**PREDICTION OF NETWORK TRAFFIC IN WIRELESS MESH NETWORKS USING HYBRID DEEP LEARNING MODEL**

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**CHAPTER 1**

**Abstract of the project:**

Wireless mesh networks are getting adopted in the domain of network communication. Their main benefits include adaptability, configuration, and flexibility, with added efficiency in cost and transmission time. Traffic prediction refers to forecasting the traffic volumes in a network. The traffic volume includes incoming requests and outgoing data transmitted by the network nodes. The previous logs of traffic in the network are used for extracting patterns that help for accurate predictions. In this paper, an analysis of various existing traffic prediction methods is done. Specifically, the analysis of a case study where the performance of the High-Speed Diesel (HSD) pump is predicted by observing its output. A network of sensors form a less mesh network; sensors act as nodes while reading the parameters, namely, three-phase Current, Voltage, Temperature, and Vibration. In this case study, a High-Speed Diesel pumps’ performance is predicted by predicting the vibration parameter as the output parameter. Other parameters affecting the performance of the High-Speed Diesel pump which are causing the change in vibration value are identified. Various algorithms, including Statistical Auto-Regressive Integration and Moving Average Poisson’s regression, and a few Machine Learning and Deep Learning algorithms like Decision Tree Regressor, Multi-Layer Perceptron, Linear Regression, and Long Short-Term Memory

Along with the comparison, a novel architecture using Convolution Neural Network and Long Short-Term Memory is described in this paper. The result and comparison between these give the clear understanding that the suggested novel Convo-LSTM model gives better performance and helps to predict the performance of the High-Speed Diesel pump. The proposed system makes a strong case for the network traffic prediction, where the use of historical data is collected over the wireless mesh network. A similar analogy can be used where this model could be implemented further for network monitoring tasks. are implemented and evaluated for this purpose.

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**INTRODUCTION**

Networks are playing an important role during this age of digital expansion. For a given network, the most critical issues are its security, load balancing ability, maintainability, and speed. Various network topologies have existed, including bus, ring, star, mesh, hybrid, etc. Out of this, mesh networks have been one of the most popular choices owing to their stronger connection ability, lesser disadvantages in terms of lag and rigidity Amount of application service that is streamed to their users has increased explosively. This type of service requires minimal installations and computing power on the user terminal because the applications are operating at the service carrier’s cloud servers instead of the local terminal; all the inputs and outputs are streamed to the users via the internet. Seeing the obvious advantage of providing high-end service to customers, who are not able to access high-end devices, many corporations have started to develop their streaming services. For instance, entertaining service such as Google Stadia makes high-end gaming, which is typically hardware demanding, now possible on any portable devices with good internet connectivity. The game is processed and rendered at Google’s cloud server with user’s inputs in real-time, then the video is streamed back to the user’s terminal via the internet. However, the extensive data exchange at the network between the cloud servers and local user terminals also expand the attack surface for intrusions. Malicious hackers may deploy various types of attacks, such as Distributed Denial-of-Service (DDoS), Port Scan and Infiltration attack to hijack valuable data or make servers unavailable to users. To stop these cyberattacks from happening, the development of a reliable and effective Intrusion Detection System (IDS) for cybersecurity

**1.2 Objectives:**

* The main objective of our project is,
* To detect traffic network effectively.
* To implement the Deep learning using LSTM
* To enhance the overall performance analysis.

**1.3 Problem statement:**

A more common approach for detecting main problem in detecting slow DDoS attacks is the inability to prevent them, since the determination process is based on the study of existing traffic without the possibility of predicting it depending on users' activity

**Scope of the project:**

DoS or Denial-of-Service attack is an attack targeting the availability of web applications. Unlike other kinds of attacks, the primary goal of a DoS attack is not to steal information but to slow or take down a web site .Prevention can be used to perform Distributed Denial-of-Service (DDoS) attacks, steal data, send spam, and allow the attacker to access the device and its connection.

A Denial-of-Service (DoS) attack is an attack meant to shut down a Deep or network, making it inaccessible to its intended users. DoS attacks accomplish this by flooding the target with traffic, or sending it information that triggers a crash.

