DETECTING EMAIL-BASED PHISHING WEBSITES USING MACHINE LEARNING

2023-123

Team Members

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Research Question

How to detect phishing websites and phishing emails using machine learning and deep learning.

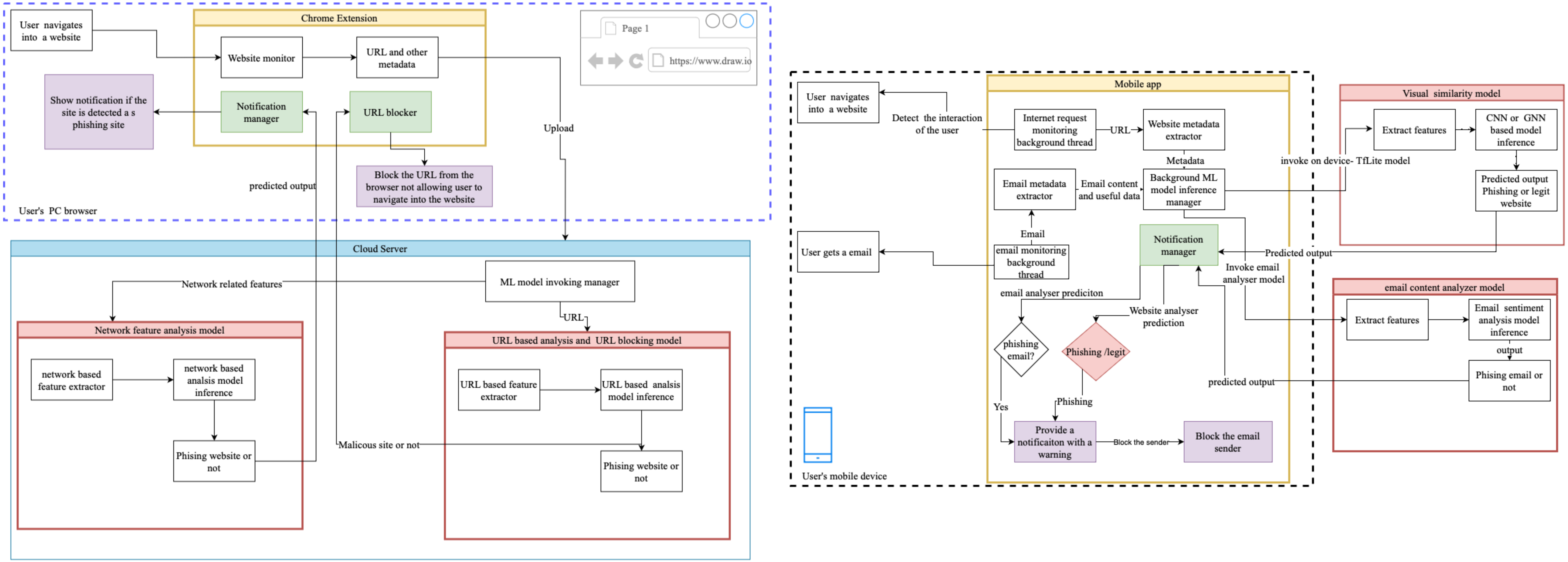
Main Objective

To implement a mobile application and a web extension capable of detecting phishing emails and websites utilizing machine learning and deep learning models.

Sub-objectives

- To employ the visual similarity features to classify phishing websites out of legit websites.
- Detecting Phishing sites using website feature analysis
- To identify phishing emails using the heading and the textual content in the email.
- To discover phishing websites using the URL.

system diagram


User navigates into a website
Chrome Extension
Website monitor
URL and other metadata
Page 1
https://www.draw.io
Show notification if the site is detected a s phishing site
Notification manager
URL blocker
Upload
Block the URL from the browser not allowing user to navigate into the website
predicted output
User's PC browser
Cloud Server
Network related features
ML model invoking manager
URL
Network feature analysis model
network based feature extractor
network based analsis model inference
Phising website or not
URL based analysis and URL blocking model
URL based feature extractor
URL based analsis model inference
Malicous site or not
Phising website or not
Mobile app
User navigates into a website
Detect the interaction of the user
Internet request monitoring background thread
URL
Website metadata extractor
Metadata
Email metadata extractor
Email content and useful data
Background ML model inference manager
Email
email monitoring background thread
User gets a email
Notification manager
Predicted output
Invoke email analyser model
email analyser prediciton
Website analyser prediction
phishing email?
Phishing /legit
Yes
Phishing
Provide a notificaiton with a warning
Block the sender
Block the email sender
predicted output
User's mobile device
invoke on device- TfLite model
Visual similarity model
Extract features
CNN or GNN based model inference
Predicted output Phishing or legit website
email content analyzer model
Extract features
Email sentiment analysis model inference
output
Phising email or not

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Research Problem

How to use visual similarity features of a website to detect if a website is a phishing website or a legitimate website

Objectives

- To utilize Vision GNN for the first time for classifying phishing websites.
  - Vision GNN: An Image is Worth Graph of Nodes(2022)
  - Was trained on ImageNet dataset.
- To optimize the developed model for mobile devices.
- To deploy the deep learning model on android mobile app.
- How to run the prediction on the edge device itself without running it on cloud server

Contributions

Introduced VisionGNN architecture based on Graph neural networks into phishing website classification for the first time

Utilized visual features alone with graph neural network representations for the first time.

Tuned hyperparameters to obtain the best accuracy.

Converted implemented PyTorch model into PyTorch mobile version to be deployed on Android mobile app.

Implemented a mobile app to detect phishing websites using a screenshot of the page.

Integrated deep learning model into the mobile app as a PyTorch mobile model to done the prediction on the edge device itself.

Graph Neural Network Concept and Vision GNN

Propose the image as a graph structure and introduce a new Vision GNN (ViG) architecture to extract graph level feature for visual tasks.

- Split the image to several patches which are viewed as nodes.
- Patches are transferred into the feature vector.

