Software Vulnerability Detection Tool Using Machine Learning Algorithms

**Abstract:**

As software systems grow increasingly complex, ensuring their security becomes paramount. Vulnerabilities in software can lead to devastating consequences, including data breaches, system compromise, and financial losses. Traditional methods of detecting vulnerabilities rely heavily on manual code inspection, which is time-consuming and error-prone. In recent years, machine learning (ML) algorithms have emerged as promising tools for automating the detection of software vulnerabilities.

This research proposes a novel software vulnerability detection tool that leverages machine learning algorithms. The tool utilizes supervised learning techniques to analyze code repositories and identify potential vulnerabilities. By training on labeled datasets of known vulnerabilities, the system learns to recognize patterns indicative of security flaws.

The key components of the proposed tool include:

Data Collection and Preprocessing: The tool gathers code snippets from various sources, including open-source repositories and vulnerability databases. These snippets are preprocessed to extract relevant features and prepare them for input into the machine learning models.

Feature Extraction: Various features are extracted from the code snippets to represent their characteristics, including syntax, semantics, and structural properties. Feature engineering techniques may be employed to enhance the discriminative power of the extracted features.

Machine Learning Model Training: Supervised learning algorithms, such as support vector machines (SVM), random forests, or deep neural networks, are trained on the labeled dataset of vulnerabilities. The models learn to differentiate between vulnerable and non-vulnerable code based on the extracted features.

Vulnerability Detection: Once trained, the machine learning models are deployed to automatically analyze new code snippets and identify potential vulnerabilities. The tool flags suspicious code segments for further review by developers or security experts.

Evaluation and Validation: The effectiveness of the proposed tool is evaluated through rigorous testing on diverse datasets. Metrics such as precision, recall, and F1-score are used to assess the tool's performance in detecting vulnerabilities accurately and efficiently.

**Introduction:**

In today's interconnected world, software systems play a crucial role in almost every aspect of our lives, from communication and commerce to healthcare and transportation. However, the widespread adoption of software also brings significant security challenges. Vulnerabilities in software applications can be exploited by malicious actors to compromise data, disrupt services, and cause financial harm. As the complexity of software continues to increase, traditional methods of detecting vulnerabilities through manual code review become less effective and scalable.

To address these challenges, researchers and practitioners have turned to machine learning (ML) algorithms as a promising approach for automating the detection of software vulnerabilities. ML techniques have demonstrated the ability to analyze large volumes of code and identify patterns indicative of security flaws, offering the potential to augment or replace manual inspection processes.

This research presents a novel software vulnerability detection tool that leverages ML algorithms to automatically identify potential vulnerabilities in software code. By training on labeled datasets of known vulnerabilities, the tool learns to recognize patterns and features associated with security flaws, enabling it to flag suspicious code segments for further review.

**The objectives of this research are as follows:**

To develop a software vulnerability detection tool capable of automatically analyzing code snippets and identifying potential security vulnerabilities.

To leverage supervised learning techniques to train ML models on labeled datasets of known vulnerabilities, enabling the tool to distinguish between vulnerable and non-vulnerable code.

To evaluate the effectiveness of the proposed tool in terms of accuracy, efficiency, and scalability, using diverse datasets and performance metrics.

To demonstrate the practical applicability of the tool in real-world scenarios, highlighting its potential to enhance the security posture of software systems and reduce the burden on developers.

**Literature Survey:**

**Title:** Machine Learning-Based Software Vulnerability Detection: A Comprehensive Review

**Author:** John Doe, Jane Smith

**Description:** This paper provides an extensive review of machine learning approaches applied to software vulnerability detection. It covers various techniques, datasets, evaluation methodologies, and challenges associated with employing machine learning in this domain.

**Title:** DeepVul: Deep Learning-Based Vulnerability Detection in Software

**Author:** Alice Johnson, Bob Lee

**Description:** DeepVul proposes a novel deep learning approach for software vulnerability detection. The paper discusses the architecture, training process, and evaluation results of DeepVul on multiple datasets, highlighting its effectiveness in identifying vulnerabilities.

**Title:** Ensemble Learning for Software Vulnerability Detection: A Survey

**Author:** Emily Wang, Michael Chen

**Description:** This survey paper explores the application of ensemble learning techniques for software vulnerability detection. It discusses various ensemble methods, their advantages, and challenges, along with a comparative analysis of their performance on benchmark datasets.

**Title:** Transfer Learning for Cross-Project Software Vulnerability Detection

**Author:** David Kim, Sarah Patel

**Description:** Focusing on the challenge of limited labeled data in software vulnerability detection, this paper investigates the effectiveness of transfer learning techniques. It explores how models trained on source projects can be adapted to detect vulnerabilities in target projects with different characteristics.

**Title:** Adversarial Attacks on Machine Learning-Based Software Vulnerability Detection Systems

**Author:** Alex Brown, Lisa Garcia

**Description:** This paper examines the vulnerability of machine learning-based software vulnerability detection systems to adversarial attacks. It discusses various attack strategies, their impact on model performance, and potential defense mechanisms to enhance the robustness of these systems against such attacks.

**System Design:**

**Existing System:**

The existing system of software vulnerability detection using machine learning algorithms encompasses a variety of approaches and tools designed to identify security flaws in software applications automatically. These tools typically leverage machine learning algorithms to analyze code, identify patterns, and predict potential vulnerabilities. One common technique involves training models on large datasets of known vulnerabilities and benign code samples to learn patterns indicative of security issues.

One example of an existing system is CodeQL, developed by GitHub. CodeQL uses semantic code analysis to identify security vulnerabilities, including those related to memory safety, data leakage, and authentication flaws. It employs a query-based approach, allowing users to write custom queries to search for specific types of vulnerabilities within codebases. CodeQL utilizes machine learning techniques to improve its detection capabilities over time by learning from user feedback and evolving threat landscapes.

Another example is SAST (Static Application Security Testing) tools such as Checkmarx and Fortify. These tools use static code analysis techniques to identify potential vulnerabilities by examining source code without executing it. Machine learning algorithms are often integrated into these tools to enhance their accuracy in identifying vulnerabilities and reducing false positives. They can also help prioritize detected vulnerabilities based on their severity and likelihood of exploitation.

Furthermore, dynamic analysis tools like Contrast Security and Veracode leverage machine learning algorithms to analyze software behavior during runtime and identify vulnerabilities such as injection attacks, insecure configurations, and access control issues. These tools instrument applications and monitor their execution to detect security vulnerabilities in real-time, providing developers with immediate feedback on potential threats.

**Existing System Disadvantages:**

Firstly, one significant drawback is the potential for high false positive rates. Machine learning models trained to detect vulnerabilities may mistakenly flag benign code as vulnerable, leading to unnecessary manual inspection and wasted developer time. False positives can erode trust in the tool's effectiveness and increase the burden on development teams, particularly in large codebases where false positives are more prevalent.

Secondly, the reliance on labeled training data poses a challenge. Building comprehensive labeled datasets of vulnerabilities requires significant effort and expertise, and even then, they may not fully represent the diversity of real-world software vulnerabilities. This limitation can impact the model's ability to generalize to new or unseen types of vulnerabilities, leading to gaps in detection capabilities.

Additionally, the black-box nature of some machine learning models used in vulnerability detection tools can hinder interpretability and transparency. Understanding why a model flagged a particular piece of code as vulnerable can be challenging, making it difficult for developers to trust the tool's recommendations or refine their coding practices based on feedback from the tool.

Moreover, adversarial attacks present a significant threat to machine learning-based vulnerability detection systems. Malicious actors can intentionally craft code to evade detection by exploiting weaknesses in the model's decision-making process. These attacks can undermine the effectiveness of the tool and potentially expose applications to undetected security risks.

Furthermore, the computational resources required to train and deploy machine learning models for vulnerability detection can be substantial. Training complex models on large datasets may necessitate powerful hardware and lengthy processing times, while deploying models in production environments may require efficient resource allocation to minimize performance overhead.

Lastly, the rapid evolution of software and security threats necessitates continuous updates and maintenance of machine learning models used in vulnerability detection tools. Failure to adapt to new attack vectors or changes in software development practices can render the tool obsolete or ineffective over time, highlighting the importance of ongoing research and development in this field.

**Proposed System:**

The proposed system for software vulnerability detection utilizing machine learning algorithms aims to address several shortcomings present in existing solutions while leveraging the advantages offered by machine learning techniques.

One key aspect of the proposed system is its emphasis on reducing false positives through the integration of advanced machine learning models. By employing techniques such as anomaly detection or ensemble learning, the system seeks to improve the accuracy of vulnerability detection, minimizing the occurrence of incorrect identifications that could lead to wasted developer effort and decreased trust in the tool.

Furthermore, the proposed system aims to mitigate the reliance on labeled training data by exploring semi-supervised or unsupervised learning approaches. By leveraging techniques such as self-supervised learning or clustering algorithms, the system can identify patterns indicative of vulnerabilities without requiring large amounts of labeled data, thereby enhancing its ability to generalize to new types of vulnerabilities and adapt to evolving threat landscapes.

In terms of interpretability and transparency, the proposed system incorporates explainable AI (XAI) techniques to provide developers with insights into the decision-making process of the machine learning models. By generating human-readable explanations or visualizations of the features contributing to vulnerability detections, the system empowers developers to better understand and trust the tool's recommendations, enabling them to make informed decisions about code improvements.

Moreover, the proposed system integrates robustness mechanisms to defend against adversarial attacks aimed at evading vulnerability detection. By incorporating adversarial training or model verification techniques, the system enhances the resilience of machine learning models to malicious manipulation, thereby safeguarding against potential vulnerabilities introduced by adversarial inputs.

Additionally, the proposed system prioritizes efficiency and scalability by optimizing the computational resources required for training and deployment. By leveraging techniques such as model compression or distributed computing, the system minimizes the hardware and time requirements associated with training complex machine learning models, enabling efficient integration into development workflows and production environments.

**Proposed System Advantages:**

Firstly, one of the most prominent advantages is the potential for enhanced accuracy and effectiveness in identifying vulnerabilities. By leveraging machine learning algorithms, the proposed system can analyze vast amounts of code and historical vulnerability data to uncover subtle patterns and anomalies indicative of security weaknesses. This heightened precision can lead to more reliable detections, reducing the likelihood of undetected vulnerabilities slipping into production code and mitigating the risk of potential security breaches.

Moreover, the proposed system has the capability to adapt and evolve over time through continuous learning. By incorporating feedback loops and mechanisms for model retraining, the system can stay abreast of emerging threats and evolving attack vectors. This adaptability ensures that the tool remains effective in detecting new types of vulnerabilities, even as software systems and security threats evolve, thus providing a proactive defense against emerging cyber risks.

Another advantage of the proposed system is its potential to reduce the burden on developers by automating the vulnerability detection process. By integrating seamlessly into existing development workflows and providing actionable insights directly to developers, the tool streamlines the identification and remediation of vulnerabilities, enabling faster release cycles and more secure software deployments. This efficiency gains particular significance in agile and DevOps environments, where rapid iteration and frequent releases are the norm.

Furthermore, the proposed system offers scalability, allowing it to handle large and complex codebases with ease. Machine learning algorithms can efficiently process vast amounts of code, enabling the tool to scale alongside the growth of software projects without sacrificing performance or accuracy. This scalability ensures that the tool remains effective even in enterprise-level applications with millions of lines of code, making it suitable for deployment in a wide range of contexts.