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**CHAPTER 2**

**LITERATURE REVIEW**

**2.1 Introduction:**

The DDoS attacks on the cloud computing environment are mainly application layer which sends out requests following the communication protocol which are then hard to distinguish in the network layer because their pattern matches the legitimate requests thus making the traditional defence systems not applicable. DDoS flooding attacks on cloud can be of various categories like session and request flooding attacks, slow response and asymmetric attack. All these flooding attacks generate traffic which resembles that of a legitimate user which becomes tougher for the target to distinguish between attack and legitimate traffic thus blocking the services for the legitimate user

**2.2 Review of the existing system:**

# **2.2.1 *Existing System 1:***

# **Title**: Cloud security architecture based on user authentication and symmetric key cryptographic techniques, 2020

# **Author: Abdul Raoof**

# **Technologies and Algorithm Used:**

The study is implemented on the Structure for cloud security with efficient security in communication system and AES based file encryption system. This security architecture can be easily applied on PaaS, IaaS and SaaS and one time password provides extra security in the authenticating users.

**Advantages**:

* Performance time and accuracy

**Disadvantages:**

* Training model prediction on Time is High

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**2.2.2 *Existing System 2:***

# **Title**: Analysis and Countermeasures for Security and Privacy Issues in Cloud Computing, 2019

# **Author:** Q. P. Rana, Nitin Pandey

**Technologies and Algorithm Used:**

The cloud computing environment is adopted by a large number of organizations so the rapid transition toward the clouds has fuelled concerns about security perspective. There are numbers of risks and challenges that have emerged due to use of cloud computing. The aim of this paper is to identify security issues in cloud computing which will be helpful to both cloud service providers and users to resolve those issues. As a result, this paper will access cloud security by recognizing security requirements and attempt to present the feasible solution that can reduce these potential threats.

**Advantages**:

More effective and efficient**.**

**Disadvantages:**

Not give accurate prediction result.

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# **2.2.3 *Existing System 3:***

# **Title**: Using Firefly and Genetic Metaheuristics for Anomaly Detection based on Network Flows, 2014

# **Author:** Faisal Hussain

# **2.2.4 *Existing System 4:***

# **Title**: A Multiple-Layer Representation Learning Model for Network-Based Attack Detection, 2018

* **Author:** Suresh M

# **Technologies and Algorithm Used:**

* The proposed solutions are this ensures fine-grained detection of various attacks.
* The proposed framework has been compared with the existing deep learning models using three real datasets (a new dataset NBC, a combination of UNSW-NB15 and CICIDS2017 consisting of 101 classes).

**Advantages**:

It performs accurate classification of health state in comparison with other methods

**Disadvantages:**

It is low in efficiency

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**2.2.5 *Existing System 5:***

# **Title**: Detecting Distributed Denial of Service Attacks Using Data Mining Techniques, 2018

# **Author:** Linga

# **Technologies and Algorithm Used:**

In this study, we DDoS (Distributed Denial of Service) attack has affected many IoT networks in recent past that has resulted in huge losses. We have proposed deep learning models and evaluated those using latest CICIDS2017 datasets for DDoS attack detection which has provided highest accuracy as 97.16% also proposed models are compared with machine learning algorithms

**Advantages**:

* The proposed solution can successfully detect network intrusions and DDOS communication with high precision**.**
* More Reliable.

**Disadvantages:**

* It is less in efficiency and not give perfect result.
* This finding is disadvantageous to the organization experiencing such attack.
* The difficulty in identifying all articles that are related to this study:

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**3. SYSTEM ANALYSIS**

**EXISTING SYSTEM**

* In existing system, DDoS attacks and then, selected features are passed to the classifiers, i.e. support vector machine, decision tree, naïve Bayes, and multilayer perceptron to identify type of attack.
* The publicly available dataset as KDD Cup 99 are used for our experimental study. From the results of the simulation, it is clear that GOIDS with decision tree acquires high detection and accuracy with a low false–positive rate.
* For instance, the use of denoising as feature extractors may improve the performance in the presence of high levels of noise

**DISADVANTAGES**

* Doesn’t Efficient for handling large volume of data.
* Theoretical Limits
* Incorrect Classification Results.

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**PROPOSED SYSTEM**

* The proposed IDS model is aimed at detecting network intrusions by classifying all the packet trafﬁc in the network as benign or malicious classes.
* DDOS attacks based on High-Speed Diesel pump network traffic dataset has been used to train and validate.
* Classification Using LSTM and Model predict Testing dataset for anomaly detection model finally classified attack or normal.
* It is more effective of performance analysis.