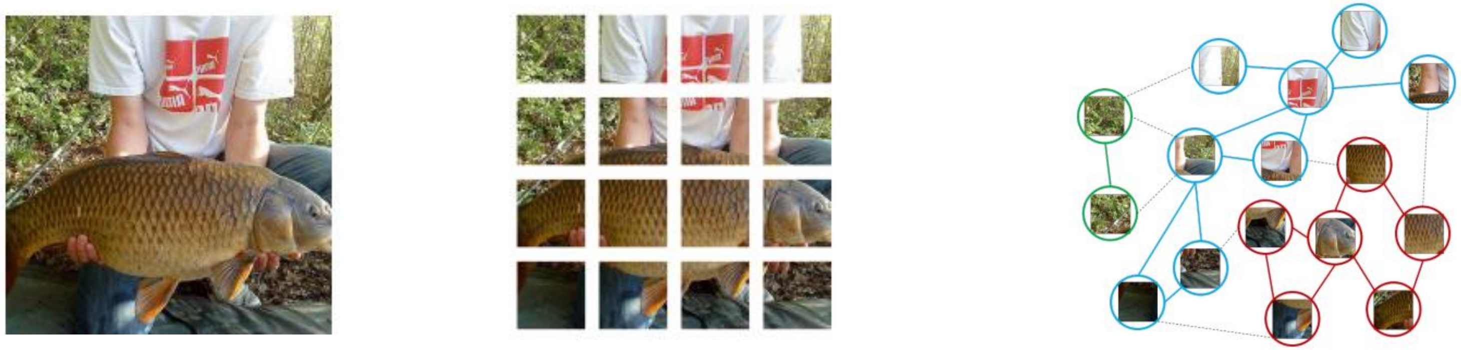


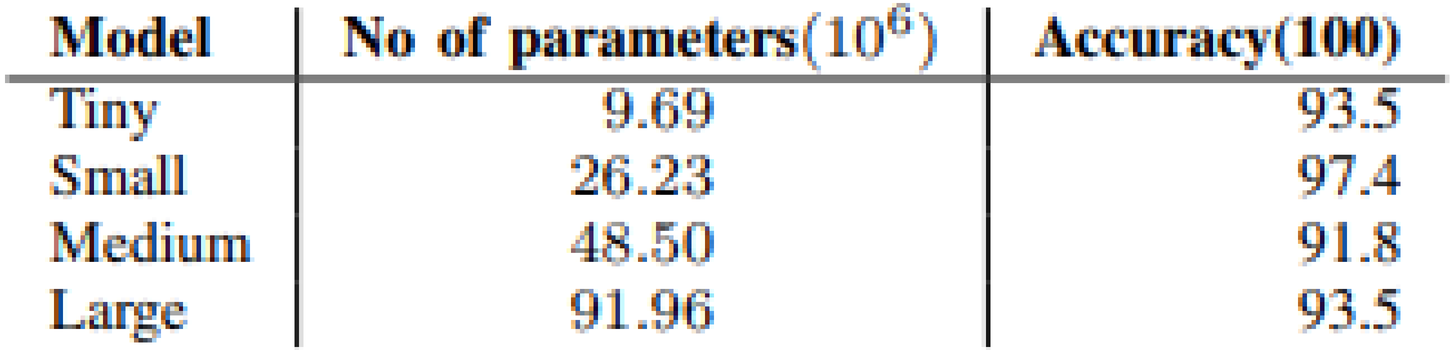
Fig 1. Image to graph construction (source-VisionGNN)

[20] Kai Han1,2∗ Yunhe Wang2∗ Jianyuan Guo2 Yehui Tang2,3 Enhua Wu1,4, "Vision GNN: An Image is Worth Graph of Nodes".

Dataset

- Visual phish dataset
  - Contain 9363 screenshots of PhishTank phishing pages that target 155 websites and 1195 phishing pages.
- 4072 data were divided into train and test with 20% split.
- Train data-3054
- Test data-1018

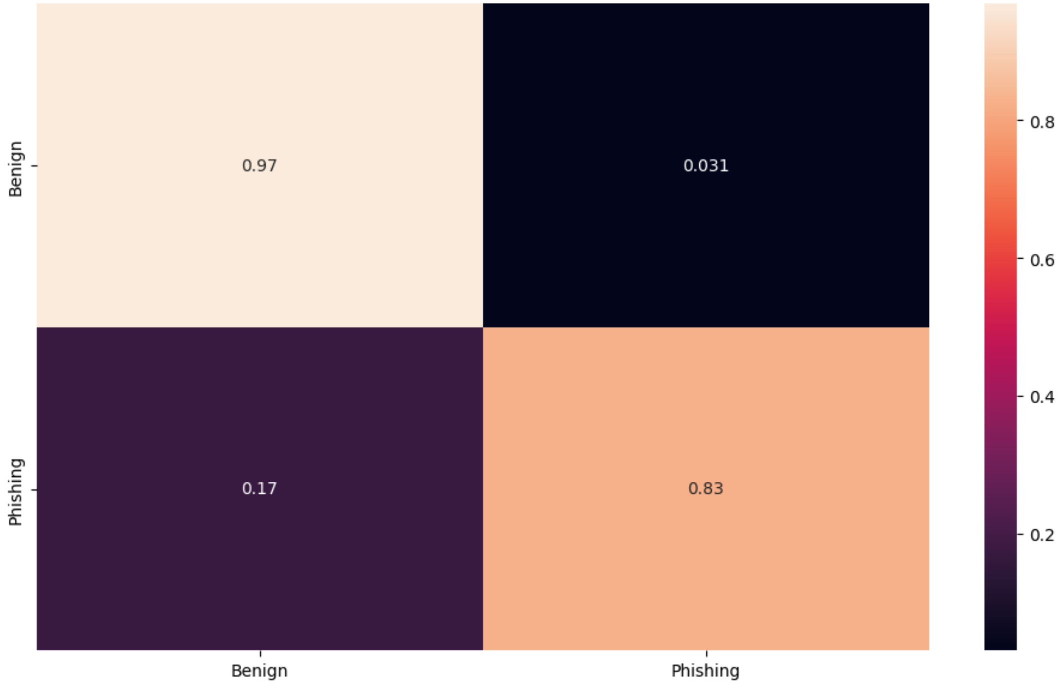
Model results



Model	No of parameters(10^6)	Accuracy(100)
Tiny	9.69	93.5
Small	26.23	97.4
Medium	48.50	91.8
Large	91.96	93.5

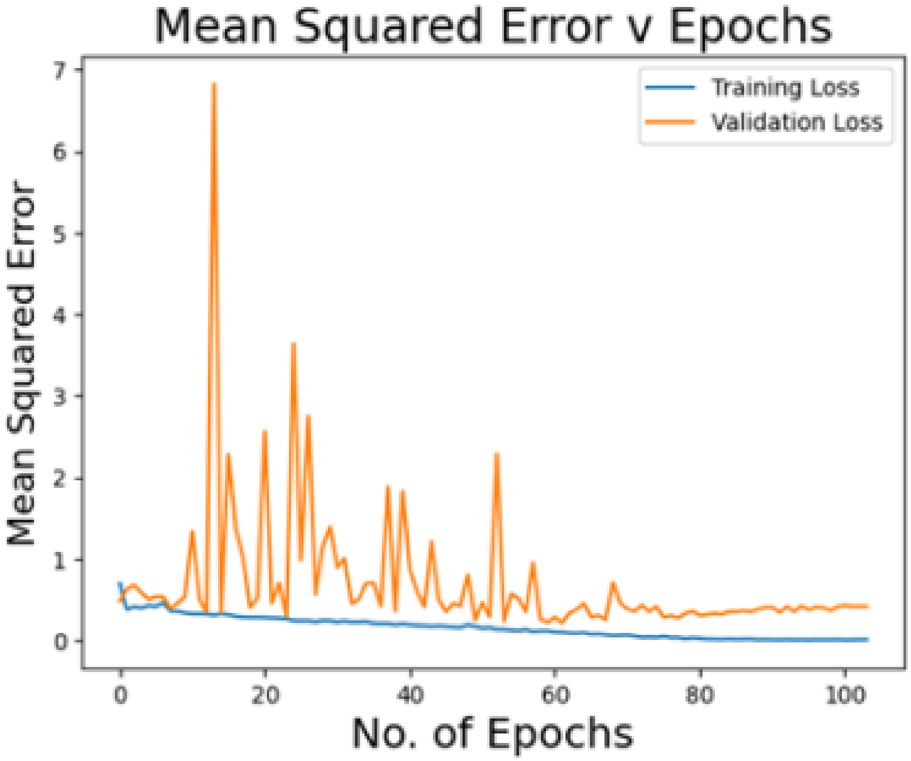
Maxium accuracy 97.4% in small model with 26.23 x 10^6 parameters

