SIT719 Security and Privacy Issues in Analytics

Distinction/Higher Distinction Task 5.1 End-to-end project delivery on cyber-security data analytics

Overview

During the last weeks, you have learned how machine learning algorithms can be implemented using python. Scikit learn is an open-source python library that can help to implement supervised and unsupervised machine learning models. More information can be obtained from the website https://sklearn.org/. In this task, machine learning algorithms will be used for cyber attack classification. The purpose of the task is to help students to build knowledge and skills related to the usages of supervised machine learning for security analysis, hands-on implementation and understand the overall goal of an end-to-end-project delivery in the area of cybersecurity analytics.

Do you know what is an end-to-end data science project? See the lifecycle of an end-to-end data science project. If you are doing a data science application for security analysis, your problem will be related to cybersecurity and your data analysis needs to follow the below steps. See the task description for the detailed instructions.

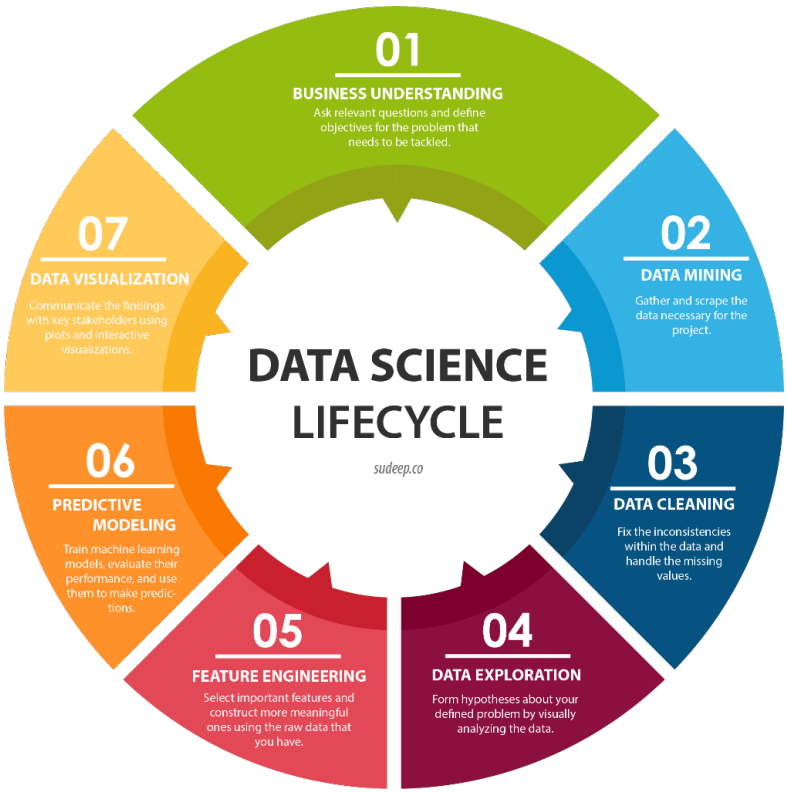


Figure 1: Data Science Lifecycle [source: Sudeep, 2019 (accessed Jan 2020)]

In this *Distinction/Higher Distinction Task*, you will experiment with Machine Learning classification algorithms. Please see more details in the Task description. Before attempting this task, please make sure you are already up to date with all previous ***Credit and Pass tasks***.

Task Description

Instructions:

Suppose, you are working in an organization as a security analyst. You need to conduct an end to end project on “cyber-attack classification in the network traffic database”. To complete the project you follow the steps in Figure 1. Here, **all of the steps are already solved for you (by the teaching team and you don’t need to take any action**) **except step 6 and 7**. You need to complete these sections (highlighted in blue) by yourself to submit this task.