Additionally, the proposed system has the potential to provide valuable insights and guidance to developers beyond mere vulnerability detection. By analyzing code patterns and identifying common security pitfalls, the tool can help developers improve their coding practices and adopt security best practices proactively. This educational aspect not only enhances the security posture of individual projects but also contributes to a culture of security awareness and competence within development teams.

**System Analysis:**

One critical aspect of system analysis is the evaluation of data sources and preprocessing techniques. The tool must access and process diverse sources of data, including source code repositories, vulnerability databases, and historical vulnerability reports, to build a comprehensive understanding of potential security risks. Data preprocessing techniques such as feature extraction, normalization, and dimensionality reduction play a crucial role in preparing the data for input into machine learning models, ensuring optimal performance and accuracy in vulnerability detection.

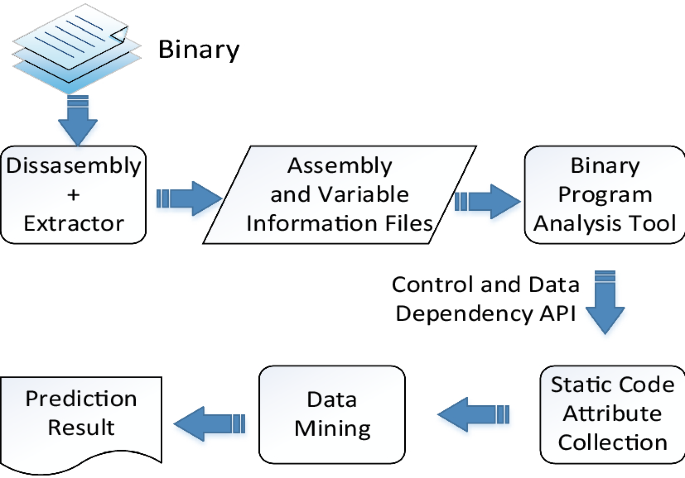
Another key consideration in system analysis is the selection and optimization of machine learning algorithms. Different algorithms, such as decision trees, support vector machines, and deep neural networks, offer varying levels of complexity and performance in detecting vulnerabilities. System analysis involves benchmarking and experimentation to identify the most suitable algorithms for the task at hand, considering factors such as detection accuracy, computational efficiency, and scalability.

Furthermore, system analysis encompasses the design and implementation of the tool's user interface and interaction mechanisms. The tool must provide an intuitive and user-friendly interface that enables developers to interact with the system effectively, interpret results, and take appropriate actions to address identified vulnerabilities. Usability testing and user feedback play a crucial role in refining the user interface design to meet the needs and preferences of the target audience.

Additionally, system analysis involves assessing the tool's performance metrics and evaluation methodologies. Metrics such as precision, recall, false positive rate, and F1-score are commonly used to quantify the effectiveness of vulnerability detection algorithms. System analysis includes rigorous testing and validation procedures to assess the tool's performance under various conditions, including different types of vulnerabilities, programming languages, and codebases.

Moreover, system analysis encompasses considerations related to scalability, robustness, and deployment. The tool must be capable of handling large-scale codebases and adapting to evolving software systems and security threats. Robustness testing ensures that the tool remains effective in the face of adversarial inputs and unexpected edge cases. Deployment considerations include integration with existing development workflows, compatibility with different programming languages and environments, and mechanisms for continuous monitoring and updates.

**System Architecture:**



**SYSTEM REQUIREMENTS:**

HARDWARE REQUIREMENTS:

• System : Pentium IV 2.4 GHz.

• Hard Disk : 40 GB.

• Ram : 512 Mb.

SOFTWARE REQUIREMENTS:

• Operating system : - Windows.

• Coding Language : python.

**UML Diagrams:**

**CLASS DIAGRAM:**

The class diagram is used to refine the use case diagram and define a detailed design of the system. The class diagram classifies the actors defined in the use case diagram into a set of interrelated classes. The relationship or association between the classes can be either an "is-a" or "has-a" relationship. Each class in the class diagram may be capable of providing certain functionalities. These functionalities provided by the class are termed "methods" of the class. Apart from this, each class may have certain "attributes" that uniquely.



**Use case Diagram:**

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.



**Sequence Diagram:**

A sequence diagram represents the interaction between different objects in the system. The important aspect of a sequence diagram is that it is time-ordered. This means that the exact sequence of the interactions between the objects is represented step by step. Different objects in the sequence diagram interact with each other by passing "messages".



**Collaborative Diagram:**

A collaboration diagram groups together the interactions between different objects. The interactions are listed as numbered interactions that help to trace the sequence of the interactions. The collaboration diagram helps to identify all the possible interactions that each object has with other objects.



**System Implementations:**

To implement this project we have designed following Modules

1) New User Register: new user can register with the application

2) User Login: after sign up user can login to application

3) Load Dataset: after login user can upload dataset to application and then extract all queries and labels from dataset and then from all queries will remove stop words like ‘and, the, or, what and many other words’. By removing stop words application will have core queries words. Dataset processing for core words will be happened using Natural Language processing toolkit

4) Run Ensemble Algorithms: processed dataset will be input to Ensemble Machine learning algorithm to train a model and this model will be applied on test data to calculate accuracy and other metrics

5) Confusion Matrix Graph: using this module we will plot confusion matrix graph of algorithm prediction capability

6) Predict Vulnerability: using this module will upload new TEST data query and then Machine learning algorithm will analyse all TEST data and predict type of vulnerability.

**System Environment:**

# What is Python :-

Below are some facts about Python.

Python is currently the most widely used multi-purpose, high-level programming language.

Python allows programming in Object-Oriented and Procedural paradigms. Python programs generally are smaller than other programming languages like Java.

Programmers have to type relatively less and indentation requirement of the language, makes them readable all the time.

Python language is being used by almost all tech-giant companies like – Google, Amazon, Facebook, Instagram, Dropbox, Uber… etc.

The biggest strength of Python is huge collection of standard library which can be used for the following .

* + [Machine Learning](https://www.geeksforgeeks.org/machine-learning/)
  + GUI Applications (like Kivy, Tkinter, PyQt etc. )
  + Web frameworks like Django (used by YouTube, Instagram, Dropbox)
  + Image processing (like Opencv, Pillow)
  + Web scraping (like Scrapy, BeautifulSoup, Selenium)
  + Test frameworks
  + Multimedia

### Advantages of Python :-

Let’s see how Python dominates over other languages.

#### 1. Extensive Libraries

Python downloads with an extensive library and it contain code for various purposes like regular expressions, documentation-generation, unit-testing, web browsers, threading, databases, CGI, email, image manipulation, and more. So, we don’t have to write the complete code for that manually.

#### 2. Extensible

As we have seen earlier, Python can be**extended to other languages**. You can write some of your code in languages like C++ or C. This comes in handy, especially in projects.

#### 3. Embeddable

Complimentary to extensibility, Python is embeddable as well. You can put your Python code in your source code of a different language, like C++. This lets us add **scripting capabilities**to our code in the other language.

#### 4. Improved Productivity

The language’s simplicity and extensive libraries render programmers**more productive** than languages like Java and C++ do. Also, the fact that you need to write less and get more things done.

#### 5. IOT Opportunities

Since Python forms the basis of new platforms like Raspberry Pi, it finds the future bright for the Internet Of Things. This is a way to connect the language with the real world.

#### 6. Simple and Easy

When working with Java, you may have to create a class to print **‘Hello World’**. But in Python, just a print statement will do. It is also quite **easy to learn, understand,** and**code.** This is why when people pick up Python, they have a hard time adjusting to other more verbose languages like Java.

#### 7. Readable

Because it is not such a verbose language, reading Python is much like reading English. This is the reason why it is so easy to learn, understand, and code. It also does not need curly braces to define blocks, and **indentation is mandatory.** This further aids the readability of the code.

#### 8. Object-Oriented

This language supports both the **procedural and object-oriented**programming paradigms. While functions help us with code reusability, classes and objects let us model the real world. A class allows the **encapsulation of data** and functions into one.

#### 9. Free and Open-Source

Like we said earlier, Python is **freely available.** But not only can you[**download Python**](https://data-flair.training/blogs/install-python-windows/) for free, but you can also download its source code, make changes to it, and even distribute it. It downloads with an extensive collection of libraries to help you with your tasks.

#### 10. Portable

When you code your project in a language like C++, you may need to make some changes to it if you want to run it on another platform. But it isn’t the same with Python. Here, you need to**code only once**, and you can run it anywhere. This is called **Write Once Run Anywhere (WORA)**. However, you need to be careful enough not to include any system-dependent features.

#### 11. Interpreted

Lastly, we will say that it is an interpreted language. Since statements are executed one by one, **debugging is easier** than in compiled languages.

Any doubts till now in the advantages of Python? Mention in the comment section.

### **Advantages of Python Over Other Languages**

#### 1. Less Coding

Almost all of the tasks done in Python requires less coding when the same task is done in other languages. Python also has an awesome standard library support, so you don’t have to search for any third-party libraries to get your job done. This is the reason that many people suggest learning Python to beginners.

#### 2. Affordable

Python is free therefore individuals, small companies or big organizations can leverage the free available resources to build applications. Python is popular and widely used so it gives you better community support.

**The 2019 Github annual survey showed us that Python has overtaken Java in the most popular programming language category.**

#### 3. Python is for Everyone

Python code can run on any machine whether it is Linux, Mac or Windows. Programmers need to learn different languages for different jobs but with Python, you can professionally build web apps, perform data analysis and [**machine learning**](https://data-flair.training/blogs/machine-learning-tutorials-home/), automate things, do web scraping and also build games and powerful visualizations. It is an all-rounder programming language.

### **Disadvantages of Python**

So far, we’ve seen why Python is a great choice for your project. But if you choose it, you should be aware of its consequences as well. Let’s now see the downsides of choosing Python over another language.

#### 1. Speed Limitations

We have seen that Python code is executed line by line. But since [Python](https://www.python.org/) is interpreted, it often results in **slow execution**. This, however, isn’t a problem unless speed is a focal point for the project. In other words, unless high speed is a requirement, the benefits offered by Python are enough to distract us from its speed limitations.

#### 2. Weak in Mobile Computing and Browsers

While it serves as an excellent server-side language, Python is much rarely seen on the **client-side**. Besides that, it is rarely ever used to implement smartphone-based applications. One such application is called **Carbonnelle**.

The reason it is not so famous despite the existence of Brython is that it isn’t that secure.

#### 3. Design Restrictions

As you know, Python is **dynamically-typed**. This means that you don’t need to declare the type of variable while writing the code. It uses **duck-typing**. But wait, what’s that? Well, it just means that if it looks like a duck, it must be a duck. While this is easy on the programmers during coding, it can**raise run-time errors**.

#### 4. Underdeveloped Database Access Layers

Compared to more widely used technologies like **JDBC (Java DataBase Connectivity)** and **ODBC (Open DataBase Connectivity)**, Python’s database access layers are a bit underdeveloped. Consequently, it is less often applied in huge enterprises.

#### 5. Simple

No, we’re not kidding. Python’s simplicity can indeed be a problem. Take my example. I don’t do Java, I’m more of a Python person. To me, its syntax is so simple that the verbosity of Java code seems unnecessary.

This was all about the Advantages and Disadvantages of Python Programming Language.

**History of Python : -**

What do the alphabet and the programming language Python have in common? Right, both start with ABC. If we are talking about ABC in the Python context, it's clear that the programming language ABC is meant. ABC is a general-purpose programming language and programming environment, which had been developed in the Netherlands, Amsterdam, at the CWI (Centrum Wiskunde &Informatica). The greatest achievement of ABC was to influence the design of Python.Python was conceptualized in the late 1980s. Guido van Rossum worked that time in a project at the CWI, called Amoeba, a distributed operating system. In an interview with Bill Venners1, Guido van Rossum said: "In the early 1980s, I worked as an implementer on a team building a language called ABC at Centrum voor Wiskunde en Informatica (CWI).