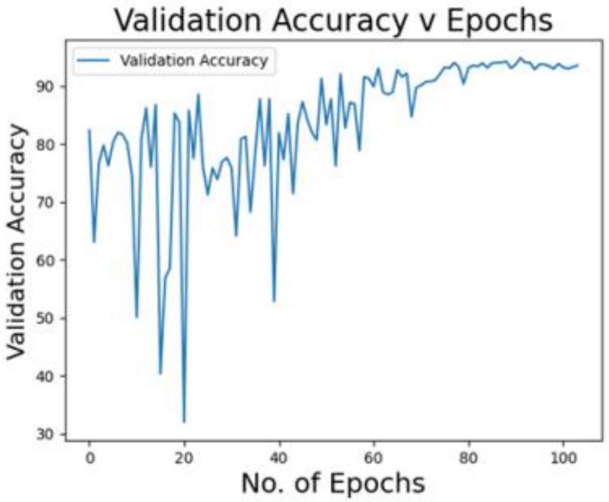
83% phishing sites detected
97% beign sites are correctly classified



VisionGNN for phishing website detection model training

Train epochs -100
Batch size=64
Optimizer – AdamW
Learning rate – 0.02
Learning rate decay – cosine
Image augmentations – horizontal and verital flips

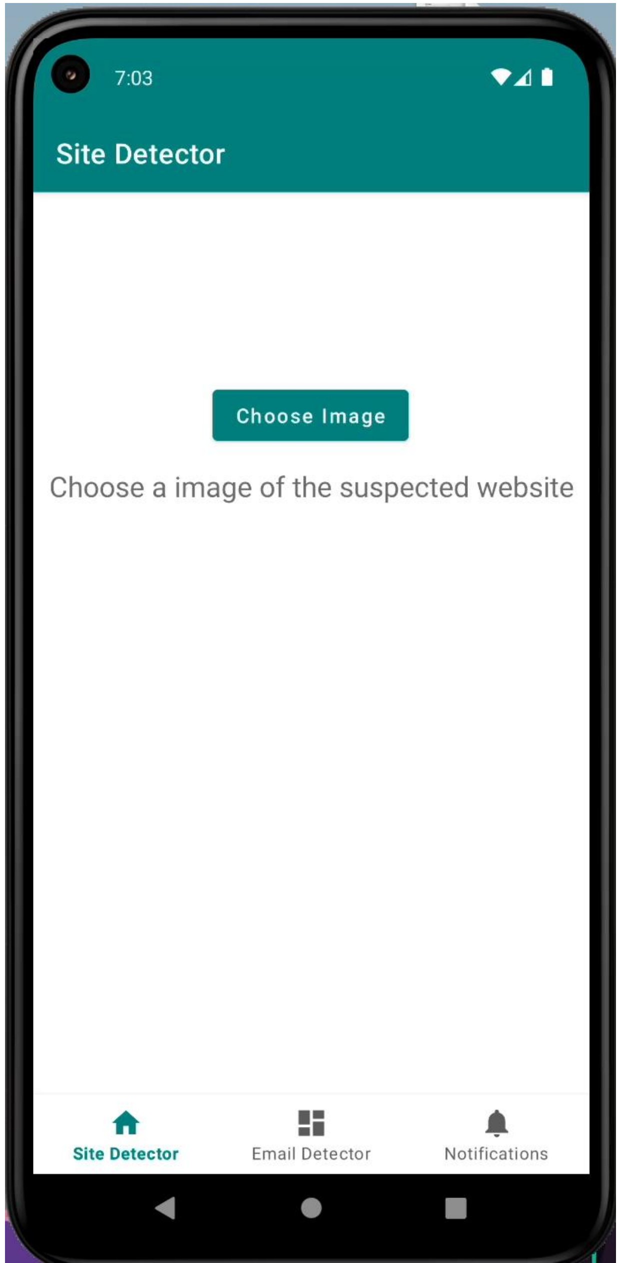




Model mobile app integration

- Optimized model for edge computing using Pytorch mobile
- Converted Pytorch model into Torchscript
- Model works on Andorid (works on Java)
- Model runs on GPU if the mobile device has a compatible GPU
- Advantages:
  - Preserves privacy of the user
  - Saves network bandwidth
  - Low latency

Mobile app demo



7:03

Site Detector

Choose Image

Choose a image of the suspected website

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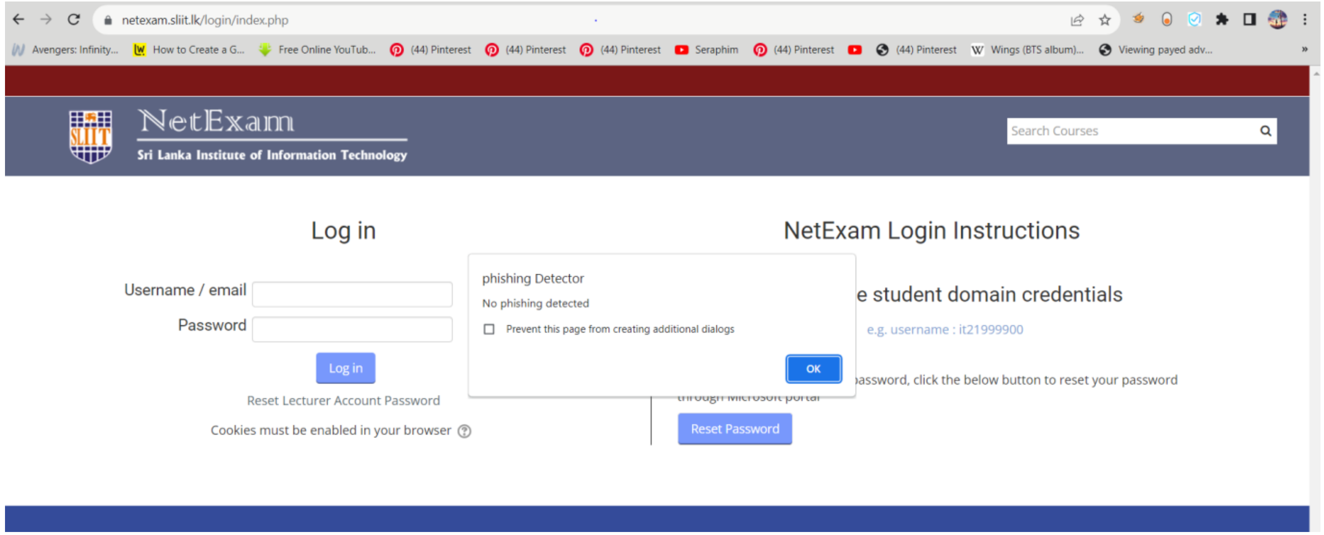
WEBSITE FEATURES