**ADVANTAGES**

* High performance.
* Provide accurate prediction results.
* It avoid sparsity problems.
* Reduces the information Loss and the bias of the inference due to the multiple estimates.

**3.1 SYSTEM ARCHITECTURE**

Train set

Feature Selection

Pre-processed data

Dataset

Test set

Prediction

Classification

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**3.2 FLOW DIAGRAM**

Clean Dataset

Select Dataset

Count Vectorizer

Classification

Prediction

Feature Selection

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**USE CASE DIAGRAM**

USER

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**ER DIAGRAM**

**COUNT VECTORIZER**

**FEATURE SELECTION**

**DATA SELECTION & LOAD**

**CLASSIFICATION**

**RESULT**

**GENERATION**

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**SEQUENCE DIAGRAM**

Clean

Prediction

Count Vectorizer

Model Selection

Classification

Select

Select dataset

 Load dataset

Start

Result Generation

**5. SYSTEM REQUIREMENTS SPECIFICATION**

**Software Requirements**

* O/S : Windows 7.
* Language : Python
* Front End : Anaconda Navigator – Spyder

**Hardware Requirements**

* System : Pentium IV 2.4 GHz
* Hard Disk : 200 GB
* Ram : 4GB
* Mouse : Logitech.
* Keyboard : 110 keys enhanced
* Ram : 4GB

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**External Interface Requirements:**

**User Interfaces:**

A user interface specification (UI specification) is a document that captures the details of the software user interface into a written document. The specification covers all possible actions that an end user may perform and all visual, auditory and other interaction elements. A user interface (UI) is the space where interactions between humans and machines occur.

In our process, the user choose the input by using tkinter and load or read the input by using panda’s package.

**Hardware Interfaces:**

A hardware interface specifies the plugs, sockets, cables and electrical signals that pass through each line between the CPU and a peripheral device or communications network.

In our process, there is no connection between software and hardware. Here we are used the hardware devices such as mouse, keyboard.

**Software Interfaces:**

Software interfaces (programming interfaces) are the languages, codes and messages that programs use to communicate with each other and to the hardware. Examples are the Windows, Mac and Linux operating systems, SMTP email, IP network protocols and the software drivers that activate the peripheral devices.

In our process, we are using PYTHON language to detect the different types of botnet attacks. Here we are running our process in SPYDER IDE from Anaconda Navigator.

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**Communication Interfaces:**

Communications interfaces: wireless or wired technologies are used to connect devices to one another, the Internet, remote servers, etc. From: Internet of Things. In our process, the input dataset as DDOS dataset. For each of the IoT devices we trained and optimized on 2/3 of its benign data (i.e., the training set of each device). This was done to capture normal network traffic patterns.

The test data of each device comprised of the remaining 1/3 of benign data plus all the malicious data. On each test set we applied the respective trained Search Similarity based for prediction as an anomaly detector. The detection of anomalies (i.e., the cyber-attacks launched from each of the above IoT devices) concluded with 100% TPR.

**Feasibility Analysis of the Requirements:**

In our process, the feasibility analysis is, the tool which we are used as Spyder IDE from Anaconda Navigator. The programming language which we are used as Python.

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**6. MODULES**

* Data Selection and Loading
* Data Preprocessing
* Splitting Dataset into Train and Test Data
* Classification
* Prediction
* Result Generation

**DATA SELECTION AND LOADING**

* Data selection is the process of determining the appropriate data type and source, as well as suitable instruments to collect data.
* Data selection precedes the actual practice of data collection and it is the process where data relevant to the analysis is decided and retrieved from the data collection.
* In this project, the Malware dataset is used for detecting KddCup99 type prediction.

**DATA PREPROCESSING**

* The data can have many irrelevant and missing parts. To handle this part, data cleaning is done. It involves handling of missing data, noisy data etc.
* **Missing Data:**   
  This situation arises when some data is missing in the data. It can be handled in various ways.
  + - Ignore the tuples:   
      This approach is suitable only when the dataset we have is quite large and multiple values are missing within a tuple.
    - Fill the Missing values:   
      There are various ways to do this task. You can choose to fill the missing values manually, by attribute mean or the most probable value.
* **Encoding Categorical data**: That categorical data is defined as variables with a finite set of label values. That most machine learning algorithms require numerical input and output variables. That an integer and one hot encoding is used to convert categorical data to integer data.
* **Count Vectorizer:** Scikit-learn's Count Vectorizer is used to convert a collection of text documents to a vector of term/token **counts**. It also enables the pre-processing of text data prior to generating the vector representation. This functionality makes it a highly flexible feature representation module for text.