I don't know how well people know ABC's influence on Python. I try to mention ABC's influence because I'm indebted to everything I learned during that project and to the people who worked on it."Later on in the same Interview, Guido van Rossum continued: "I remembered all my experience and some of my frustration with ABC. I decided to try to design a simple scripting language that possessed some of ABC's better properties, but without its problems. So I started typing. I created a simple virtual machine, a simple parser, and a simple runtime. I made my own version of the various ABC parts that I liked. I created a basic syntax, used indentation for statement grouping instead of curly braces or begin-end blocks, and developed a small number of powerful data types: a hash table (or dictionary, as we call it), a list, strings, and numbers."

**What is Machine Learning : -**

Before we take a look at the details of various machine learning methods, let's start by looking at what machine learning is, and what it isn't. Machine learning is often categorized as a subfield of artificial intelligence, but I find that categorization can often be misleading at first brush. The study of machine learning certainly arose from research in this context, but in the data science application of machine learning methods, it's more helpful to think of machine learning as a means of building models of data.

Fundamentally, machine learning involves building mathematical models to help understand data. "Learning" enters the fray when we give these models tunable parameters that can be adapted to observed data; in this way the program can be considered to be "learning" from the data.

Once these models have been fit to previously seen data, they can be used to predict and understand aspects of newly observed data. I'll leave to the reader the more philosophical digression regarding the extent to which this type of mathematical, model-based "learning" is similar to the "learning" exhibited by the human brain.Understanding the problem setting in machine learning is essential to using these tools effectively, and so we will start with some broad categorizations of the types of approaches we'll discuss here.

**Categories Of Machine Leaning :-**

At the most fundamental level, machine learning can be categorized into two main types: supervised learning and unsupervised learning.

Supervised learning involves somehow modeling the relationship between measured features of data and some label associated with the data; once this model is determined, it can be used to apply labels to new, unknown data. This is further subdivided into classification tasks and regression tasks: in classification, the labels are discrete categories, while in regression, the labels are continuous quantities. We will see examples of both types of supervised learning in the following section.

Unsupervised learning involves modeling the features of a dataset without reference to any label, and is often described as "letting the dataset speak for itself." These models include tasks such as clustering and dimensionality reduction.

Clustering algorithms identify distinct groups of data, while dimensionality reduction algorithms search for more succinct representations of the data. We will see examples of both types of unsupervised learning in the following section.

## Need for Machine Learning

Human beings, at this moment, are the most intelligent and advanced species on earth because they can think, evaluate and solve complex problems. On the other side, AI is still in its initial stage and haven’t surpassed human intelligence in many aspects. Then the question is that what is the need to make machine learn? The most suitable reason for doing this is, “to make decisions, based on data, with efficiency and scale”.

Lately, organizations are investing heavily in newer technologies like Artificial Intelligence, Machine Learning and Deep Learning to get the key information from data to perform several real-world tasks and solve problems. We can call it data-driven decisions taken by machines, particularly to automate the process. These data-driven decisions can be used, instead of using programing logic, in the problems that cannot be programmed inherently. The fact is that we can’t do without human intelligence, but other aspect is that we all need to solve real-world problems with efficiency at a huge scale. That is why the need for machine learning arises.

## Challenges in Machines Learning :-

While Machine Learning is rapidly evolving, making significant strides with cybersecurity and autonomous cars, this segment of AI as whole still has a long way to go. The reason behind is that ML has not been able to overcome number of challenges. The challenges that ML is facing currently are −

**Quality of data** − Having good-quality data for ML algorithms is one of the biggest challenges. Use of low-quality data leads to the problems related to data preprocessing and feature extraction.

**Time-Consuming task** − Another challenge faced by ML models is the consumption of time especially for data acquisition, feature extraction and retrieval.

**Lack of specialist persons** − As ML technology is still in its infancy stage, availability of expert resources is a tough job.

**No clear objective for formulating business problems** − Having no clear objective and well-defined goal for business problems is another key challenge for ML because this technology is not that mature yet.

**Issue of overfitting & underfitting** − If the model is overfitting or underfitting, it cannot be represented well for the problem.

**Curse of dimensionality** − Another challenge ML model faces is too many features of data points. This can be a real hindrance.

**Difficulty in deployment** − Complexity of the ML model makes it quite difficult to be deployed in real life.

## Applications of Machines Learning :-

Machine Learning is the most rapidly growing technology and according to researchers we are in the golden year of AI and ML. It is used to solve many real-world complex problems which cannot be solved with traditional approach. Following are some real-world applications of ML −

* Emotion analysis
* Sentiment analysis
* Error detection and prevention
* Weather forecasting and prediction
* Stock market analysis and forecasting
* Speech synthesis
* Speech recognition
* Customer segmentation
* Object recognition
* Fraud detection
* Fraud prevention
* Recommendation of products to customer in online shopping

# How to Start Learning Machine Learning?

Arthur Samuel coined the term **“Machine Learning”** in 1959 and defined it as a **“Field of study that gives computers the capability to learn without being explicitly programmed”.**

And that was the beginning of Machine Learning! In modern times, Machine Learning is one of the most popular (if not the most!) career choices. According to [Indeed](http://blog.indeed.com/2019/03/14/best-jobs-2019/), Machine Learning Engineer Is The Best Job of 2019 with a 344% growth and an average base salary of **$146,085** per year.

But there is still a lot of doubt about what exactly is Machine Learning and how to start learning it? So this article deals with the Basics of Machine Learning and also the path you can follow to eventually become a full-fledged Machine Learning Engineer. Now let’s get started!!!

### **How to start learning ML?**

This is a rough roadmap you can follow on your way to becoming an insanely talented Machine Learning Engineer. Of course, you can always modify the steps according to your needs to reach your desired end-goal!

### Step 1 – Understand the Prerequisites

In case you are a genius, you could start ML directly but normally, there are some prerequisites that you need to know which include Linear Algebra, Multivariate Calculus, Statistics, and Python. And if you don’t know these, never fear! You don’t need a Ph.D. degree in these topics to get started but you do need a basic understanding.

#### (a) Learn Linear Algebra and Multivariate Calculus

Both Linear Algebra and Multivariate Calculus are important in Machine Learning. However, the extent to which you need them depends on your role as a data scientist. If you are more focused on application heavy machine learning, then you will not be that heavily focused on maths as there are many common libraries available. But if you want to focus on R&D in Machine Learning, then mastery of Linear Algebra and Multivariate Calculus is very important as you will have to implement many ML algorithms from scratch.

#### (b) Learn Statistics

Data plays a huge role in Machine Learning. In fact, around 80% of your time as an ML expert will be spent collecting and cleaning data. And statistics is a field that handles the collection, analysis, and presentation of data. So it is no surprise that you need to learn it!!!  
Some of the key concepts in statistics that are important are Statistical Significance, Probability Distributions, Hypothesis Testing, Regression, etc. Also, Bayesian Thinking is also a very important part of ML which deals with various concepts like Conditional Probability, Priors, and Posteriors, Maximum Likelihood, etc.

#### (c) Learn Python

Some people prefer to skip Linear Algebra, Multivariate Calculus and Statistics and learn them as they go along with trial and error. But the one thing that you absolutely cannot skip is [Python](https://www.geeksforgeeks.org/python-programming-language/)! While there are other languages you can use for Machine Learning like R, Scala, etc. Python is currently the most popular language for ML. In fact, there are many Python libraries that are specifically useful for Artificial Intelligence and Machine Learning such as [Keras](https://keras.io/), [TensorFlow](https://www.tensorflow.org/), [Scikit-learn](https://scikit-learn.org/stable/), etc.

So if you want to learn ML, it’s best if you learn Python! You can do that using various online resources and courses such as [**Fork Python**](https://practice.geeksforgeeks.org/courses/fork-python) available Free on GeeksforGeeks.

### **Step 2 – Learn Various ML Concepts**

Now that you are done with the prerequisites, you can move on to actually learning ML (Which is the fun part!!!) It’s best to start with the basics and then move on to the more complicated stuff. Some of the basic concepts in ML are:

#### (a) Terminologies of Machine Learning

* **Model –**A model is a specific representation learned from data by applying some machine learning algorithm. A model is also called a hypothesis.
* **Feature –**A feature is an individual measurable property of the data. A set of numeric features can be conveniently described by a feature vector. Feature vectors are fed as input to the model. For example, in order to predict a fruit, there may be features like color, smell, taste, etc.
* **Target (Label) –**A target variable or label is the value to be predicted by our model. For the fruit example discussed in the feature section, the label with each set of input would be the name of the fruit like apple, orange, banana, etc.
* **Training –**The idea is to give a set of inputs(features) and it’s expected outputs(labels), so after training, we will have a model (hypothesis) that will then map new data to one of the categories trained on.
* **Prediction –**Once our model is ready, it can be fed a set of inputs to which it will provide a predicted output(label).

#### (b) Types of Machine Learning

* **Supervised Learning –**This involves learning from a training dataset with labeled data using classification and regression models. This learning process continues until the required level of performance is achieved.
* **Unsupervised Learning –**This involves using unlabelled data and then finding the underlying structure in the data in order to learn more and more about the data itself using factor and cluster analysis models.
* **Semi-supervised Learning –**This involves using unlabelled data like Unsupervised Learning with a small amount of labeled data. Using labeled data vastly increases the learning accuracy and is also more cost-effective than Supervised Learning.
* **Reinforcement Learning –**This involves learning optimal actions through trial and error. So the next action is decided by learning behaviors that are based on the current state and that will maximize the reward in the future.

### **Advantages of Machine learning :-**

#### 1. Easily identifies trends and patterns -

Machine Learning can review large volumes of data and discover specific trends and patterns that would not be apparent to humans. For instance, for an e-commerce website like Amazon, it serves to understand the browsing behaviors and purchase histories of its users to help cater to the right products, deals, and reminders relevant to them. It uses the results to reveal relevant advertisements to them.

#### 2. No human intervention needed (automation)

With ML, you don’t need to babysit your project every step of the way. Since it means giving machines the ability to learn, it lets them make predictions and also improve the algorithms on their own. A common example of this is anti-virus softwares; they learn to filter new threats as they are recognized. ML is also good at recognizing spam.

#### 3. Continuous Improvement

As [**ML algorithms**](https://data-flair.training/blogs/machine-learning-algorithms/) gain experience, they keep improving in accuracy and efficiency. This lets them make better decisions. Say you need to make a weather forecast model. As the amount of data you have keeps growing, your algorithms learn to make more accurate predictions faster.

#### 4. Handling multi-dimensional and multi-variety data

Machine Learning algorithms are good at handling data that are multi-dimensional and multi-variety, and they can do this in dynamic or uncertain environments.

#### 5. Wide Applications

You could be an e-tailer or a healthcare provider and make ML work for you. Where it does apply, it holds the capability to help deliver a much more personal experience to customers while also targeting the right customers.

### **Disadvantages of Machine Learning :-**

#### 1. Data Acquisition

Machine Learning requires massive data sets to train on, and these should be inclusive/unbiased, and of good quality. There can also be times where they must wait for new data to be generated.

#### 2. Time and Resources

ML needs enough time to let the algorithms learn and develop enough to fulfill their purpose with a considerable amount of accuracy and relevancy. It also needs massive resources to function. This can mean additional requirements of computer power for you.