- **Attributes and characteristics of a web page.**
- **These attributes provide insights into a webpage's behavior, structure, and content.**
- **Are like pieces of a puzzle that make up a webpage.**
- **They include elements related to URLs, HTML, JavaScript, domains, and more.**
- **Think of website features as clues that help us understand a webpage's intent.**
- **They can reveal whether a webpage is legitimate or potentially malicious (phishing).**
  - Address Bar-based Features
  - Abnormal Behavior Features
  - HTML and JavaScript Features
  - Domain-related Features
  - Statistical Reports-based Features

Current Progress

- Model Development
- Model Serialization
- Extension Integration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Avengers: Infinity... How to Create a G... Free Online YouTub... (44) Pinterest (44) Pinterest (44) Pinterest Seraphim (44) Pinterest (44) Pinterest Wings (BTS album)... Viewing payed adv...
NetExam
Sri Lanka Institute of Information Technology
Search Courses

Log in

Username / email

Password

Log in

Reset Lecturer Account Password

Cookies must be enabled in your browser

NetExam Login Instructions

e student domain credentials

e.g. username : it21999900

assword, click the below button to reset your password

through Microsoft portal

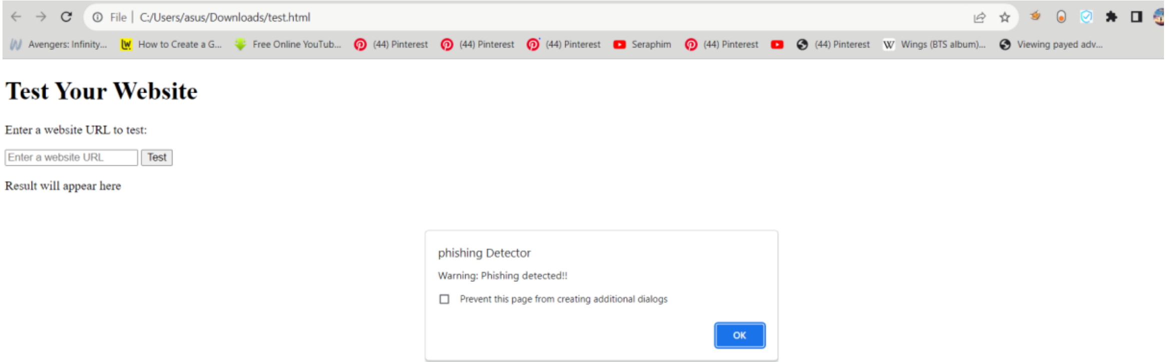
Reset Password

phishing Detector

No phishing detected

☐ Prevent this page from creating additional dialogs

OK


File | C:/Users/asus/Downloads/test.html
Avengers: Infinity... How to Create a G... Free Online YouTub... (44) Pinterest (44) Pinterest (44) Pinterest Seraphim (44) Pinterest (44) Pinterest Wings (BTS album)... Viewing payed adv...

Test Your Website

Enter a website URL to test:

Enter a website URL | Test

Result will appear here

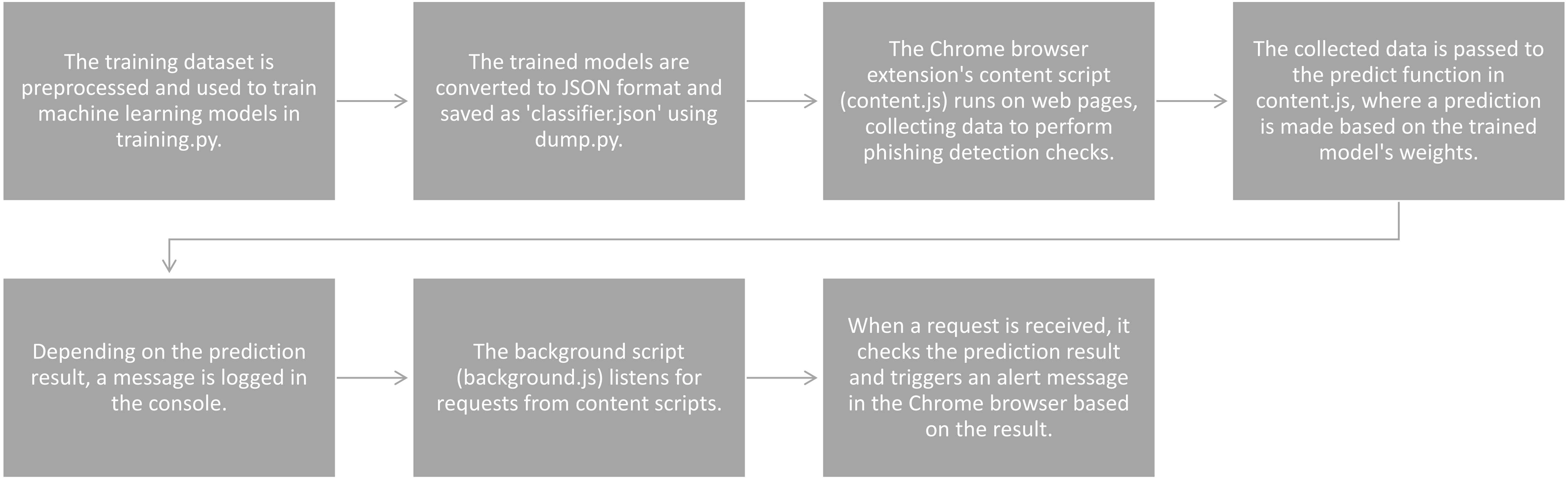
phishing Detector

Warning: Phishing detected!!

☐ Prevent this page from creating additional dialogs

OK

Connection Flow:



The training dataset is preprocessed and used to train machine learning models in training.py.

The trained models are converted to JSON format and saved as 'classifier.json' using dump.py.

The Chrome browser extension's content script (content.js) runs on web pages, collecting data to perform phishing detection checks.

The collected data is passed to the predict function in content.js, where a prediction is made based on the trained model's weights.

Depending on the prediction result, a message is logged in the console.

The background script (background.js) listens for requests from content scripts.

When a request is received, it checks the prediction result and triggers an alert message in the Chrome browser based on the result.