**SPLITTING DATASET INTO TRAIN AND TEST DATA**

* Data splitting is the act of partitioning available data into two portions, usually for cross-validator purpose

One Portion of the data is used to develop a predictive model and the other to evaluate the model's performance.

* Separating data into training and testing sets is an important part of evaluating data mining models.
* Typically, when you separate a data set into a training set and testing set, most of the data is used for training, and a smaller portion of the data is used for testing.
* To train any machine learning model irrespective what type of dataset is being used you have to split the dataset into training data and testing data.

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**CLASSIFICATION**

Classification is the problem of identifying to which of a set of categories, a new observation belongs to, on the basis of a training set of data containing observations and whose categories membership is known.

**Random forests** or random decision forests are an [ensemble learning](https://en.wikipedia.org/wiki/Ensemble_learning) method for [classification](https://en.wikipedia.org/wiki/Statistical_classification), [regression](https://en.wikipedia.org/wiki/Regression_analysis) and other tasks that operate by constructing a multitude of [decision trees](https://en.wikipedia.org/wiki/Decision_tree_learning) at training time and outputting

the class that is the [mode](https://en.wikipedia.org/wiki/Mode_(statistics)) of the classes (classification) or mean/average prediction (regression) of the individual trees.

**Decision Trees** are a type of Supervised Machine Learning (that is you **explain** what the input is and what the corresponding output is in the training data) where the data is continuously split according to a certain parameter. An **example** of a **decision tree** can be **explained** using above binary **tree.**

**LSTM MODEL**

The introduction to long short-term memory, we learned that it resolves the vanishing gradient problem faced by RNN, so now, in this section, we will see how it resolves this problem by learning the architecture of the LSTM. At a high level, LSTM works very much like an RNN cell. Here is the internal functioning of the LSTM network. The LSTM network architecture consists of three parts, as shown in the image below, and each part performs an individual function

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**PREDICTION**

Predictive analytics algorithms try to achieve the lowest error possible by either using “boosting” or “bagging”.

**Accuracy** − Accuracy of classifier refers to the ability of classifier. It predict the class label correctly and the accuracy of the predictor refers to how well a given predictor can guess the value of predicted attribute for a new data.

**Speed** − Refers to the computational cost in generating and using the classifier or predictor.

**Robustness** − It refers to the ability of classifier or predictor to make correct predictions from given noisy data.

**Scalability** − Scalability refers to the ability to construct the classifier or predictor efficiently; given large amount of data.

**Interpretability** − It refers to what extent the classifier or predictor understands.

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**RESULT GENERATION**

The Final Result will get generated based on the overall classification and prediction. The performance of this proposed approach is evaluated using some measures like,

* Accuracy

**Accuracy** of classifier refers to the ability of classifier It predicts the class label correctly and the accuracy of the predictor refers to how well a given predictor can guess the value of predicted attribute for a new data.

AC=

* Precision

**Precision** is defined as the number of true positives divided by the number of true positives plus the number of false position.

Precision=

* Recall

**Recall** is the number of correct results divided by the number of results that should have been returned. In binary classification, recall is called sensitivity. It can be viewed as the probability that a relevant document is retrieved by the query.

* ROC

**ROC** curves are frequently used to show in a graphical way

The connection/trade-off between clinical sensitivity and specificity for every possible cut-off for a test or a combination of tests. In addition the area under the ROC curve gives an idea about the benefit of using the test(s) in question.

* Confusion matrix

A **confusion**  **matrix** is a table that is often used to describe the performance of a classification model (or "classifier") on a set of test data for which the true values are known. The confusion matrix itself is relatively simple to understand, but the related terminology can be confusing.

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**7. ALGORITHMS**

### **Decision Tree Regressor**

The Decision Tree Regressor(DTR) takes together all the input features and iteratively generates multiple trees trying out possible combinations of the root, internal, and leaf nodes amongst all the features .The tree with the closest predicted output to the actual traffic is considered the best tree for subsequent inference.