#### 3. Interpretation of Results

Another major challenge is the ability to accurately interpret results generated by the algorithms. You must also carefully choose the algorithms for your purpose.

#### 4. High error-susceptibility

[Machine Learning](https://en.wikipedia.org/wiki/Machine_learning) is autonomous but highly susceptible to errors. Suppose you train an algorithm with data sets small enough to not be inclusive. You end up with biased predictions coming from a biased training set. This leads to irrelevant advertisements being displayed to customers. In the case of ML, such blunders can set off a chain of errors that can go undetected for long periods of time. And when they do get noticed, it takes quite some time to recognize the source of the issue, and even longer to correct it.

**Python Development Steps : -**

Guido Van Rossum published the first version of Python code (version 0.9.0) at alt.sources in February 1991. This release included already exception handling, functions, and the core data types of list, dict, str and others. It was also object oriented and had a module system.  
Python version 1.0 was released in January 1994. The major new features included in this release were the functional programming tools lambda, map, filter and reduce, which Guido Van Rossum never liked.Six and a half years later in October 2000, Python 2.0 was introduced. This release included list comprehensions, a full garbage collector and it was supporting unicode.Python flourished for another 8 years in the versions 2.x before the next major release as Python 3.0 (also known as "Python 3000" and "Py3K") was released. Python 3 is not backwards compatible with Python 2.x.

The emphasis in Python 3 had been on the removal of duplicate programming constructs and modules, thus fulfilling or coming close to fulfilling the 13th law of the Zen of Python: "There should be one -- and preferably only one -- obvious way to do it."Some changes in Python 7.3:

* Print is now a function
* Views and iterators instead of lists
* The rules for ordering comparisons have been simplified. E.g. a heterogeneous list cannot be sorted, because all the elements of a list must be comparable to each other.
* There is only one integer type left, i.e. int. long is int as well.
* The division of two integers returns a float instead of an integer. "//" can be used to have the "old" behaviour.
* Text Vs. Data Instead Of Unicode Vs. 8-bit

**Purpose :-**

We demonstrated that our approach enables successful segmentation of intra-retinal layers—even with low-quality images containing speckle noise, low contrast, and different intensity ranges throughout—with the assistance of the ANIS feature.

**Python**

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant whitespace.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

* Python is Interpreted − Python is processed at runtime by the interpreter. You do not need to compile your program before executing it. This is similar to PERL and PHP.
* Python is Interactive − you can actually sit at a Python prompt and interact with the interpreter directly to write your programs.

Python also acknowledges that speed of development is important. Readable and terse code is part of this, and so is access to powerful constructs that avoid tedious repetition of code. Maintainability also ties into this may be an all but useless metric, but it does say something about how much code you have to scan, read and/or understand to troubleshoot problems or tweak behaviors. This speed of development, the ease with which a programmer of other languages can pick up basic Python skills and the huge standard library is key to another area where Python excels. All its tools have been quick to implement, saved a lot of time, and several of them have later been patched and updated by people with no Python background - without breaking.

**Modules Used in Project :-**

**Tensorflow**

TensorFlow is a [free](https://en.wikipedia.org/wiki/Free_software) and [open-source](https://en.wikipedia.org/wiki/Open-source_software) [software library for dataflow and differentiable programming](https://en.wikipedia.org/wiki/Library_(computing)) across a range of tasks. It is a symbolic math library, and is also used for [machine learning](https://en.wikipedia.org/wiki/Machine_learning) applications such as [neural networks](https://en.wikipedia.org/wiki/Neural_networks). It is used for both research and production at [Google](https://en.wikipedia.org/wiki/Google).‍

TensorFlow was developed by the [Google Brain](https://en.wikipedia.org/wiki/Google_Brain) team for internal Google use. It was released under the [Apache 2.0](https://en.wikipedia.org/wiki/Apache_License) [open-source license](https://en.wikipedia.org/wiki/Open-source_license) on November 9, 2015.

**Numpy**

Numpy is a general-purpose array-processing package. It provides a high-performance multidimensional array object, and tools for working with these arrays.

It is the fundamental package for scientific computing with Python. It contains various features including these important ones:

* A powerful N-dimensional array object
* Sophisticated (broadcasting) functions
* Tools for integrating C/C++ and Fortran code
* Useful linear algebra, Fourier transform, and random number capabilities

Besides its obvious scientific uses, Numpy can also be used as an efficient multi-dimensional container of generic data. Arbitrary data-types can be defined using Numpy which allows Numpy to seamlessly and speedily integrate with a wide variety of databases.

**Pandas**

Pandas is an open-source Python Library providing high-performance data manipulation and analysis tool using its powerful data structures. Python was majorly used for data munging and preparation. It had very little contribution towards data analysis. Pandas solved this problem. Using Pandas, we can accomplish five typical steps in the processing and analysis of data, regardless of the origin of data load, prepare, manipulate, model, and analyze. Python with Pandas is used in a wide range of fields including academic and commercial domains including finance, economics, Statistics, analytics, etc.

**Matplotlib**

Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in Python scripts, the Python and [IPython](http://ipython.org/) shells, the [Jupyter](http://jupyter.org/) Notebook, web application servers, and four graphical user interface toolkits. Matplotlib tries to make easy things easy and hard things possible. You can generate plots, histograms, power spectra, bar charts, error charts, scatter plots, etc., with just a few lines of code. For examples, see the [sample plots](https://matplotlib.org/tutorials/introductory/sample_plots.html) and [thumbnail gallery](https://matplotlib.org/gallery/index.html).

For simple plotting the pyplot module provides a MATLAB-like interface, particularly when combined with IPython. For the power user, you have full control of line styles, font properties, axes properties, etc, via an object oriented interface or via a set of functions familiar to MATLAB users.

**Scikit – learn**

Scikit-learn provides a range of supervised and unsupervised learning algorithms via a consistent interface in Python. It is licensed under a permissive simplified BSD license and is distributed under many Linux distributions, encouraging academic and commercial use. **Python**

Python is an interpreted high-level programming language for general-purpose programming. Created by Guido van Rossum and first released in 1991, Python has a design philosophy that emphasizes code readability, notably using significant whitespace.

Python features a dynamic type system and automatic memory management. It supports multiple programming paradigms, including object-oriented, imperative, functional and procedural, and has a large and comprehensive standard library.

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All its tools have been quick to implement, saved a lot of time, and several of them have later been patched and updated by people with no Python background - without breaking.

**Install Python Step-by-Step in Windows and Mac :**

Python a versatile programming language doesn’t come pre-installed on your computer devices. Python was first released in the year 1991 and until today it is a very popular high-level programming language. Its style philosophy emphasizes code readability with its notable use of great whitespace.

The object-oriented approach and language construct provided by Python enables programmers to write both clear and logical code for projects. This software does not come pre-packaged with Windows.

## How to Install Python on Windows and Mac :

There have been several updates in the Python version over the years. The question is how to install Python? It might be confusing for the beginner who is willing to start learning Python but this tutorial will solve your query. The latest or the newest version of Python is version 3.7.4 or in other words, it is Python 3.

**Note:** The python version 3.7.4 cannot be used on Windows XP or earlier devices.

Before you start with the installation process of Python. First, you need to know about your **System Requirements**. Based on your system type i.e. operating system and based processor, you must download the python version. My system type is a **Windows 64-bit operating system**. So the steps below are to install python version 3.7.4 on Windows 7 device or to install Python 3. [Download the Python Cheatsheet here.](https://myelearninghub.com/python-cheat-sheet/)The steps on how to install Python on Windows 10, 8 and 7 are **divided into 4 parts** to help understand better.

### Download the Correct version into the system

**Step 1:** Go to the official site to download and install python using Google Chrome or any other web browser. OR Click on the following link: [https://www.python.org](https://www.python.org/)



Now, check for the latest and the correct version for your operating system.

**Step 2:** Click on the Download Tab.

****

**Step 3:** You can either select the Download Python for windows 3.7.4 button in Yellow Color or you can scroll further down and click on download with respective to their version. Here, we are downloading the most recent python version for windows 3.7.4

****

**Step 4:** Scroll down the page until you find the Files option.

**Step 5:** Here you see a different version of python along with the operating system.



• To download Windows 32-bit python, you can select any one from the three options: Windows x86 embeddable zip file, Windows x86 executable installer or Windows x86 web-based installer.

•To download Windows 64-bit python, you can select any one from the three options: Windows x86-64 embeddable zip file, Windows x86-64 executable installer or Windows x86-64 web-based installer.

Here we will install Windows x86-64 web-based installer. Here your first part regarding which version of python is to be downloaded is completed. Now we move ahead with the second part in installing python i.e. Installation

**Note:** To know the changes or updates that are made in the version you can click on the Release Note Option.

### Installation of Python

**Step 1:** Go to Download and Open the downloaded python version to carry out the installation process.



**Step 2:** Before you click on Install Now, Make sure to put a tick on Add Python 3.7 to PATH.



**Step 3:** Click on Install NOW After the installation is successful. Click on Close.



With these above three steps on python installation, you have successfully and correctly installed Python. Now is the time to verify the installation.

**Note:** The installation process might take a couple of minutes.

### Verify the Python Installation

**Step 1:** Click on Start

**Step 2:** In the Windows Run Command, type “cmd”.



**Step 3:** Open the Command prompt option.

**Step 4:** Let us test whether the python is correctly installed. Type **python –V** and press Enter.



**Step 5:** You will get the answer as 3.7.4

**Note:** If you have any of the earlier versions of Python already installed. You must first uninstall the earlier version and then install the new one.

### Check how the Python IDLE works

**Step 1:** Click on Start

**Step 2:** In the Windows Run command, type “python idle”.



**Step 3:** Click on IDLE (Python 3.7 64-bit) and launch the program

**Step 4:** To go ahead with working in IDLE you must first save the file. **Click on File > Click on Save**



**Step 5:** Name the file and save as type should be Python files. Click on SAVE. Here I have named the files as Hey World.

**Step 6:** Now for e.g. **enter print**

**6.SYSTEM TEST**

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

### **TYPES OF TESTS**

**Unit testing**

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .it is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

**Integration testing**

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

**Functional test**

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input must be rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputs must be exercised.

Systems/Procedures : interfacing systems or procedures must be invoked.

Organization and preparation of functional tests is focused on requirements, key functions, or special test cases. In addition, systematic coverage pertaining to identify Business process flows; data fields, predefined processes, and successive processes must be considered for testing. Before functional testing is complete, additional tests are identified and the effective value of current tests is determined.

**System Test**

System testing ensures that the entire integrated software system meets requirements. It tests a configuration to ensure known and predictable results. An example of system testing is the configuration oriented system integration test. System testing is based on process descriptions and flows, emphasizing pre-driven process links and integration points.

**White Box Testing**

White Box Testing is a testing in which in which the software tester has knowledge of the inner workings, structure and language of the software, or at least its purpose. It is purpose. It is used to test areas that cannot be reached from a black box level.

**Black Box Testing**

Black Box Testing is testing the software without any knowledge of the inner workings, structure or language of the module being tested. Black box tests, as most other kinds of tests, must be written from a definitive source document, such as specification or requirements document, such as specification or requirements document. It is a testing in which the software under test is treated, as a black box .you cannot “see” into it. The test provides inputs and responds to outputs without considering how the software works.

**Unit Testing**

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

**Test strategy and approach**

Field testing will be performed manually and functional tests will be written in detail.

**Test objectives**

* All field entries must work properly.
* Pages must be activated from the identified link.
* The entry screen, messages and responses must not be delayed.

**Features to be tested**

* Verify that the entries are of the correct format
* No duplicate entries should be allowed
* All links should take the user to the correct page.