Future Works

- User Interface
- Enhanced Features
- Hosting

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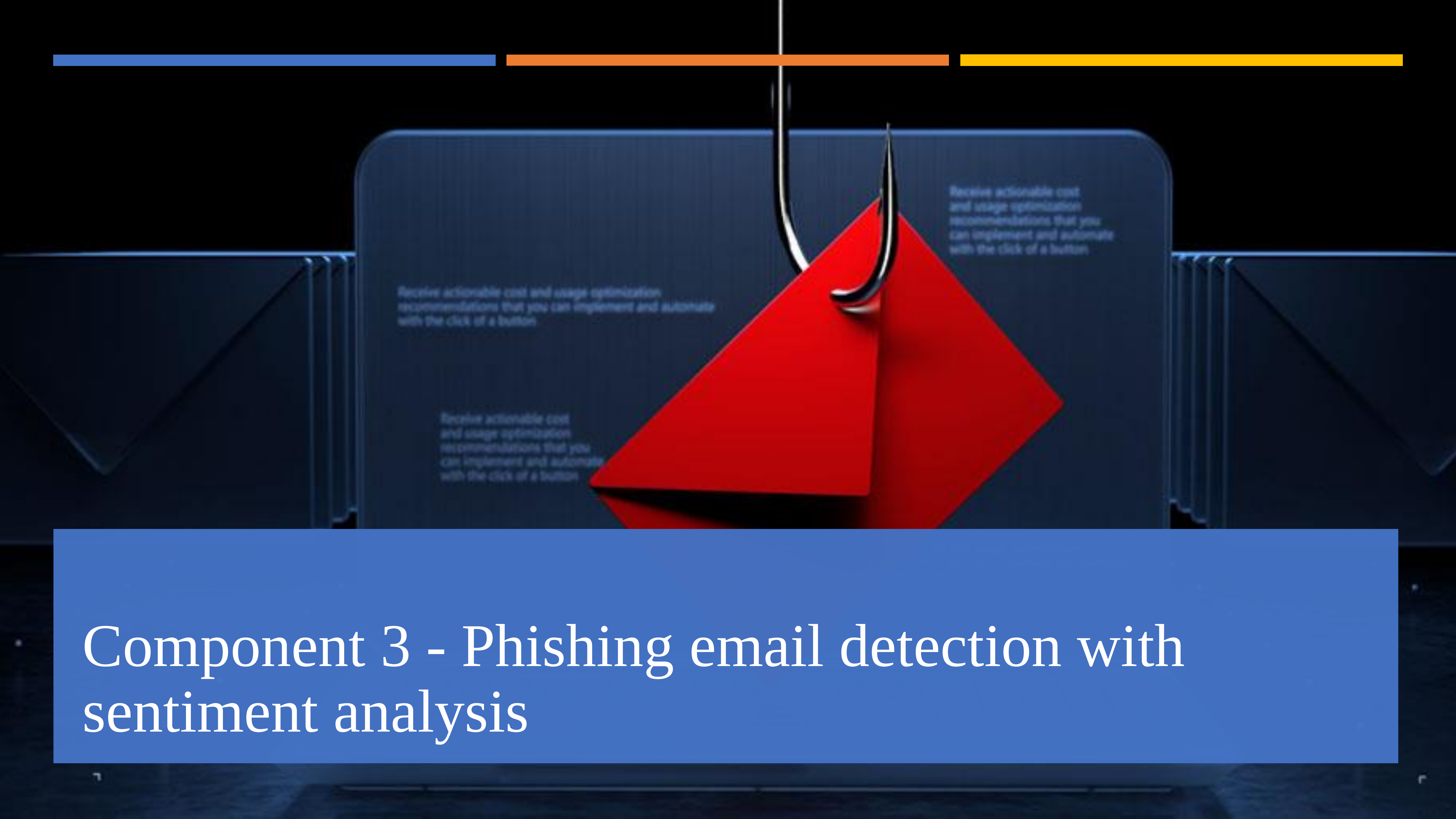


Receive actionable cost and usage optimization recommendations that you can implement and automate with the click of a button
Receive actionable cost and usage optimization recommendations that you can implement and automate with the click of a button
Receive actionable cost and usage optimization recommendations that you can implement and automate with the click of a button

Component 3 - Phishing email detection with sentiment analysis

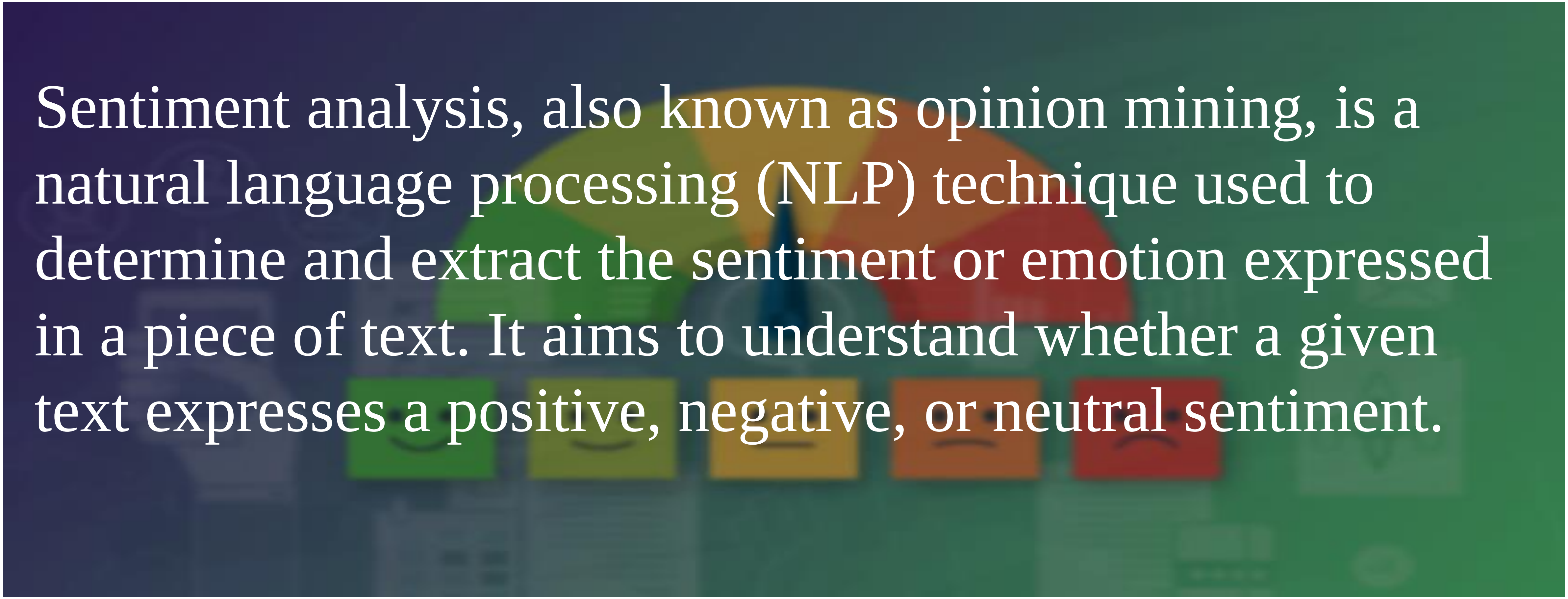
What is Phishing ?

Phishing is a cyberattack technique in which malicious actors impersonate legitimate entities to deceive individuals into revealing sensitive information or performing actions that compromise their security.

email Phishing

Email phishing is a deceptive cyberattack method where attackers send fraudulent emails that appear to be from trustworthy sources, aiming to trick recipients into divulging sensitive information or clicking on malicious links.