For each tree, for each node, two metrics can be calculated: Gini index and entropy. Gini index is a probabilistic measure that indicates the probability that the particular feature being at the given node would lead to the prediction error crossing a set threshold. At a particular node index n , the Gini index for a feature fi is calculated as follows:

Gini Indexn=1−Σni=1p2(fi)

E(S)=Σni=1−pilog2pi

**Linear Regression**

The Linear Regression model uses a linear mapping of features to get a continuous prediction output. It is one of the most primitive algorithms represented mathematically as:

H(x)=∑i=1nwiXi+ϵ

where ϵ is the error factor put in to accommodate normalization

**Multilayer perceptron**

The multi-layer perceptron model is a type of deep learning architecture where there is a combination of hidden layers through which the input features are passed to derive the output value. Each node in the hidden layer assigns an importance weight to each input that it receives from its preceding layer along with a bias value for error normalization. Generally, a fully connected setup is used wherein each node in a layer is connected to all nodes in its next layer

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Mathematically, the value at a particular node i in a given layer l is derived as follows:

H(x)li=∑j=1nwjH(x)l−1j+b

**Poisson Regression**

The Poisson regression is a probabilistic model .It deploys a probabilistic mass function (PMF) to check what could be the probability of observing a particular continuous output y for a given input containing a set of dependent variables X∈[X1,X2,..,Xn] . This function is defined as follows:

PMF(yi|xi)=e−λi∗λyiiyi!

where λi is the mean rate, also meant to be the predicted value.

Here, β is the regression coefficient or feature importance that is given to each dependent variable. The training objective of a Poisson regressor model is to find this β value. The best β value would be the one that produces the maximum value for PMF . The maximum value would be when the slope of the PMF curve is minimum, which is better derived by taking derivatives of the logarithm of PMF. This derivative equation is as follows:

ln(PMF)=∑x=1n(yixiβ−exiβ−lnyi!)

This is equated to zero to find the best β value. This value is then used to derive the prediction for a new test input xp :

yp=λp=expβ

### **Auto Regressive Integration and Moving Average :**

ARIMA, that stands for Auto Regressive Integrated Moving Average, deploys a combination of auto-regression and moving average algorithms to get future predictions from past time series value  Mathematically, it is represented as follows:

ht=yt=α+β1Yt−1+β2Yt−2+…+βpYt−pϵtht+ϕ1ϵt−1+ϕ2ϵt−2+…+ϕqϵt−q

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There are some terms based on auto-regression and some terms based on moving average. If terms in the time series are under-different, add more AR terms, and in cases of excess difference, then add more MA terms. ARIMA (p, d, q) method applies lag at the 1st or 2nd level if the non-stationary problem exists in the data; otherwise, if stationary without lag, then ARMA (p, q) is an alternative method; hence p for Moving Average (MA) and q for Autoregressive (AR) order that is the number of errors lag in ARIMA model forecast. The most common method used for making a sequence stationary is to subtract the initial value from the current value. Depending upon if the type of time series, i.e. univariate or multivariate, one or more lag is anticipated. Subsequently, the value of d signifies the smallest number of differentiation which is prescribed to keep the series stationary, so if without differentiation, the data series is still stationary, then d = 0.

### **Long Short Term Memory**

Long Short-Term Memory is a recurrent network-based architecture where it keeps track of a cell state to remember certain memory trends in the series, shown in Figure. For every point in the state, the model decides whether to let go of some information, update some pattern information, or output any new information. LSTM’s are specifically developed to prevent the problem of long-term dependency. All recurrent neural networks are made up of a series of repeated neural network modules. This recurring module in standard Recurrent Neural Networks (RNNs), will have a simple structure, such as a single tanh layer

ft=σ(αfxt+βfht−1)ot=σ(αoxt+βoht−1)(13)(14)

### **Convo-LSTM**

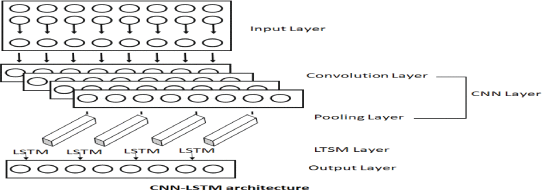
This proposes a novel combination of CNN along with LSTM such that the feature extraction ability of CNN can benefit the sequence recurrence mapping ability of the Recurrent Neural Networks(RNN).  An input layer, one-dimensional convolution layer, pooling layer, LSTM hidden layer, and full connection layer are the main constituents that build the main structure of Convo-LSTM. Pooling layers are deployed to reduce storage requirements and avoid the huge training costs

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The pooling layer subdivides the convolutional layer’s small rectangular chunks to generate a single output from each block. Pooling can be done in various ways, such as by calculating the average or the maximum.

