections populated. You can obviously change the content in these sections in your final submission.
  - Abstract, Introduction and Mathematical Formulation, Identification and Extraction of Features
  - Due: Week 9, 18th March, Friday 23:55 pm
- **Deliverable 3:** Submit mid-term report and code with the following tasks completed and added in the report
  - Implementation of feature extraction
  - Feature Engineering (e.g., dimensionality reduction)
  - Implementation of at least two of the classification algorithms
  - Due: Week 12: 8th April, Friday 23:55 pm
- **Deliverable 4:** Submit code (documented), final report and video presentation (8-10 minutes)
  - Due: Week 14: 22nd April, Friday 23:55 (No extensions will be given)