Sentiment analysis

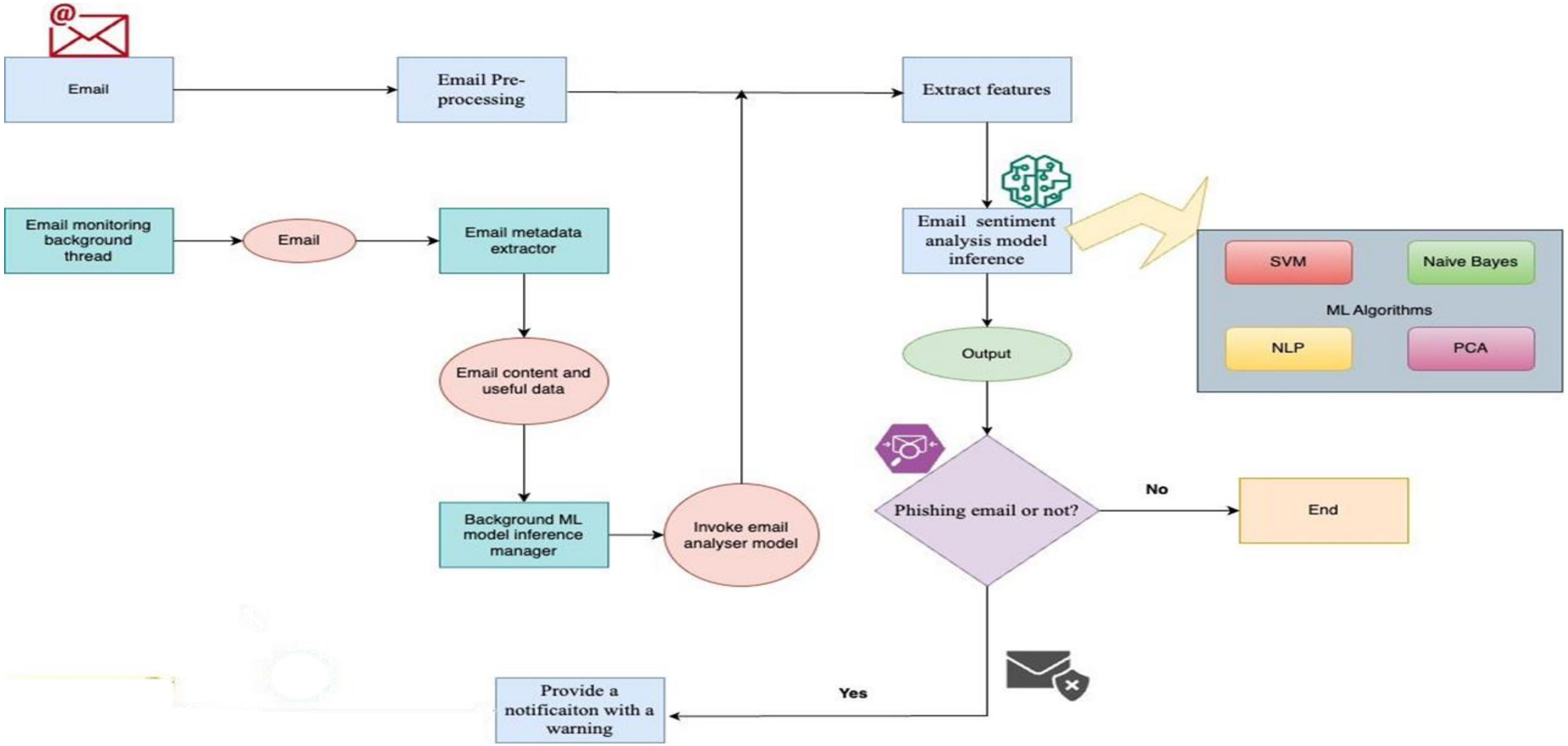


Sentiment analysis, also known as opinion mining, is a natural language processing (NLP) technique used to determine and extract the sentiment or emotion expressed in a piece of text. It aims to understand whether a given text expresses a positive, negative, or neutral sentiment.

Research Problem

- How to address the issue of imbalanced datasets, which can affect the accuracy of the model
- Using Large dataset to train the model
- How to use sentiment analysis for detect phishing emails.
- Using Naive Bayes algorithm to train the model

System Diagram


Email
Email Pre-processing
Extract features
Email monitoring background thread
Email
Email metadata extractor
Email sentiment analysis model inference
SVM
Naive Bayes
ML Algorithms
NLP
PCA
Output
Email content and useful data
Phishing email or not?
No
End
Background ML model inference manager
Invoke email analyser model
Yes
Provide a notificaiton with a warning

Objectives

- ❖ Detect emotion of the text using sentiment analysis.
- ❖ Improve the model to detect the text phishing or not.
- ❖ Display a warning message when detect a phishing email.
- ❖ Integrate the developed model to a mobile application.

REQUIREMENTS

Software Requirements

VS Code
Jupiter Notebook
Google CoLab

Algorithms

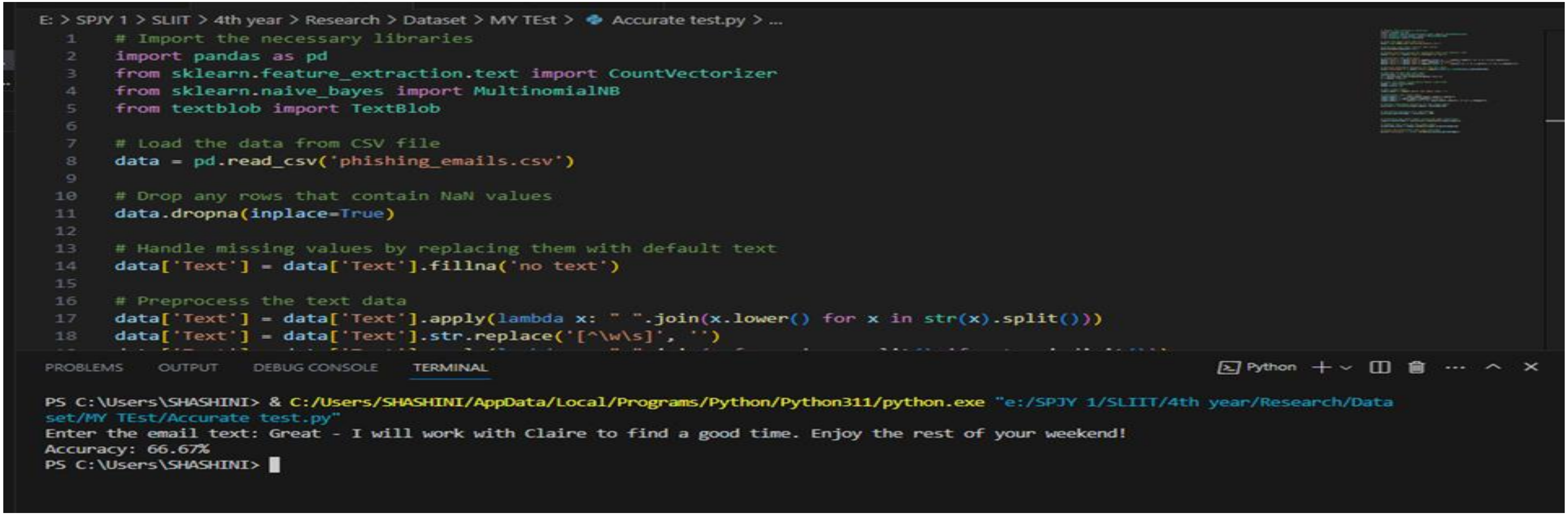
Naive Bayes (BernoulliNB)
Random Forest
Natural Language Processing (NLP)