The average pooling takes the average value of the block it is pooling, whereas the max-pooling takes the maximum of the block it is pooling . Firstly, the CNN layer extracts the features from the data, which are the readings from the Current, Voltage, Temperature and Vibration sensor’s readings collected over the previous year. The LSTM is then used to forecast the output, Vibration, based on the retrieved feature data. As per the experiment’s findings, With the maximum prediction accuracy, the CNN-LSTM that is Convo-LSTM, can provide credible forecasting of the output parameter (Vibration).

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[](https://ieeexplore.ieee.org/mediastore_new/IEEE/content/media/6287639/9668973/9672109/r6-3140646-large.gif)

Proposed Convo-LSTM architecture

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**8. SYSTEM FEASIBILITY**

**FEASIBILITY STUDY**

The feasibility study is carried out to test whether the proposed system is worth being implemented. The proposed system will be selected if it is best enough in meeting the performance requirements.

The feasibility carried out mainly in three sections namely.

**•** Economic Feasibility

• Technical Feasibility

• Behavioural Feasibility

**Economic Feasibility**

Economic analysis is the most frequently used method for evaluating effectiveness of the proposed system. More commonly known as cost benefit analysis. This procedure determines the benefits and saving that are expected from the system of the proposed system. The hardware in system department if sufficient for system development.

**Technical Feasibility**

This study centre around the system’s department hardware, software and to what extend it can support the proposed system department is having the required hardware and software there is no question of increasing the cost of implementing the proposed system. The criteria, the proposed system is technically feasible and the proposed system can be developed with the existing facility.

**Behavioural Feasibility**

People are inherently resistant to change and need sufficient amount of training, which would result in lot of expenditure for the organization. The proposed system can generate reports with day-to-day information immediately at the user’s request, instead of getting a report, which doesn’t contain much detail.

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**9. TESTING OF PRODUCT**

**Testing of Product**

System testing is the stage of implementation, which aimed at ensuring that system works accurately and efficiently before the live operation commence. Testing is the process of executing a program with the intent of finding an error. A good test case is one that has a high probability of finding an error. A successful test is one that answers a yet undiscovered error.

Testing is vital to the success of the system.  System testing makes a logical assumption that if all parts of the system are correct, the goal will be successfully achieved.  The candidate system is subject to variety of tests-on-line response, Volume Street, recovery and security and usability test.  A series of tests are performed before the system is ready for the user acceptance testing.  Any engineered product can be tested in one of the following ways.  Knowing the specified function that a product has been designed to from, test can be conducted to demonstrate each function is fully operational.  Knowing the internal working of a product, tests can be conducted to ensure that “al gears mesh”, that is the internal operation of the product performs according to the specification and all internal components have been adequately exercised.

**UNIT TESTING**

Unit testing is the testing of each module and the integration of the overall system is done.  Unit testing becomes verification efforts on the smallest unit of software design in the module.  This is also known as ‘module testing’.  The modules of the system are tested separately.  This testing is carried out during the programming itself.  In this testing step, each model is found to be working satisfactorily as regard to the expected output from the module.  There are some validation checks for the fields.  For example, the validation check is done for verifying the data given by the user where both format and validity of the data entered is included.  It is very easy to find error and debug the system.

**INTEGRATION TESTING**

Data can be lost across an interface, one module can have an adverse effect on the other sub function, when combined, may not produce the desired major function.  Integrated testing is systematic testing that can be done with sample data.  The need for the integrated test is to find the overall system performance. There are two types of integration testing. They are:

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Top-down integration testing.

Bottom-up integration testing

**WHITE BOX TESTING**

White Box testing is a test case design method that uses the control structure of the procedural design to drive cases.  Using the white box testing methods, we derived test cases that guarantee that all independent paths within a module have been exercised at least once.

**BLACK BOX TESTING**

* Black box testing is done to find incorrect or missing function
* Interface error
* Errors in external database access
* Performance errors
* Initialization and termination errors

In ‘functional testing’, is performed to validate an application conforms to its specifications of correctly performs all its required functions. So this testing is also called ‘black box testing’.  It tests the external behaviour of the system.  Here the engineered product can be tested knowing the specified function that a product has been designed to perform, tests can be conducted to demonstrate that each function is fully operational.