Step 1: Business Understanding (Problem Definitions)

Your aim is to develop **a multi-class machine learning-based classification model to identify different network traffic classes for TWO BENCHMARK DATASETS.**

Step 2: Data Gathering (Identify the source of data)

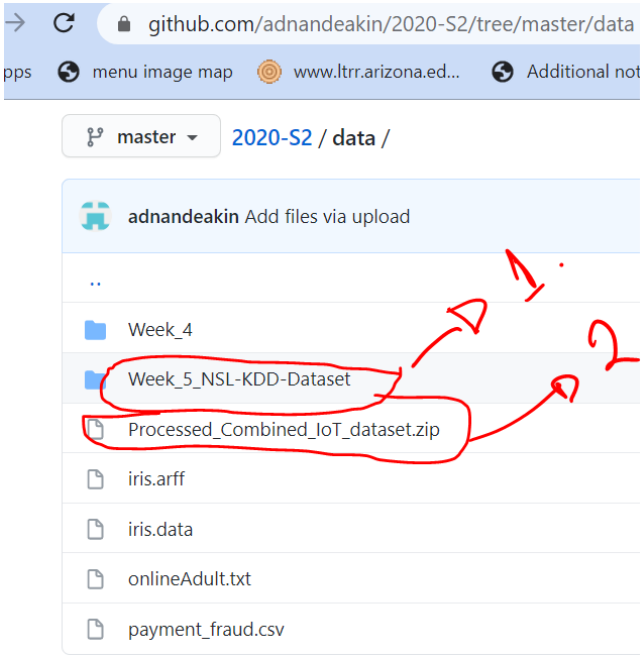
In the industry/real-world, you need to communicate either with your manager, client, other stakeholders and/or IT team to understand the source of data and to gather it.

Here, the teaching team already gathered data for you. You can access the dataset from the given github link.

In this task, you need to perform experiments on **TWO DATASETS.**

1. The first dataset “NSL-KDD” can be obtained from the data folder, go to the “Week_5_NSL-KDD-Dataset” subfolder.

2. The second dataset is “Processed Combined IoT dataset”



If you are interested to learn more about the datasets, please visit the websites/links below (not mandatory for the HD task).

Datset 1 description https://www.unb.ca/cic/datasets/nsl.html
Datset 2 description https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9189760

*****One starting example code for the 5 class classification (Dataset 1) is also given for your convenience, where some of the steps are already implemented. Please see the "SIT719_Prac05_Task02_HD_task_sample_done" notebook file (obtain from the github link) for Dataset 1 (NSL KDD).**

*****Another starting example code for the second dataset (TON IoT) is also given where the data has been preprocessed for you. See the link "https://github.com/adnandeakin/2020-S2/blob/master/Copy_of_RF_on_IoT_Combined_Dataset.ipynb"**

Step 3: Data Cleaning (Filtering anomalous data)

In a typical analysis, you may need to take care of missing values and inconsistent data. In week 2, you have learnt how to deal with missing values and manipulate a database. **Here, it has already been taken care of for this dataset (so no action is needed for this task).**

Step 4: Data Exploration (Understanding the data)

Some examples of data exploration are "Identification of the attribute names (Header), Checking the length of the Train and Test dataset, Checking the total number of samples that belong to each of the five classes of the training dataset", etc. **You don't need to do anything here**. However, these actions will help you to understand the data better in practice.

Step 5: Feature Engineering (Select Important Feature)

In a typical setup, you may need to do feature extraction or selection during your data analysis process. Here, relevant feature engineering is already done for you in the sample code. So, **no action is needed for this task**

Step 6: Predictive Modelling (Prediction of the classes) – This is the task for you.

Dataset 1:

The DecisionTreeClassifier has been implemented for you. Now, you need to implement other techniques and compare. Please do the following tasks:

1. Implement **at least 5 benchmark classification** algorithms.
2. **Tune the parameters if applicable** to obtain a good solution.
3. Obtain the **confusion matrix** for each of the scenarios (**Use the test dataset**).
4. Calculate the performance measures for the each of the classification algorithms that includes Precision (%), Recall (%), F-Score (%), False Alarm- FPR (%)

You need to compare the results following the table below. Create one table for each algorithm (**Use the test dataset**)..