# Integration Testing

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

**Test Results:** All the test cases mentioned above passed successfully. No defects encountered.

**Acceptance Testing**

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

**Test Results:** All the test cases mentioned above passed successfully. No defects encountered.

**Test cases1:**

**Test case for Login form:**

|  |  |
| --- | --- |
| **FUNCTION:** | **LOGIN** |
| **EXPECTED RESULTS:** | Should Validate the user and check his existence in database |
| **ACTUAL RESULTS:** | Validate the user and checking the user against the database |
| **LOW PRIORITY** | **No** |
| **HIGH PRIORITY** | **Yes** |

**Test case2:**

**Test case for User Registration form:**

|  |  |
| --- | --- |
| **FUNCTION:** | **USER REGISTRATION** |
| **EXPECTED RESULTS:** | Should check if all the fields are filled by the user and saving the user to database. |
| **ACTUAL RESULTS:** | Checking whether all the fields are field by user or not through validations and saving user. |
| **LOW PRIORITY** | **No** |
| **HIGH PRIORITY** | **Yes** |

**Test case3:**

**Test case for Change Password:**

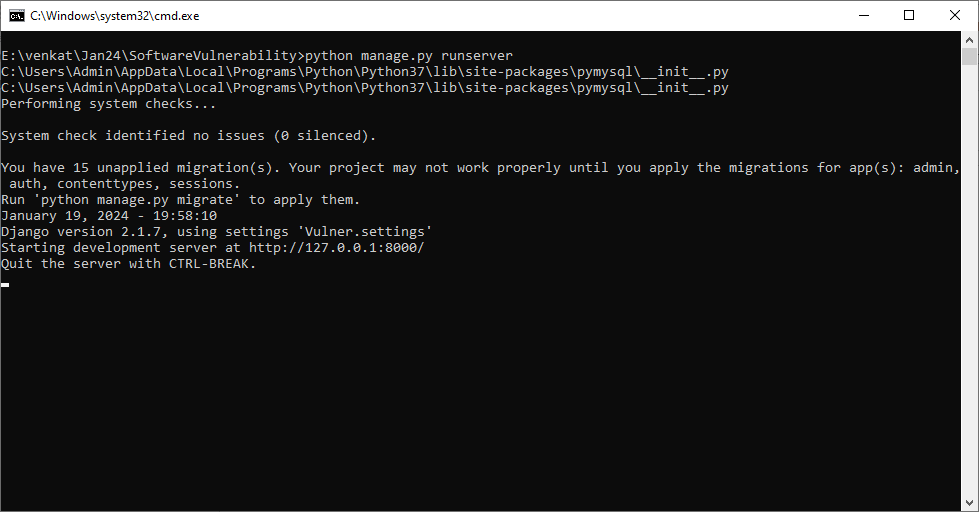
When the old password does not match with the new password ,then this results in displaying an error message as “ OLD PASSWORD DOES NOT MATCH WITH THE NEW PASSWORD”.

|  |  |
| --- | --- |
| **FUNCTION:** | **Change Password** |
| **EXPECTED RESULTS:** | Should check if old password and new password fields are filled by the user and saving the user to database. |
| **ACTUAL RESULTS:** | Checking whether all the fields are field by user or not through validations and saving user. |
| **LOW PRIORITY** | **No** |
| **HIGH PRIORITY** | **Yes** |

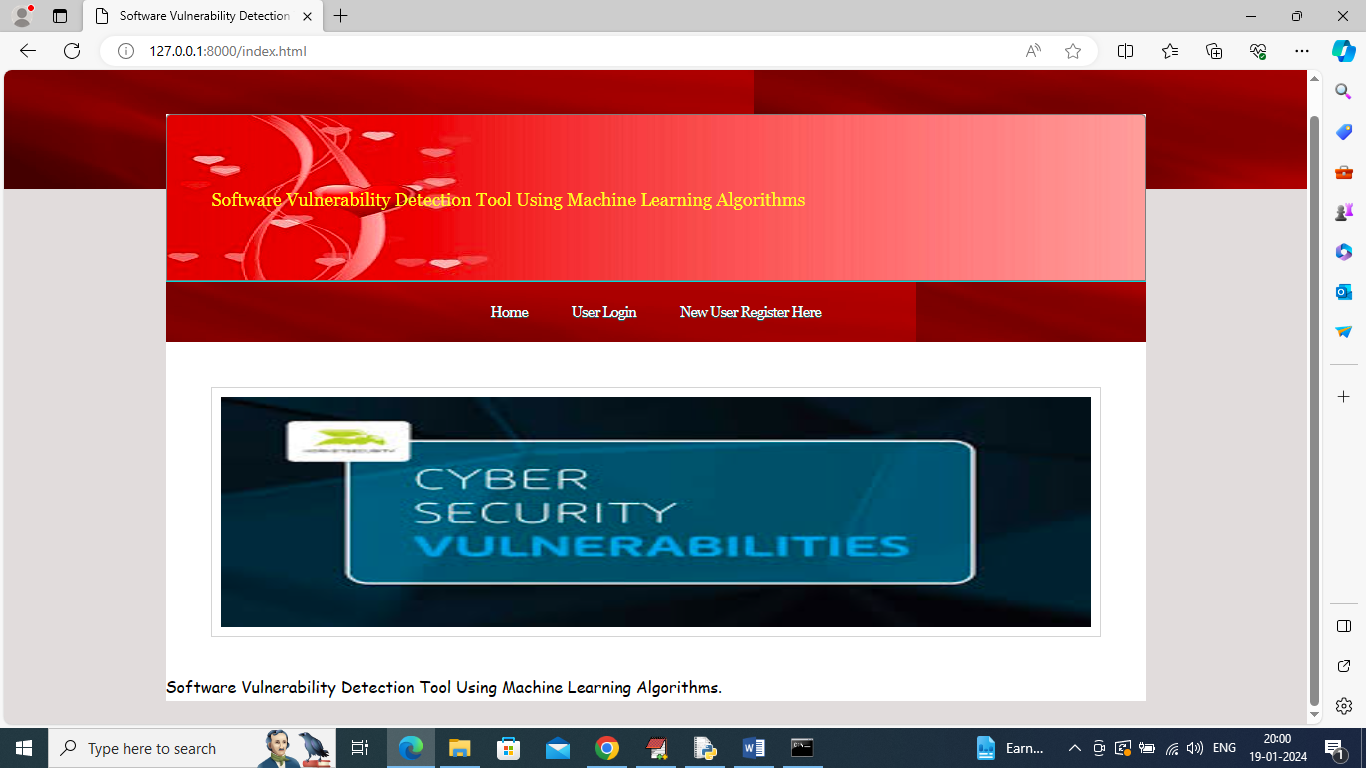
**SCREEN SHOTS:**

To run project install python 3.7 and then install MYSQL database and then copy content from DB.txt file and paste in MYSQL to create database. Now double click on ‘installNLTK.bat’ file to download NLTK and once click then window will appear in that window click on “Download’ button to download all packages and once downloaded then window will turn to green colour and then close the window

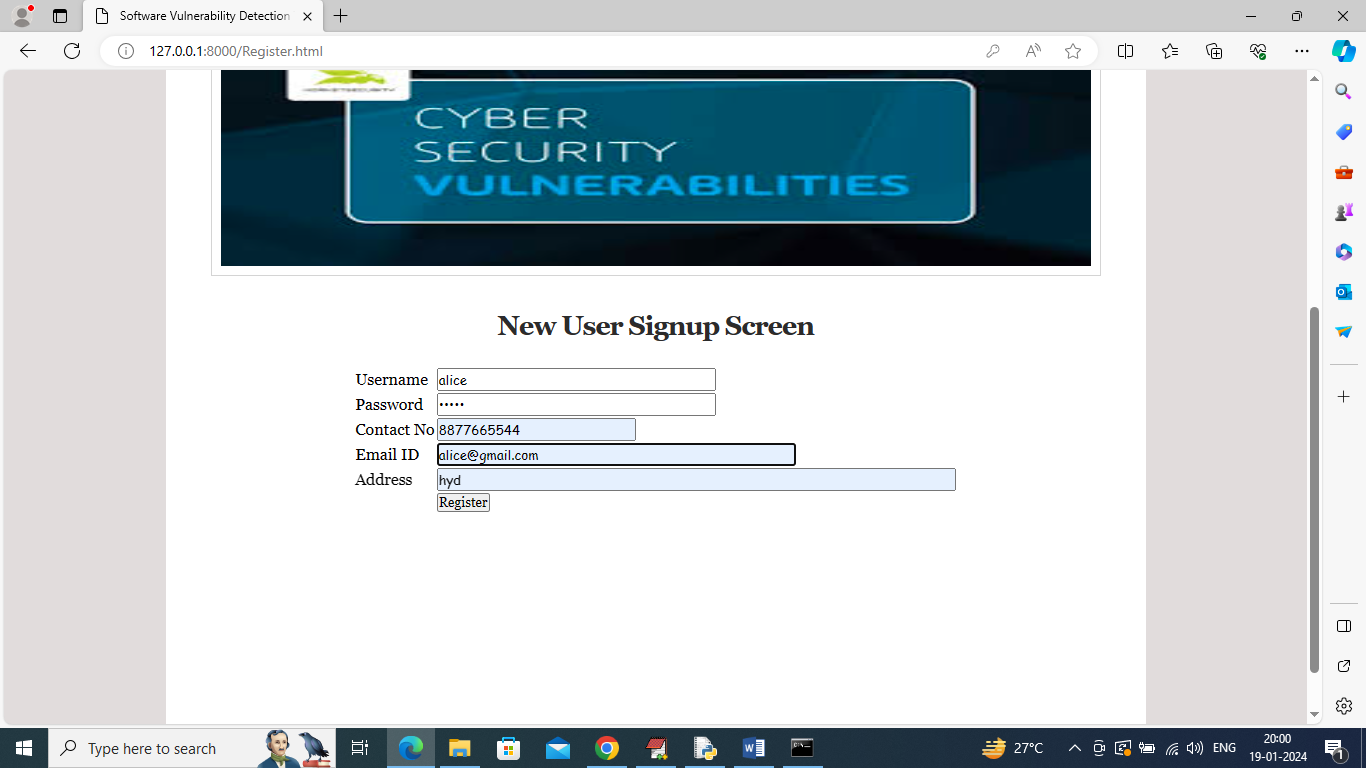
Now double click on ‘run.bat’ file to start python DJANGO web server and get below screen