**VALIDATION TESTING**

After the culmination of black box testing, software is completed assembly as a package, interfacing errors have been uncovered and corrected and final series of software validation tests begin validation testing can be defined as many, but a single definition is that validation succeeds when the software functions in a manner that can be reasonably expected by the customer.

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**USER ACCEPTANCE TESTING**

User acceptance of the system is the key factor for the success of the system.  The system under consideration is tested for user acceptance by constantly keeping in touch with prospective system at the time of developing changes whenever required.

**OUTPUT TESTING**

After performing the validation testing, the next step is output asking the user about the format required testing of the proposed system, since no system could be useful if it does not produce the required output in the specific format.  The output displayed or generated by the system under consideration.  Here the output format is considered in two ways.  One is screen and the other is printed format.  The output format on the screen is found to be correct as the format was designed in the system phase according to the user needs.  For the hard copy also output comes out as the specified requirements by the user. Hence the output testing does not result in any connection in the system.

**SYSTEM IMPLEMENTATION**

Implementation of software refers to the final installation of the package in its real environment, to the satisfaction of the intended users and the operation of the system. The people are not sure that the software is meant to make their job easier.

* The active user must be aware of the benefits of using the system
* Their confidence in the software built up
* Proper guidance is impaired to the user so that he is comfortable in using the application

Before going ahead and viewing the system, the user must know that for viewing the result, the server program should be running in the server. If the server object is not running on the server, the actual processes will not take place.

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**User Training**

To achieve the objectives and benefits expected from the proposed system it is essential for the people who will be involved to be confident of their role in the new system. As system becomes more complex, the need for education and training is more and more important. Education is complementary to training. It brings life to formal training by explaining the background to the resources for them. Education involves creating the right atmosphere and motivating user staff. Education information can make training more interesting and more understandable.

**Training on the Application Software**

After providing the necessary basic training on the computer awareness, the users will have to be trained on the new application software. This will give the underlying philosophy of the use of the new system such as the screen flow, screen design, type of help on the screen, type of errors while entering the data, the corresponding validation check at each entry and the ways to correct the data entered. This training may be different across different user groups and across different levels of hierarchy.

**Operational Documentation**

Once the implementation plan is decided, it is essential that the user of the system is made familiar and comfortable with the environment. A documentation providing the whole operations of the system is being developed. Useful tips and guidance is given inside the application itself to the user. The system is developed user friendly so that the user the system from the tips given in the application itself.

**System Maintenance**

The maintenance phase of the software cycle is the time in which software performs useful work. After a system is successfully implemented, it should be maintained in a proper manner. System maintenance is an important aspect in the software development life cycle. The need for system maintenance is to make adaptable to the changes in the system environment. There may be social, technical and other environmental changes, which affect a system which is being new functional capabilities, improving user displays and mode of interaction, upgrading the performance characteristics of the system.

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So only through proper system maintenance procedures, the system can be adapted to cope up with these changes. Software maintenance is of course, far more than “finding mistakes”.

**Corrective Maintenance**

The first maintenance activity occurs because it is unreasonable to assume that software testing will uncover all latent errors in a large software system. During the use of any large program, errors will occur and be reported to the developer. The process that includes the diagnosis and correction of one or more errors is called Corrective Maintenance.

**Adaptive Maintenance**

The second activity that contributes to a definition of maintenance occurs because of the rapid change that is encountered in every aspect of computing. Therefore Adaptive maintenance termed as an activity that modifies software properly with a changing environment is both necessary & common place.

**Perceptive Maintenance**

The third activity that may be applied to a definition of maintenance occurs when a software package is successful. As the software is used, recommendations for new capabilities, modifications to existing functions, and general enhancement are received from users. To satisfy requests in this category, Perceptive maintenance is performed. This activity accounts for the majority of all efforts expended on software maintenance.

**Preventive Maintenance**

The fourth maintenance activity occurs when software is changed to improve future maintainability or reliability, or to provide a better basis for future enhancements. Often called preventive maintenance, this activity is characterized by reverse engineering and re-engineering techniques.

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**Types of Software Testing**

**Ad-hoc testing**

This type of software testing is very informal and unstructured and can be performed by any stakeholder with no reference to any test case or test design documents. The person performing Ad-hoc testing has a good understanding of the domain and workflows of the application to try to find defects and break the software. Ad-hoc testing is intended to find defects that were not found by existing test cases.