Techniques

Machine Learning
Sentiment Analysis
Model Training

Accuracy

MultinomialNB

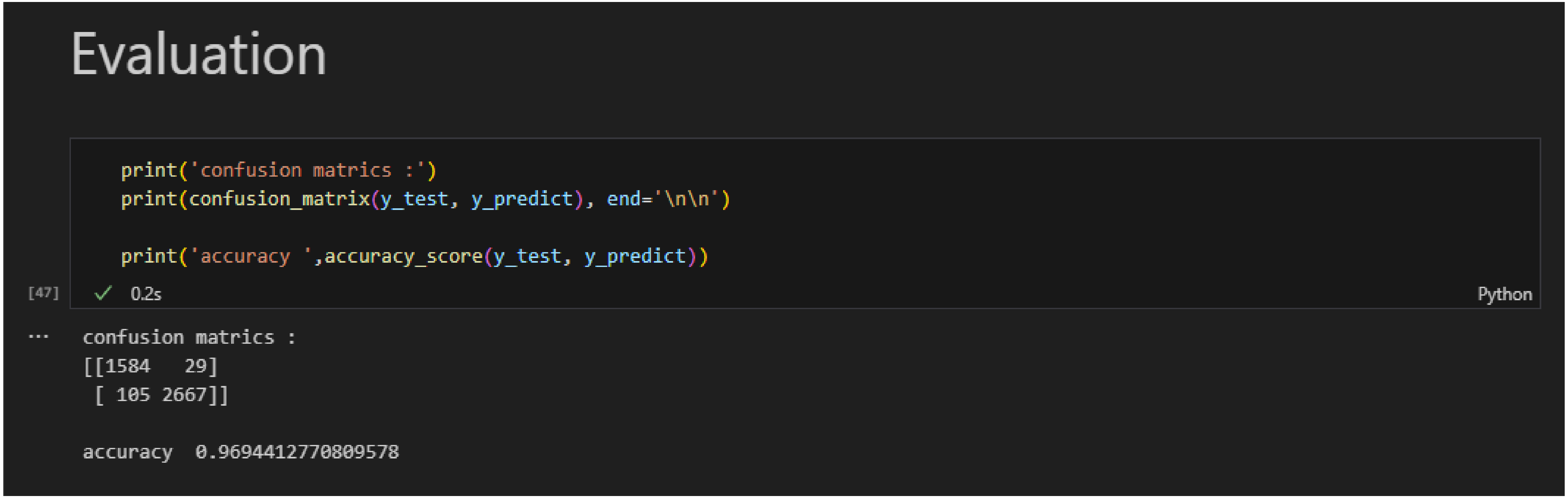

E: > SPJY 1 > SLIIT > 4th year > Research > Dataset > MY TEst > Accurate test.py > ...
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
Python

```python
# Import the necessary libraries
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.naive_bayes import MultinomialNB
from textblob import TextBlob

# Load the data from CSV file
data = pd.read_csv('phishing_emails.csv')

# Drop any rows that contain NaN values
data.dropna(inplace=True)

# Handle missing values by replacing them with default text
data['Text'] = data['Text'].fillna('no text')

# Preprocess the text data
data['Text'] = data['Text'].apply(lambda x: " ".join(x.lower() for x in str(x).split()))
data['Text'] = data['Text'].str.replace('[^\w\s]', '')
```

```
PS C:\Users\SHASHINI> & C:/Users/SHASHINI/AppData/Local/Programs/Python/Python311/python.exe "e:/SPJY 1/SLIIT/4th year/Research/Data
set/MY TEst/Accurate test.py"
Enter the email text: Great - I will work with Claire to find a good time. Enjoy the rest of your weekend!
Accuracy: 66.67%
PS C:\Users\SHASHINI>
```

Accuracy

BernoulliNB

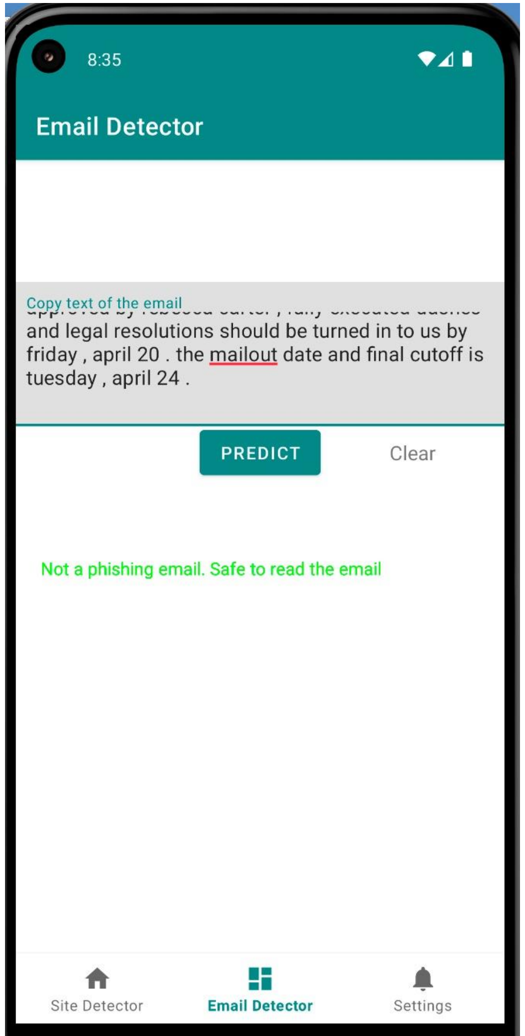


Evaluation

```
print('confusion matrics :')
print(confusion_matrix(y_test, y_predict), end='\n\n')

print('accuracy ',accuracy_score(y_test, y_predict))
```

```
confusion matrics :
[[1584   29]
 [ 105 2667]]

accuracy  0.9694412770809578
```

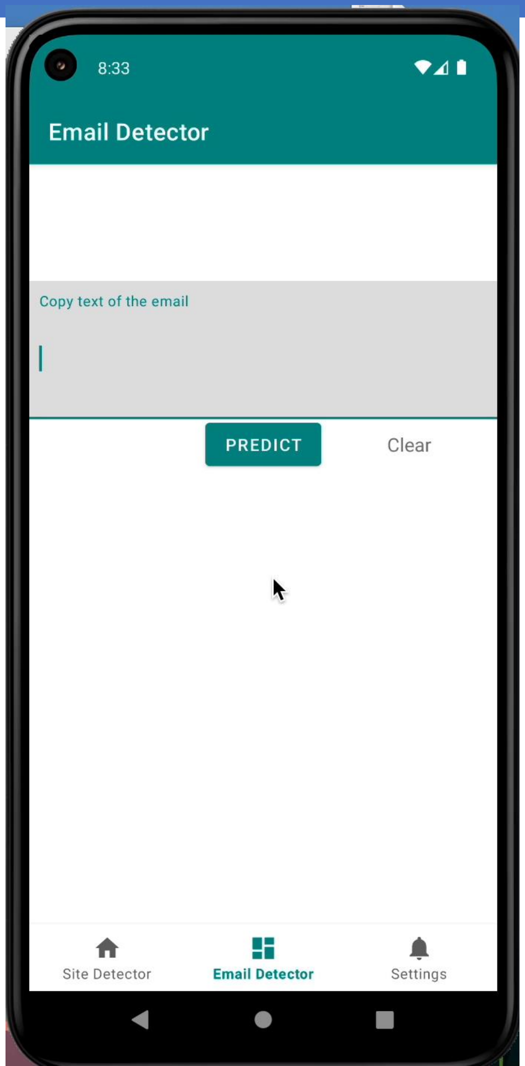
Mobile Application



and legal resolutions should be turned in to us by friday , april 20 . the mailout date and final cutoff is tuesday , april 24 .