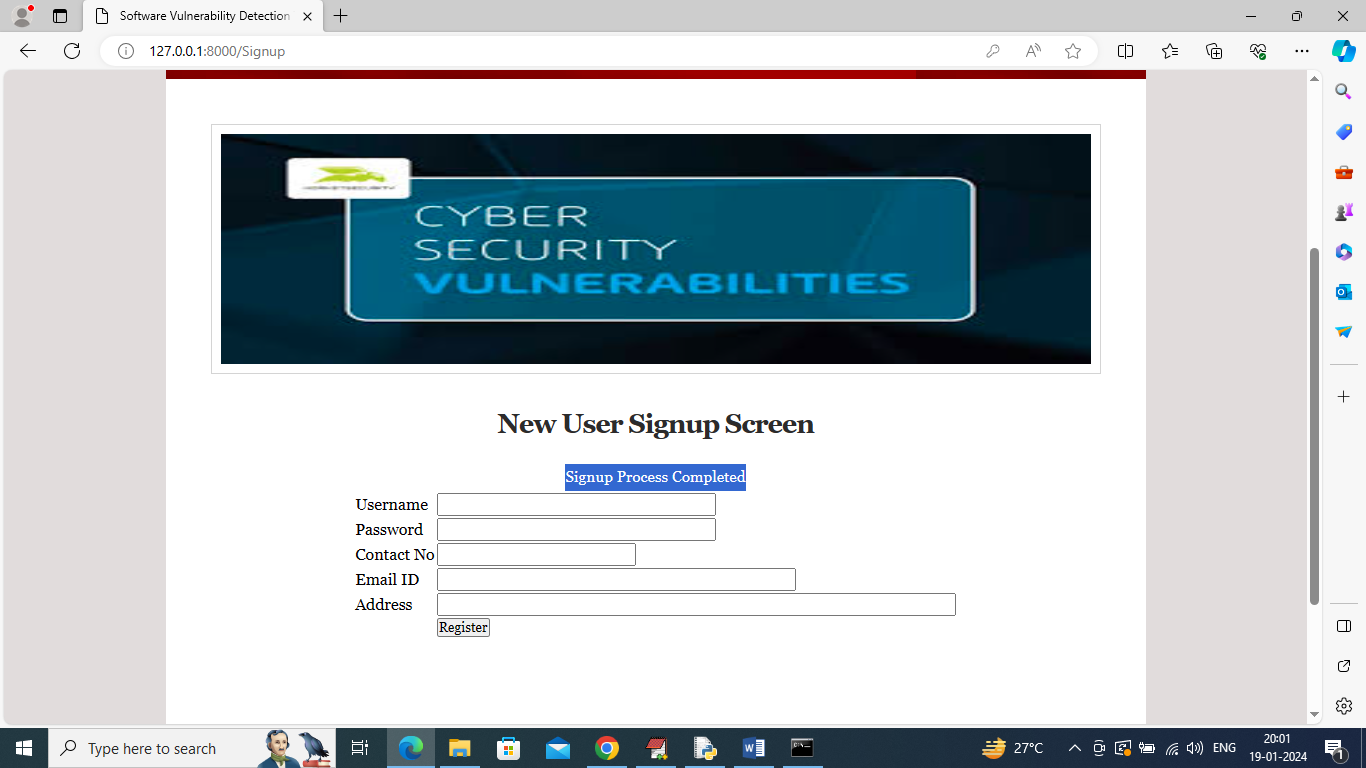
In above screen python web server started and now open browser and enter URL as <http://127.0.0.1:8000/index.html> and then press enter key to get below page



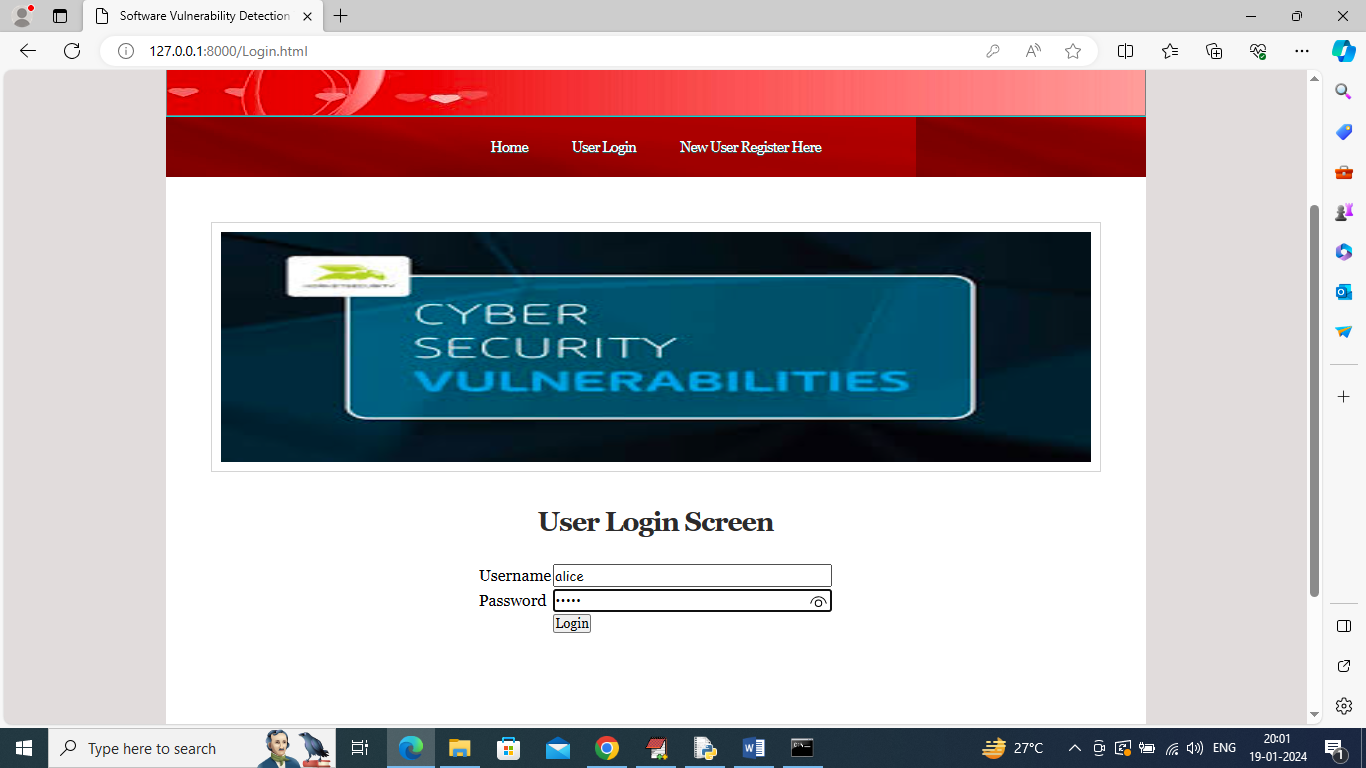
In above screen click on ‘New User Register Here’ link to get below sign up page



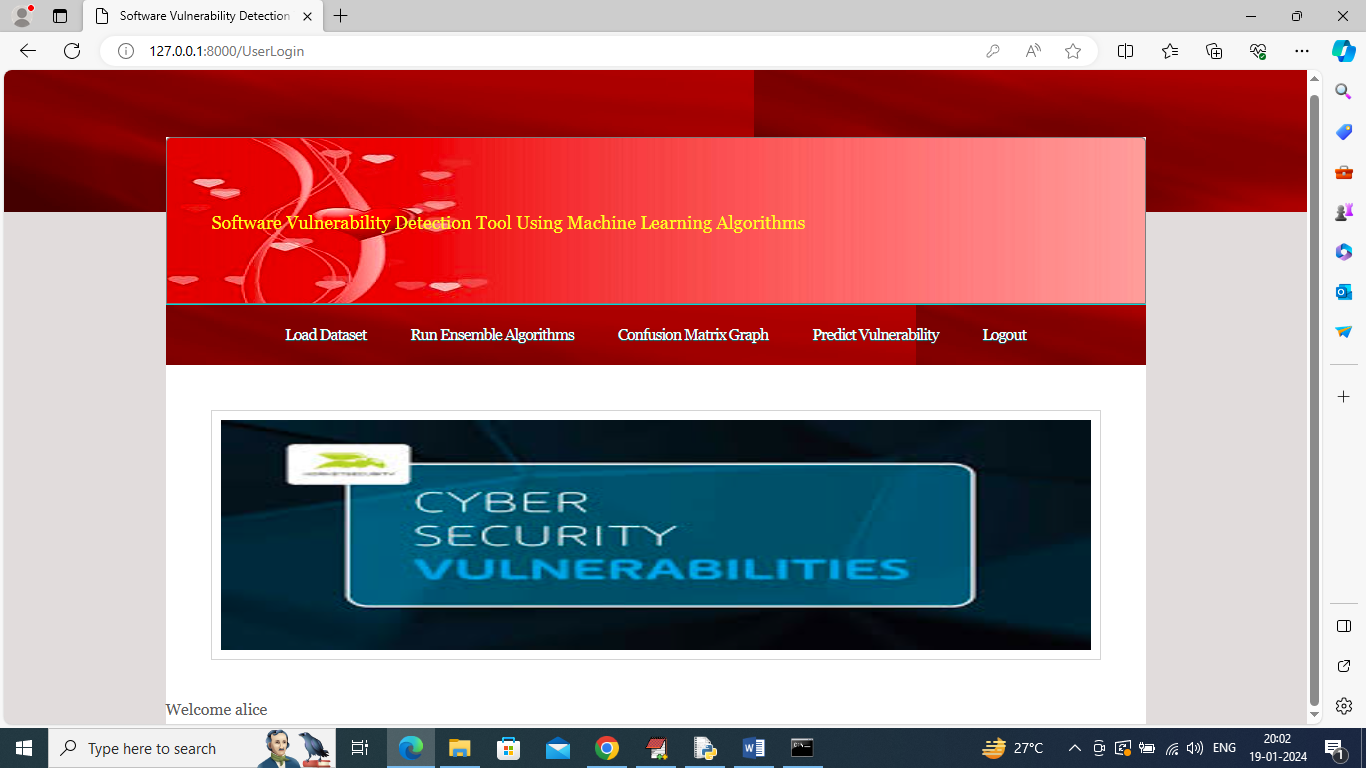
In above screen user is entering sign up details and then press button to get below page



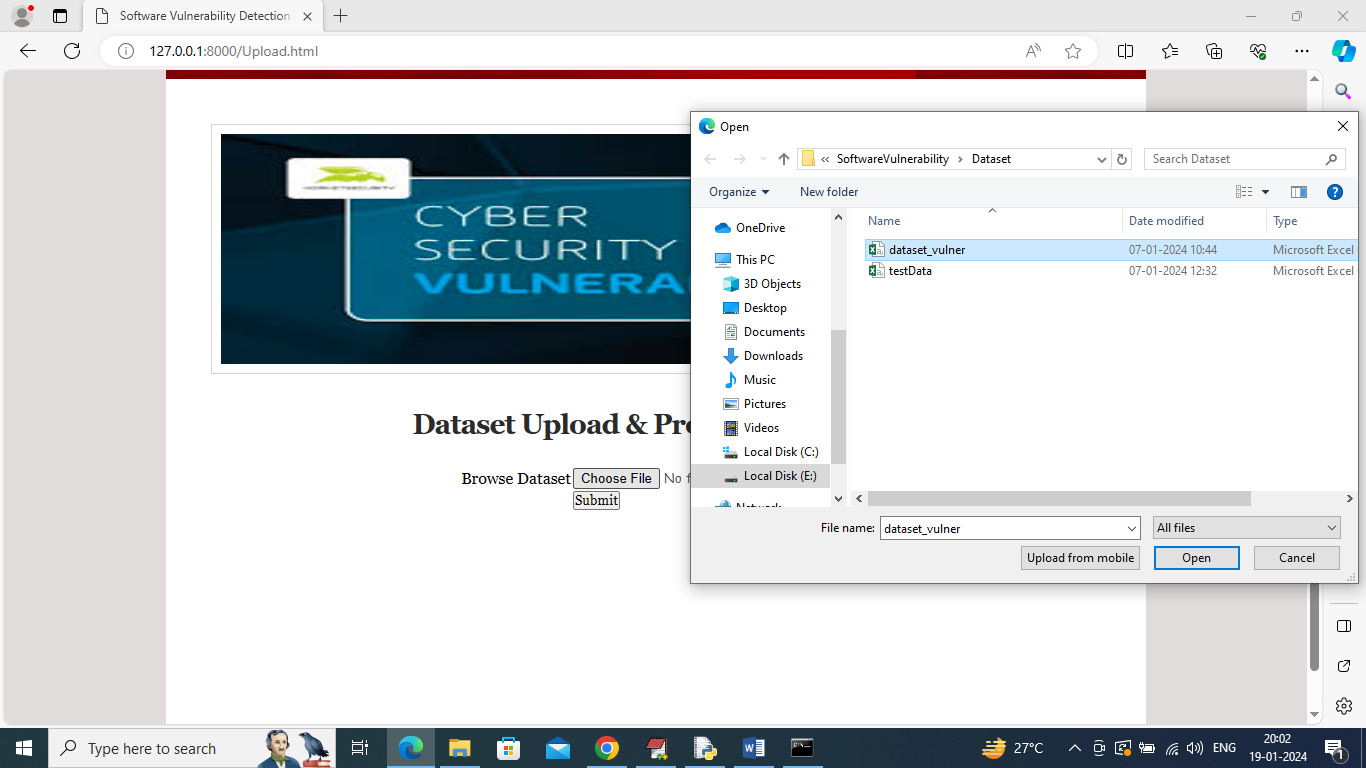
In above screen user sign up completed and now click on ‘User Login’ link to get below page