Attack Class	Precision (%)	Recall (%)…	…	…	…	...
DoS						
Normal						
Prob						
R2L						
U2R						

Finally, you summarize the results similar to the below table (**Use the test dataset**).:

Algorithms	Accuracy (%)	Precision (%)	Recall (%)…	…	…	…	...
Alg 1							
Alg 2							
…							
…							
…							

Dataset 2:

A sample Random Forest implementation is given to you. Repeat the procedure as mentioned in datset 1. The only difference will be "you need to consider 70:30 train-test split (70% for train and 30% for test)" for testing as there is no separate test set file. Please note, k-fold cross validation is also acceptable. However, as k-fold cross validation will take a huge amount of time, we have not made it mandatory.

Comparison of Results:

Your results need to be comparable against benchmark algorithms. For example, see the below results obtained from a recent article "An Adaptive Ensemble Machine Learning Model for Intrusion Detection" published in IEEE ACCESS, July 2019 for Dataset 1

TABLE 6. Result of each algorithm on KDDTest+.

Algorithms	Accuracy	Precision	Recall	F1	Time(S)
DeciTree	79.71%	83.51%	79.72%	77.31%	6.34
RanForest	76.64%	81.85%	76.64%	72.17%	1.86
kNN	75.51%	80.97%	75.51%	71.41%	86.49
LR	73.58%	74.65%	73.58%	69.13%	43.77
SVM	74.09%	80.91%	74.09%	70.38%	1785.2
DNN	81.6%	84%	81.6%	80.18%	227.8
Adaboost	76.02%	81.82%	76.02	72.12%	265.1

For Dataset 2, please see the article “TON_IoT Telemetry Dataset: A New Generation Dataset of IoT and IIoT for Data-Driven Intrusion Detection Systems” for Dataset 2.

It will not be exactly same and nothing to be worried about that. Your target will be to select the best performing algorithms that you can and achieve a comparable results.

Step 7: Data Visualization

Perform the following tasks for both of the datasets:

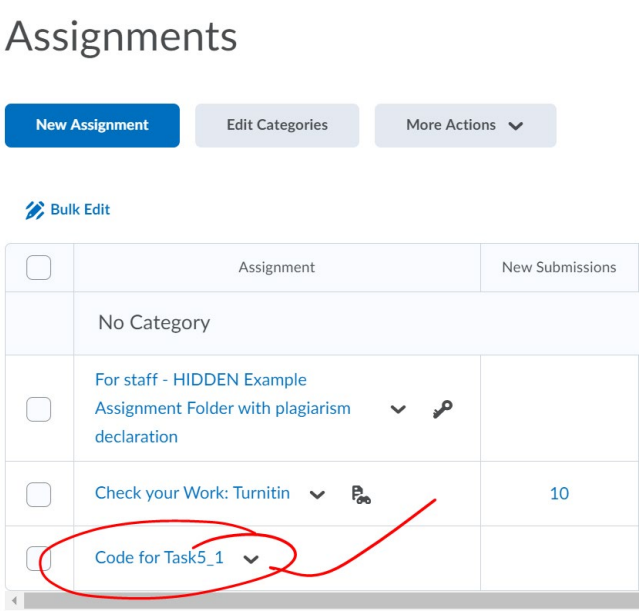
1. Visualize and compare the accuracy of different algorithms.
2. Plot the confusion matrix for each scenarios.

Step 8: Results delivery:

Once you have completed the data analysis task for your security project, you need to deliver the outcome. In real-world, results are typically delivered as a product/tool/web-app or through a presentation or by submitting the report. **However, in our unit we will consider a report based submission only (PLEASE NOTE, the results obtained from the above steps need to be submitted as a REPORT format rather than just a screenshot).**

Here, **you need to write a report (at least 3500 word)** based on the outcome and results you obtained by performing the above steps. The **report will describe the algorithms used, their working principle, key parameters, and the results. Results should consider all the key performance measures and comparative results in the form of tables, graphs, etc**.