Not a phishing email. Safe to read the email

Demonstration



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Phishing web site detection

Component 4 – Phishing email detection using URL

What is phishing

- Nowadays Phishing becomes a main area of concern for security researchers. Because it is not difficult to create the fake website which looks so close to .legitimate website. Experts can identify fake websites but not all the users can .identify the fake website and such users become the victim of phishing attack. .Main aim of the attacker is to steal banks account credentials. Phishing attacks are becoming successful because lack of user awareness. Since phishing attack exploits the weaknesses found in users, it is very difficult to mitigate them, but it is very important to enhance phishing detection techniques.

Research question

How Effective Are Machine Learning Algorithms in Detecting Phishing Websites Based on URL Features?

Sub objectives

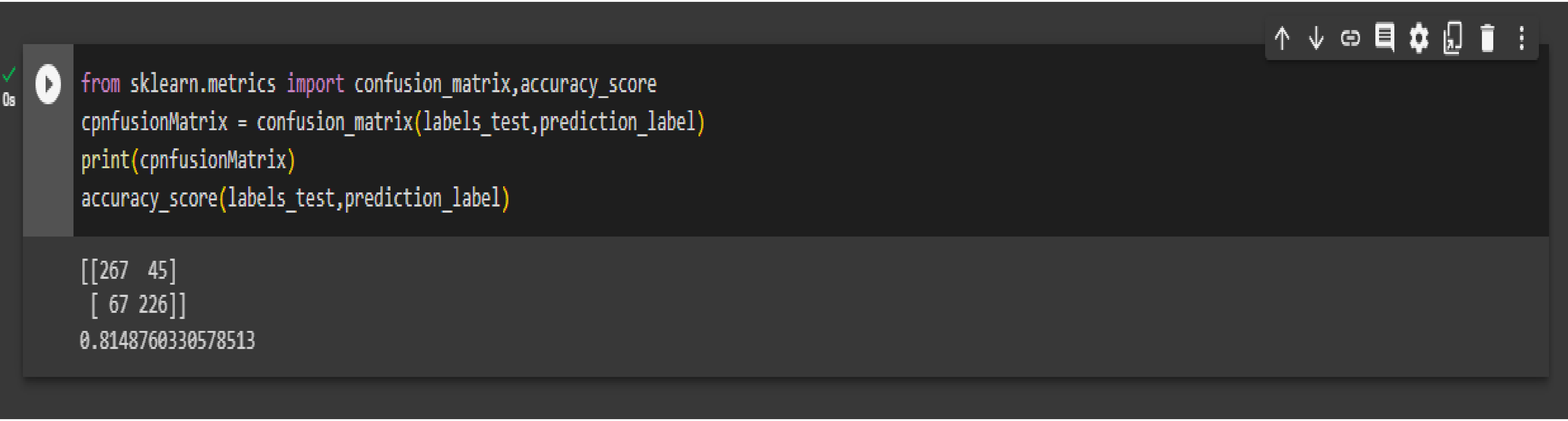
Creating web site for chcek URLS

URL blocker

Pop up message for user

Data set

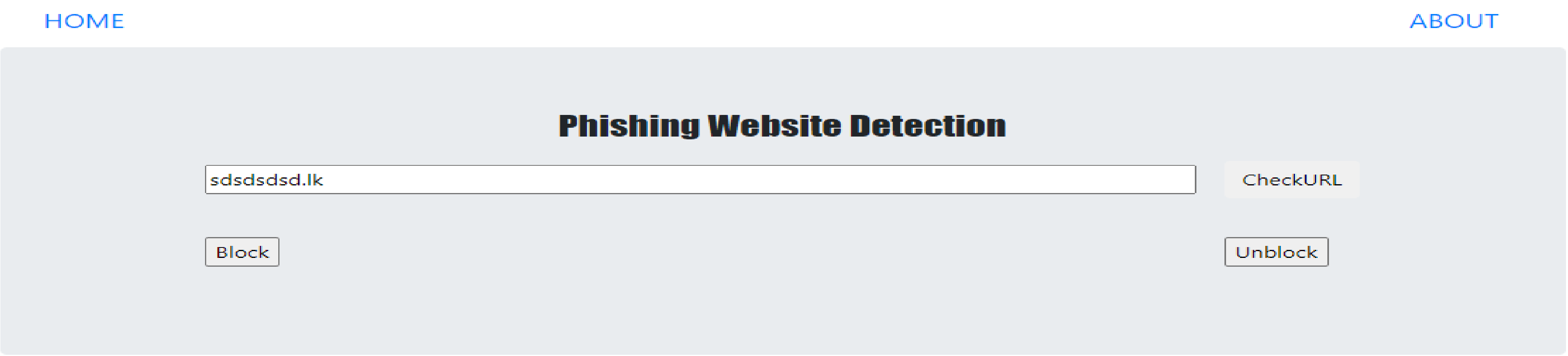
1. URL data sets
   1. 1000-pshing.txt
   2. Legitamate_urls.txt



```
from sklearn.metrics import confusion_matrix,accuracy_score
cpnfusionMatrix = confusion_matrix(labels_test,prediction_label)
print(cpnfusionMatrix)
accuracy_score(labels_test,prediction_label)
```

```
[[267  45]
 [ 67 226]]
0.8148760330578513
```

Web application



Phishing Website Detection

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- Phishing URLs Detection Using Sequential and Parallel ML Techniques: Comparative Analysis
- Modeling Hybrid Feature-Based Phishing Websites Detection Using Machine Learning Techniques
- Modeling Hybrid Feature-Based Phishing Websites Detection Using Machine Learning Techniques
- Sumitra Das Guptta, Khandaker Tayef Shahriar, Hamed Alqahtani, Dheyaaldin Alsalman & Iqbal H. Sarker
- Phishing URL Detection using Machine Learning Authors: Rutul Patel, Sanjay Kshetry, Sanket Berad, Justin Zirthantlunga
- PHISHING WEBSITE DETECTION USING NOVEL MACHINE LEARNING FUSION APPROACH
- Survey on Phishing Websites Detection using Machine Learning Authors: Mr. B Ravi Raju , S Sai likhitha, N Deepa, S Sushma
- Phishing website detection using machine learning and deep learning techniques (J. Phys.: Conf. Ser. 1916 012169)
- Detectionofphishingwebsitesusingmachinelearning techniques
- Phishing website prediction using base and ensemble classifier techniques with cross-validation Anjaneya Awasthi & Noopur Goel