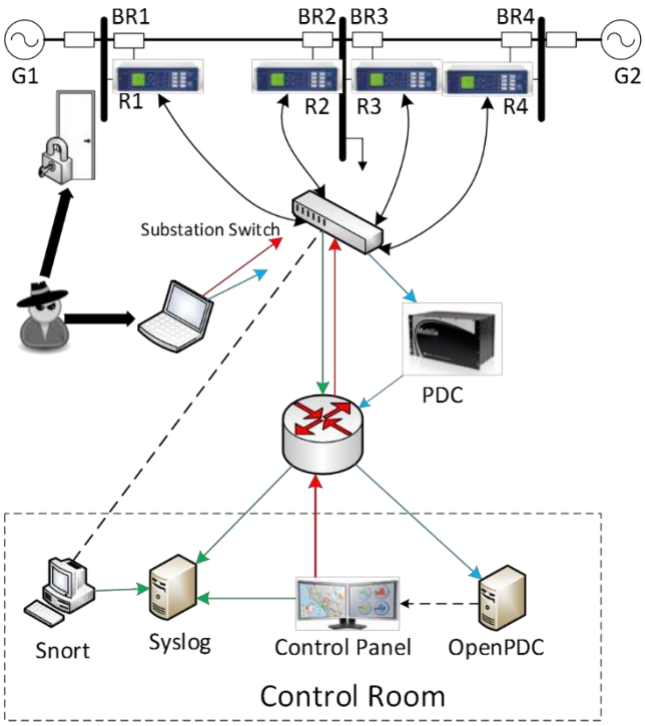
COMP3217 Security of Cyber-Physical Systems
23/24 Coursework 2

Detection of Attacks on Power System Grids

The coursework is worth 50% of the total mark for this course. It involves writing programs for the task described below, and you can choose any major programming language such as C/C++, Python, etc. The purpose of this coursework is to understand the power system attacks on electric grids CPS, understand the type of attacks, develop detection techniques for such attacks, and get familiar with some cyber-physical system security programming skills.

Consider a power system framework configuration as shown in the figure below:



In the network diagram we have several components, firstly, G1 and G2 are power generators. R1 through R4 are Intelligent Electronic Devices (IEDs) that can switch the breakers on or off. These breakers are labeled BR1 through BR4. We also have two lines. Line One spans from breaker one (BR1) to breaker two (BR2) and Line Two spans from breaker three (BR3) to breaker four (BR4). Each IED automatically controls one breaker. R1 controls BR1, R2 controls BR2 and son on accordingly. The IEDs use a distance protection scheme which trips the breaker on detected faults whether actually valid or faked since they have no internal validation to detect the difference. Operators can also manually issue commands to the IEDs R1 through R4 to manually trip the breakers BR1 through BR4. The manual override is used when performing maintenance on the lines or other system components.

Three different type of scenarios can occur in such a system:

1. Service events/natural faults: This include short circuit faults – short in a power line, and line maintenance - one or more relays are disabled on a specific line to do maintenance for that line.
2. Normal event: Regular operation with no issues.
3. Remote cyber-attacks: This includes (a) data injection - imitate a valid fault by changing values to parameters such as current, voltage, sequence components etc. This attack aims to blind the operator and causes a black out, and (b) Remote tripping command injection - this is an attack that sends a command to a relay which causes a breaker to open. It can only be done once an attacker has penetrated outside defences.

This course work has two parts:

PART A

- You are given a set of 6,000 system traces (TrainingDataBinary.csv), where half of them are labelled as 0 – normal events and the other half are labelled as 1 – abnormal data injection attack events. There are 128 numbers in each trace. These 128 numbers represent features. There are 29 types of measurements from each phasor measurement units (PMU). A phasor measurement unit (PMU) or synchrophasor is a device which measures the electrical waves on an electricity grid, using a common time source for synchronization. In our system assume there are 4 PMUs which measure 29 features totalling to **116** PMU measurement columns total. The index of each column is in the form of "R#-Signal Reference" that indicates a type of measurement from a PMU specified by "R#". The signal references and corresponding descriptions are listed below. For example, R1-PA1: VH means Phase A voltage phase angle measured by PMU R1 etc. After the PMU measurement columns, there are **12** columns for control panel logs, Snort alerts and relay logs of the 4 PMU/relay (relay and PMU are integrated together). The last column – 129th -is the label for the event – normal/abnormal. 0 indicates normal event while 1 indicates data injection attack. These 6,000 rows are basically the training data.
- You are also given 100 system traces without labels, which are the testing data (TestingDataBinary.csv), where there are 128 numbers in each row.
- You need to design and implement a machine learning technique to model the training data and compute the labels for all testing data (i.e., 0 or 1 for each system trace). In the report, you need to clearly indicate the computed label for each trace in the testing data. You also need to output a file (TestingResultsBinary.csv) with the same format as the training data and submit it together with your source code.
- In the report, you should give a clear description of the problem, and the machine learning technique used to compute the labels. You need to show the computed labels for all of the testing data – in the same order as was given to you. You should also analyse and discuss your results in terms of training error and training accuracy. The accuracy on testing data followed by accuracy on the training data will be an important factor in determining your performance on this coursework.

PART B

- You are given a set of 6,000 system traces (TrainingDataMulti.csv), where data for three types of events is unevenly distributed: normal events, abnormal data injection attack events, and abnormal command injection attack events. There are 128 features in each trace and the last column – 129th - is the label for the event. 0 indicates normal event, 1 indicates data injection attack, and 2 stands for command injection attack. These 6,000 rows are basically the training data.
- You are also given 100 system traces without labels, which are the testing data (TestingDataMulti.csv), where there are 128 numbers in each row.
- You need to design and implement a ML technique to model those training data and compute the labels for all testing data (i.e., 0 or 1 or 2 for each system trace). In the report, you need to clearly indicate the computed label for each trace in the testing data. You also need to output a file (TestingResultsMulti.csv) with the same format as the training data and submit it together with your source code.
- In the report, you should give a clear description of the problem, and the machine learning technique used to compute the labels. You need to show the computed labels for all of the testing data. You should also analyse and discuss your results in terms of training error and training accuracy. The accuracy on testing data followed by accuracy on the training data will be an important factor in determining your performance on this coursework.

It is totally ok to try many ML methods. However, in the report I only need to see the method which you used to get the best results.

For both the parts:

- You should make good use of a software repository (e.g., git or GitHub) and your code needs to be maintainable and compilable.
- Your code should contain sufficient comments.
- Your code should be laid out neatly with consistent indentation.

Assessment criteria
Correctness of classification for part A: 25%
Correctness of classification for part B: 25%
Clarity of program and comments: 25%
Quality of report and analysis: 25%

Total marks: 100

Submission
Due Date: 8th June 2023
You are required to submit the report – only in **pdf** format, link to your source code files (github/gitlab) in the report, and your two output files – each in excel format with one column for the labels into the submission system.