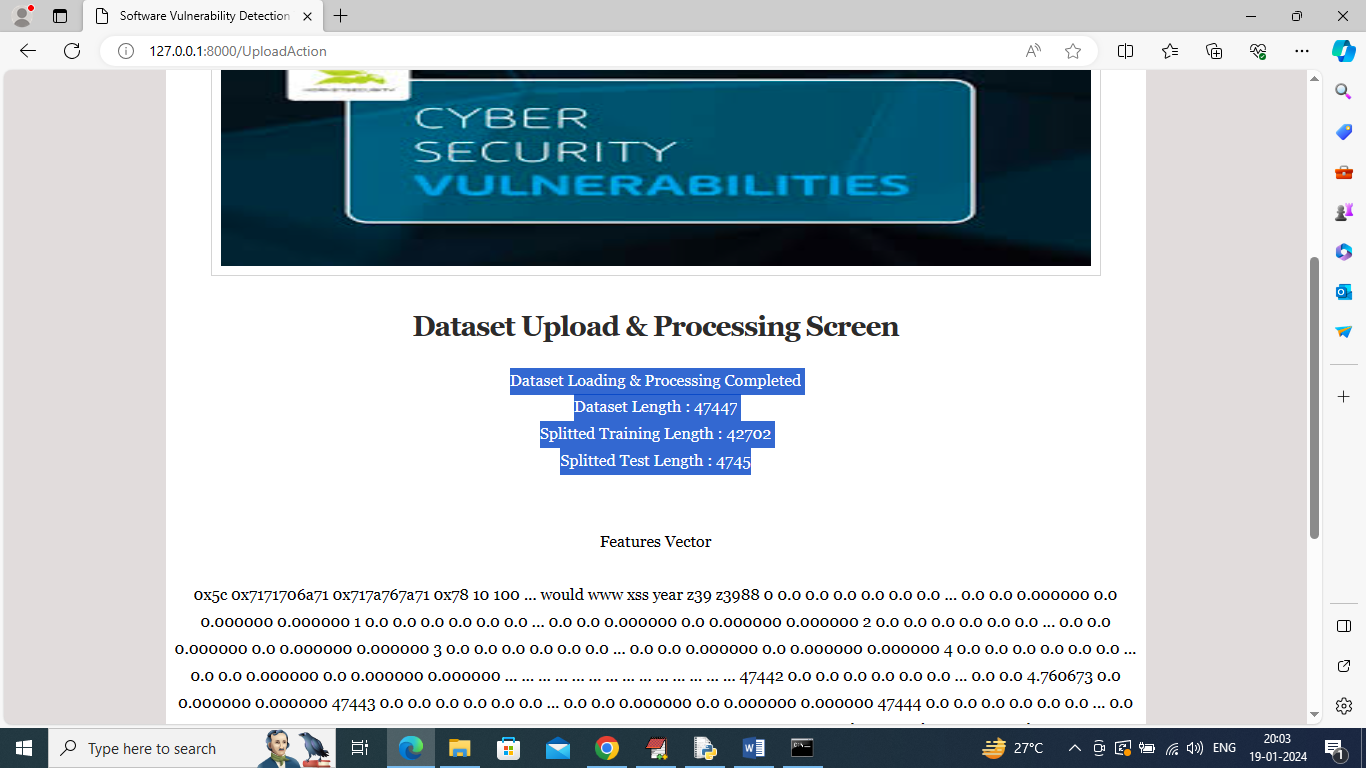
In above screen user is login and after login will get below page



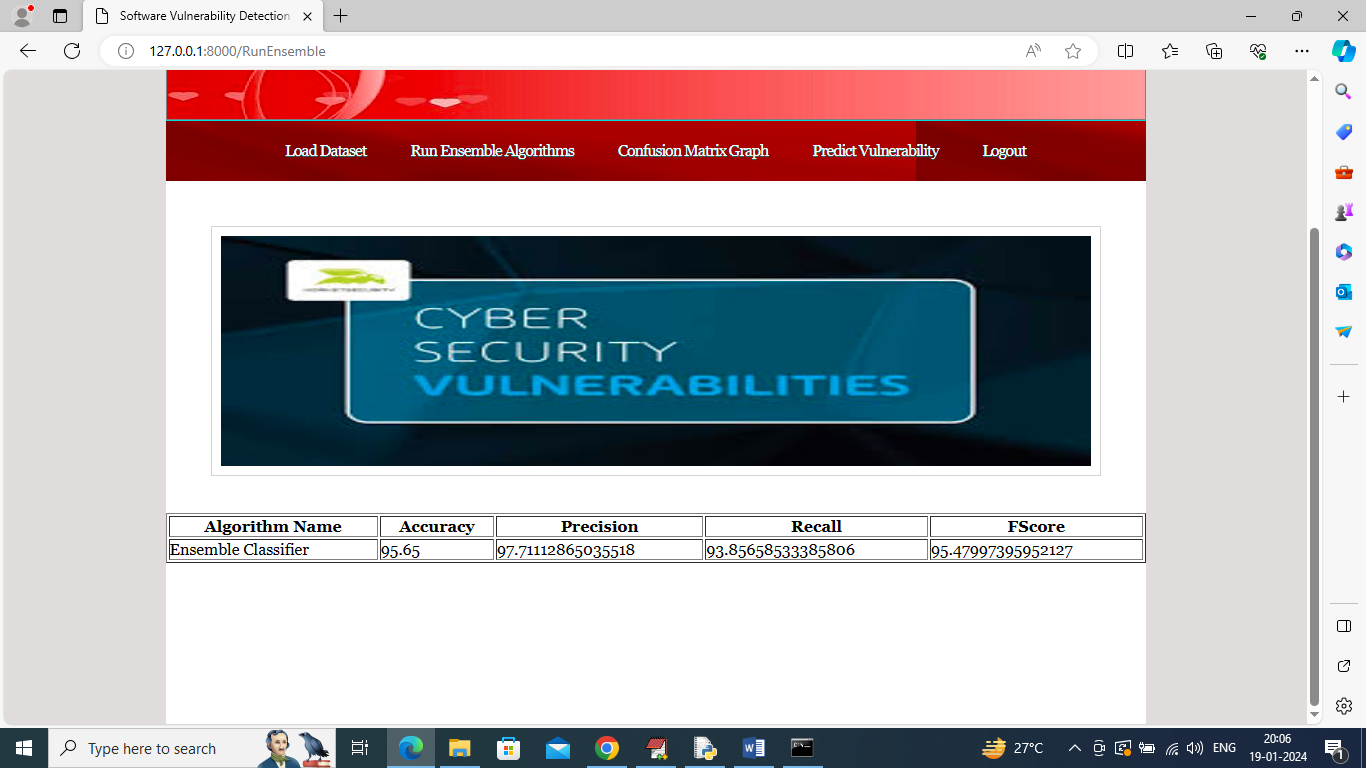
In above screen click on ‘Load Dataset’ link to get below page



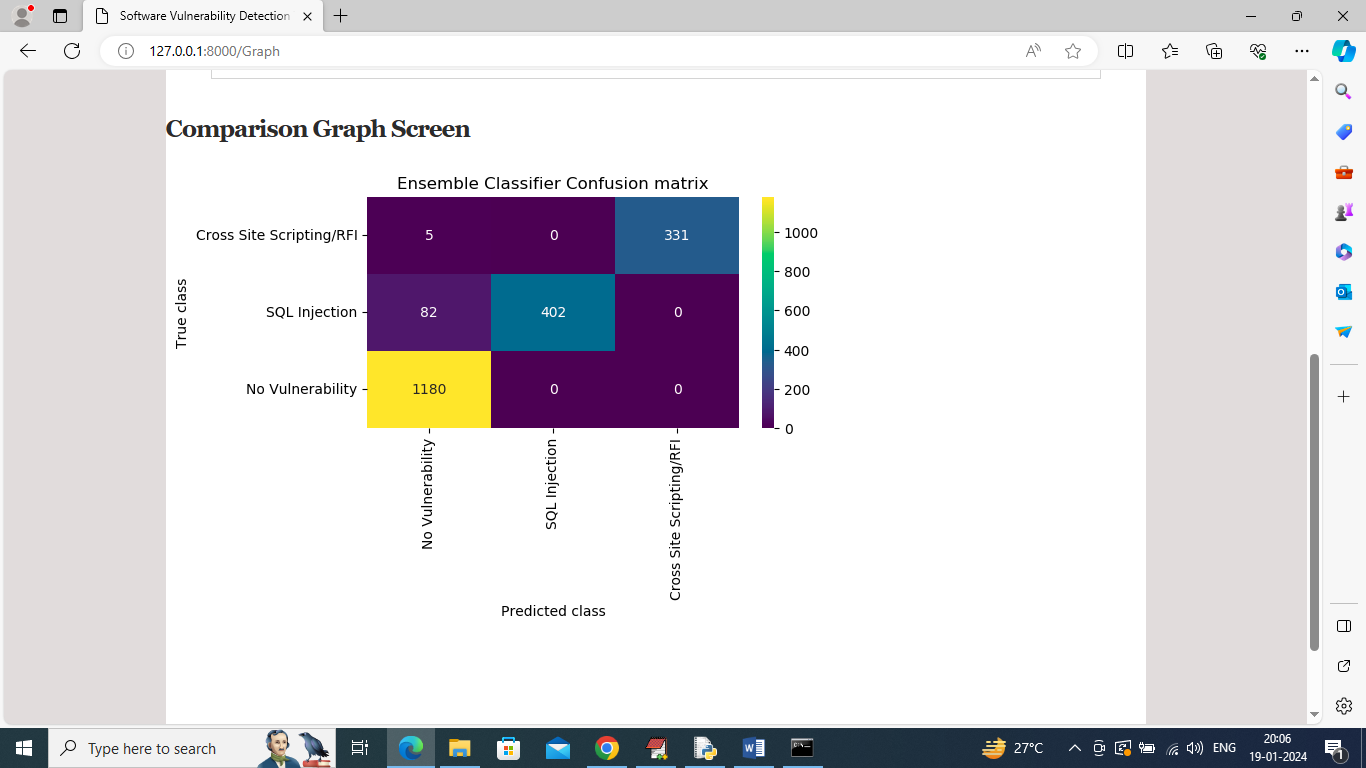
In above screen select and upload ‘dataset\_vulner.csv’ file and then click on ‘Open’ and ‘Submit’ button to load dataset and then will get below output



