CISC 499 Projects:

Hossam Hassanein & Hazem Abbas

hossam@cs.queensu.ca; hazem.abbas@queensu.ca

Project 1: Discover Nearby Resources (individual or group)

This project aims to discover resources/services offered by other mobile or non-mobile providers in close proximity. Such resources/services may be public sensing data, traffic information, navigation directions, etc. Students are required to develop a system that can store services offered by providers and enable users to discover services or resources of interest, based on location. The implementation will have mobile side and server side components. The mobile side component represents the user interface, whether to advertise or discover a service. In service advertisements, the provider can create a new service or choose from existing ones. Service discovery matches keywords from the user request with existing offerings in the service database (service directory or arbitrator). The discovery mechanism can simply rank matched services according to the matching score (i.e. how many keywords from service request are matching keywords of service description). A much desirable approach is to employ recommender systems such as collaborative filtering or context-aware methods. The collaborative filtering method uses the known taste of a group of users to produce recommendation to other users. The Context-aware method provides recommendations to the users regarding their environment and the details of the situation in which they are. Students may also explore other methods or combinations of many. Finally, the server side component is a simple centralized database that manages service offerings and performs discovery requests.

Project 2: Deep ECG Arrhythmia Classification (individual or group)

Electrocardiography is a method that registers electrical activity against time. The changes in electrical potential difference (voltage) during depolarization and repolarization of the myocardial fibers are recorded by electrodes positioned on the surface of the chest and on the limb (limb leads).
The electrocardiogram (ECG) is used to investigate some types of abnormal heart function including arrhythmias and conduction disturbances, as well as heart morphology (e.g., the orientation of the heart in the chest cavity). It is also useful for assessing performance of pacemakers.

One can easily notice that the characteristics and patterns of the ECG signals are different for different heart conditions. Due to this vast difference in morphology, it is difficult to accurately identify ECG components. Furthermore, the visual assessment which is the current standard of care might result in subjective interpretation and inter-observer biases. To address the drawbacks of visual and manual interpretations of ECG, researchers pursue the development of computer-aided diagnosis (CAD) systems to automatically diagnose ECG. Much of the work in this area has been done by incorporating machine learning approaches for an accurate assessment of ECG and to distinguish life threatening from non-threatening events including arrhythmias. Most implementations concentrate on the conventional machine learning approaches. These approaches involve preprocessing, feature extraction, feature reduction, and feature classification. Although these methods demonstrated favorable ECG heartbeat classification performance, they have numerous disadvantages. For instance, the conventional methods require designing of a feature extractor to extract predicting features from the raw ECG signals and then organize them into a set of optimal features that can be fed into the classifier. Moreover, CAD models designed and tested using the above workflow often suffer from over fitting and show lower performance when validated on a separate dataset.

Unlike the conventional approaches, deep learning-based approaches possess the capacity to self-learn useful features from the input ECG signals. Hence, with deep learning, the essential steps that are required in the conventional approaches namely feature extraction, feature selection, and classification can be developed, yet they do not need to be explicitly defined. In fact, they are embedded in the model through self-learning from the data. Numerous papers have shown that the deep learning architectures surpass hand-crafted feature extractors assembled with commonly known classifiers in terms of classification accuracy and speed. The development of deep learning based solutions is also heavily supported by information technology industry.

The objective of this project is to develop deep learning approaches that can outperform conventional signal processing or machine learning methods in identifying four different classes of abnormal ECG heartbeats. The Dataset used for the project is MIT-BIH Arrhythmia Database that can be obtained from http://www.physionet.org website.

Project 3: Data Analytics for Vehicles Crashes (individual or group)

Road accidents constitute a major problem in our societies around the world. They have a great economic impact due to their cause of injuries and fatalities. Nowadays, many researchers are paying much attention to determining common factors that significantly affect traffic accidents and analysis. There are several approaches that researchers have applied to investigate this problem.

The objective of this project is to explore how a data analytic pipeline can help us understand the causes and the factors that affect road accidents severity. A complete machine learning pipeline, from getting data, performing exploratory data analysis (EDA) and formulating a real-world problem into a machine learning model, is to be carried out. In the EDA part, it is required to show the effect of road conditions, driver behavior, weather conditions, and time of accidents on the type and severity of vehicle accidents and severity. It is also desired to do some geographic data visualizations to indicate clearly where clashes happen and whether these findings will agree with the normal expectation (most crashes happen along roads and mostly in cities).

The machine learning will employ supervised/semi-supervised learning methods to predict the number of fatalities based on the attributes of the crash dataset. One can also use classification methods to predict the severity of the crash and to expect the behavior of the driver given certain road and weather conditions.

The use of big data techniques and deep learning methods to improve the performance of the pipeline is highly desired.

Project 4: Gaze Detection System for Driver’s State Monitoring (individual or group)

One of the most important factors in driving accidents is the driver’s inattention which may involve the driver being distracted, asleep or fatigued or otherwise “lost in thought”. The field of detecting the driver’s state has gradually broadened throughout the past decade.

The project will be mainly concerned with “Gaze Detection”. Generally, the use of multiple camera-based gaze detection method was considered the most suitable solution for wide gaze coverage but it required more processing time as images from two cameras are being used. In a single camera approach, using Near Infrared (NIR) illumination became popular for this task as the visible light cameras are greatly affected by things like illumination and wearable eye accessories.

Various algorithms were implemented for this task which vary in complexity, from trying to predict driver distraction based on gaze direction from just the head orientation which is not accurate but was the only solution when using low resolution cameras, to using eye motion data in Support Vector Machine (SVM) model or a logistic regression model, to using more complicated algorithms for detecting the face and the Regions Of Interest (ROI) like eyes from the images and using different methods for feature extraction and prediction. Most of the implemented systems had some common drawbacks like the need for camera calibration, the inefficiency when exposed to different lighting conditions, the dependency on corneal reflection (bright pupil effect) for eye detection when using NIR cameras, not to mention that a small number of gaze regions were covered.

The objective of this project is to introduce a system that solves most of these drawbacks. First, it is required to estimate several possible gaze regions using NIR illumination and camera aimed at the driver's face for image acquisition. Then, employment of facial feature trackers to identify the face in these images and the facial landmarks like eyes, mouth, nose, among others, is used to extract separate images of the face, right eye, and left eye. The set of extracted images are used to train a deep architecture to determine the gaze direction and further tested on a new image set to determine the applicability of the proposed architecture.