Submit the PDF report through onTrack. You also need to submit – (i) the code file and (ii) the word/source file of the REPORT separately (within the “Code for task 5.1” folder) under the assignment tab of the CloudDeakin.



Please note, it is a graded task where you will receive some feedback and marks. Your tutor/marker will assign you some marks based on the **quality of your submission, performance of your algorithms, selection and novelty in your algorithm, tuning and understanding the algorithms, how well you have explained the results, your usage of scientific language, authenticity of the claims and finally the aesthetic look of your submission and reflection of the quality of your work from the tutor's judgement**. You will receive the feedback based on the following marking rubric. The marker will judge how you have performed in the following categories.

Marking Rubric:

Criteria	Unsatisfactory – Beginning	Developing	Accomplished	Exemplary	Total
Report Focus: Purpose/ Position Statement	**0-7 points**	**8-11 points**	**12-15 points**	**16-20 points**	/20
	Fails to clearly relate the report topic or is not clearly defined and/or the report lacks focus throughout.	The report is too broad in scope (outside of the title topic) and/or the report is somewhat unclear and needs to be developed further. Focal point is not consistently maintained throughout the report.	The report provides adequate direction with some degree of interest for the reader. The report states the position, and maintains the focal point of the analysis for the most part.	The report provides direction for the discussion part of the analysis that is engaging and thought provoking, The report clearly and concisely states the position, and consistently maintain the focal point.	
Comparative analysis and Discussion	**0-15 points**	**16-20 points**	**21-24 points**	**25-30 points**	/30
	Demonstrates a lack of understanding and inadequate knowledge of the topic. Analysis is very superficial and contains flaws. The report is also not clear.	Demonstrates general understanding of python scripting. Analysis is good and has addressed all criteria. Comparative analysis is presented. Sufficient discussion is also presented.	Demonstrates good level of understanding of python scripting. Algorithms are fine-tuned and comprise good selection of algorithms. Comparative results are presented using standard performance measures.	Demonstrates superior level of understanding of python scripting and algorithms. Algorithms are fine-tuned with some novelty or hybridization or advanced and/or recent algorithm. Comparative results are presented using performance measures in a way that it provides very clear and meaningful insights of the output.	
Organization	**0-6 points**	**7-11 points**	**12-15 points**	**16-20 points**	/20
	Report lacks logical organization and impedes readers' comprehension of ideas. Central position is rarely evident from paragraph to paragraph and/or the report is missing multiple required components.	Report is somewhat organized, although occasionally ideas from paragraph to paragraph may not flow well and/or connect to the central position or be clear as a whole. May be missing a required component and/or components may be less than complete. Discussion related to analysis result is presented but not very clear and insightful.	Report is adequately organized. Results are arranged reasonably well with a progression of thought from paragraph to paragraph connecting to the central position of the analysis. Includes required components, like visualization, table and graphs. The report is well organized and easy to follow.	Report is effectively organized. Ideas and results are arranged logically, flow smoothly, with a strong progression of thought from paragraph to paragraph connecting to the central position related to the analysis tasks. Includes all required components with supportive figures, tables, references, charts/graphs, equation, etc.	
Writing Quality & Adherence to Format Guidelines	**0-10 points**	**11-17 points**	**18-21 points**	**22-30 points**	/30
	Report shows a below average/poor writing style lacking in elements of appropriate standard English. Frequent errors in spelling, grammar, punctuation, spelling, usage, and/or formatting.	Report shows an average and/or casual writing style using standard English. Some errors in spelling, grammar, punctuation, usage, and/or formatting.	Report shows above average writing style (can be considered good) and clarity in writing using standard English. Minor errors in grammar, punctuation, spelling, usage, and/or formatting. Author has demonstrated the use of scientific language and results are well explained.	Article is well written and clear and standard English characterized by elements of a strong writing style. Basically free from grammar, punctuation, spelling, usage, or formatting errors. Author has demonstrated advanced use of scientific language and results are well explained with insights.	

Rubric adopted from: Denise Kreiger, Instructional Design and Technology Services, SC&I, Rutgers University, 4/2014