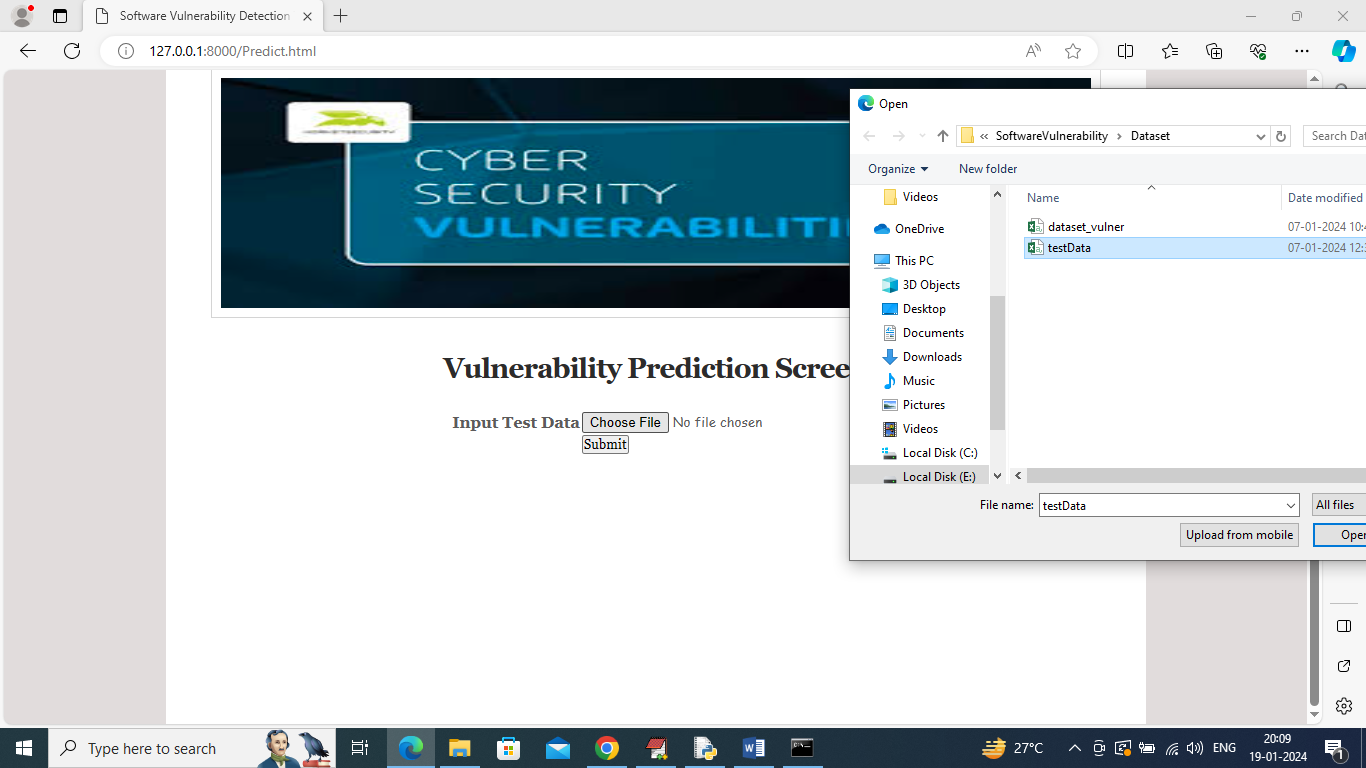
In above screen can see dataset loaded and can see total number of records available in dataset and then can see training number of records on which Machine Learning algorithm get trained and then can see number of test records on which ML will perform prediction to calculate its prediction accuracy %. Now click on ‘Run Ensemble Algorithms’ link to train ensemble algorithm and then will get below output



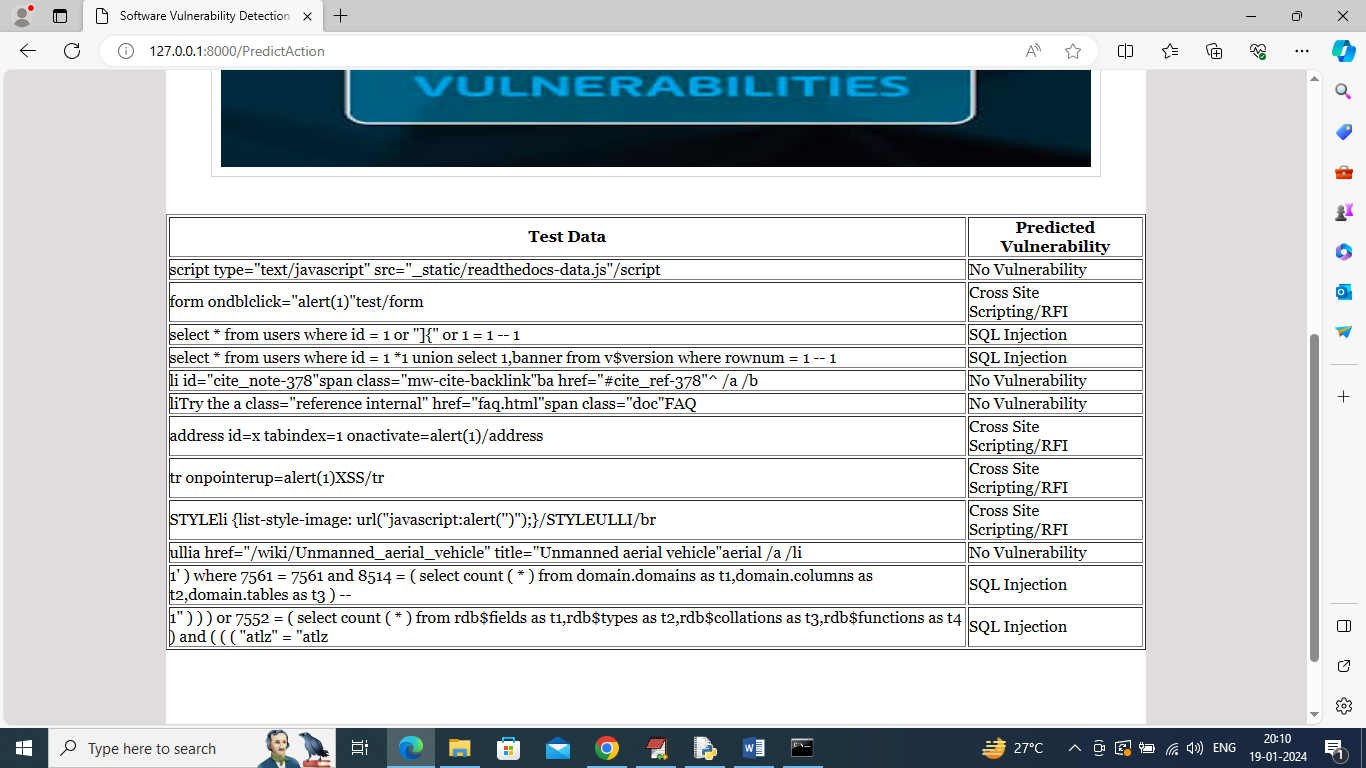
In above screen Ensemble Machine Learning algorithm training completed and can see its prediction accuracy as 95% and can see other metrics like precision, recall and FCSORE.Now click on ‘Confusion Matrix Graph’ link to view visually how many records ensemble predicted correctly and incorrectly



In above graph x-axis represents Predicted Labels and y-axis represents True Labels and then all different colour boxes in diagnol represents correct prediction count and remaining all blue boxes represents incorrect prediction count which are very few. Now click on ‘Predict Vulnerability’ link to upload test data and predict Vulnerability



In above screen selecting and uploading ‘testData.csv’ file which contains SQL, XSS and RFI coding commands and then click on ‘Submit’ button to get below output



In above table in first column can see SQL queries, XSS and RFI coding commands and in second column can see predicted vulnerability.

So by using above tool you can easily detect all vulnerability and you can add NEW test command in ‘testData.csv’ file which is available inside ‘Dataset’ folder

**Conclusion:**

In conclusion, the development of a software vulnerability detection tool utilizing machine learning algorithms represents a significant advancement in the field of cybersecurity. Through this project, we have explored various techniques, methodologies, and considerations essential for building an effective and reliable tool for identifying security vulnerabilities in software applications.

Machine learning algorithms offer immense potential for enhancing the accuracy, efficiency, and scalability of vulnerability detection processes. By leveraging advanced data analysis techniques and predictive modeling, these algorithms can uncover subtle patterns and anomalies indicative of security weaknesses, enabling developers to identify and remediate vulnerabilities before they can be exploited by malicious actors.

Throughout the development process, we have conducted extensive research, analysis, and experimentation to identify the most suitable data sources, preprocessing techniques, and machine learning algorithms for the task at hand. We have explored different approaches to user interface design, performance evaluation, scalability testing, and deployment considerations to ensure that the tool meets the needs and preferences of developers while delivering robust and reliable vulnerability detection capabilities.

Moving forward, there are several avenues for further research and development. We must continue to explore new machine learning techniques, algorithms, and methodologies to improve the accuracy and efficiency of vulnerability detection processes further. Additionally, ongoing collaboration with industry partners and security experts will be crucial for staying abreast of emerging threats and evolving best practices in software security.

In conclusion, the development of a software vulnerability detection tool using machine learning algorithms represents a significant step forward in enhancing the security of software applications. By leveraging the power of machine learning, we can empower developers to build more secure and resilient software systems, thereby mitigating the risk of cyber attacks and safeguarding sensitive data and critical infrastructure in an increasingly interconnected and digital world.

**Future Work:**

In envisioning the future development of a software vulnerability detection tool leveraging machine learning algorithms, several avenues for further exploration and enhancement emerge, offering potential to refine and expand the capabilities of the tool.

One promising direction for future work involves the integration of more advanced machine learning techniques, such as deep learning and reinforcement learning. Deep learning models, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), have shown promise in various domains for their ability to learn complex patterns from large datasets. By incorporating deep learning architectures into the vulnerability detection tool, we can potentially improve the accuracy and granularity of vulnerability identification, especially in scenarios where vulnerabilities exhibit intricate patterns or dependencies within code.

Additionally, future work could focus on enhancing the tool's ability to handle diverse programming languages and software architectures. While existing tools often focus on specific languages or platforms, there is a growing need for cross-language and cross-platform vulnerability detection capabilities. By developing techniques for language-agnostic vulnerability detection and adapting machine learning models to different programming paradigms, the tool can provide broader coverage and utility across a wide range of software development environments.

Moreover, there is an opportunity to explore the integration of contextual information and domain-specific knowledge into the vulnerability detection process. By incorporating insights from software engineering principles, security guidelines, and threat intelligence feeds, the tool can better contextualize detected vulnerabilities and prioritize them based on their potential impact and likelihood of exploitation. Additionally, techniques such as natural language processing (NLP) can be employed to analyze documentation, commit messages, and code comments for valuable contextual information that may inform vulnerability detection decisions.

Furthermore, future work could focus on addressing the challenges of adversarial attacks and evasion techniques aimed at undermining the effectiveness of machine learning-based vulnerability detection systems. Research into adversarial robustness, including techniques for adversarial training, model verification, and anomaly detection, can help fortify the tool against malicious manipulation and ensure its reliability in adversarial environments.

Finally, ongoing efforts in usability testing, user feedback collection, and iterative design refinement are essential to ensure that the tool remains accessible, intuitive, and effective for developers in real-world software development workflows. By engaging with end-users and stakeholders throughout the development lifecycle, we can identify areas for improvement, prioritize feature enhancements, and continuously enhance the tool's usability and utility.

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