**Acceptance Testing**

Acceptance testing is a formal type of software testing that is performed by end user when the features have been delivered by developers. The aim of this testing is to check if the software confirms to their business needs and to the requirements provided earlier. Acceptance tests are normally documented at the beginning of the sprint (in agile) and is a means for testers and developers to work towards a common understanding and shared business domain knowledge.

**Accessibility Testing**

In accessibility testing, the aim of the testing is to determine if the contents of the website can be easily accessed by disable people.

Various checks such as colour and contrast (for colour blind people), font size for visually impaired, clear and concise text that is easy to read and understand.

**Agile Testing**

Agile Testing is a type of software testing that accommodates agile software development approach and practices. In an Agile development environment, testing is an integral part of software development and is done along with coding. Agile testing allows incremental and iterative coding and testing.

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**API Testing**

API testing is a type of testing that is similar to unit testing of the Software APIs are tested as per API specification. API testing is mostly done by testing team unless APIs to be tested or complex and needs extensive coding. API testing requires understanding both API functionality and possessing good coding skills.

**Automated testing**

This is a testing approach that makes use of testing tools and/or programming to run the test cases using software or custom developed test utilities. Most of the automated tools provided capture and playback facility, however there are tools that require writing extensive scripting or programming to automate test cases.

**All Pairs testing**

Also known as Pair wise testing, is a black box testing approach and a testing method where in for each input is tested in pairs of inputs, which helps to test software works as expected with all possible input combinations.

**Beta Testing**

This is a formal type of software testing that is carried out by end customers before releasing or handing over software to end users. Successful completion of Beta testing means customer acceptance of the software.

**Black Box testing**

Black box testing is a software testing method where in testers are not required to know coding or internal structure of the software. Black box testing method relies on testing software with various inputs and validating results against expected output.

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**Backward Compatibility Testing**

Type of software testing performed to check newer version of the software can work successfully installed over previous version of the software and newer version of the software works as fine with table structure, data structures, files that were created by previous version of the software.

**Boundary Value Testing (BVT)**

Boundary Value Testing is a testing technique that is based on concept “error aggregates at boundaries”. In this testing technique, testing is done extensively to check for defects at boundary conditions. If a field accepts value 1 to 100 then testing is done for values 0, 1, 2, 99, 100 and 101.

**Big Bang Integration testing**

This is one of the integration testing approaches, in Big Bang integration testing all or all most all of the modules are developed and then coupled together.

**Bottom up Integration testing**

Bottom up integration testing is an integration testing approach where in testing starts with smaller pieces or sub systems of the software till all the way up covering entire software system. Bottom up integration testing begins with smaller portion of the software and eventually scale up in terms of size, complexity and completeness.

**Branch Testing**

Is a white box testing method for designing test cases to test code for every branching condition? Branch testing method is applied during unit testing.

**Browser compatibility Testing**

It is one of the sub types of testing of compatibility testing performed by testing team. Browser compatibility testing is performed for web applications with combination of different browsers and operating systems.

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**Compatibility testing**

Compatibility testing is one of the test types performed by testing team. Compatibility testing checks if the software can be run on different hardware, operating system, bandwidth, databases, web servers, application servers, hardware peripherals, emulators, different configuration, processor, different browsers and different versions of the browsers etc.

**Component Testing**

This type of software testing is performed by developers. Component testing is carried out after completing unit testing. Component testing involves testing a group of units as code together as a whole rather than testing individual functions, methods.

**Condition Coverage Testing**

Condition coverage testing is a testing technique used during unit testing, where in developer tests for all the condition statements like if, if else, case etc., in the code being unit tested.

**Dynamic Testing**

Testing can be performed as Static Testing and Dynamic testing, Dynamic testing is a testing approach where-in testing can be done only by executing code or software are classified as Dynamic Testing. Unit testing, Functional testing, regression testing, performance testing etc.

**Decision Coverage Testing**

Is a testing technique that is used in Unit testing, objective of decision coverage testing is to expertise and validate each and every decisions made in the code e.g. if, if else, case statements.

**End-to-end Testing**

End to end testing is performed by testing team, focus of end to end testing is to test end to end flows e.g. right from order creation till reporting or order creation till item return etc. and checking. End to end testing is usually focused mimicking real life scenarios and usage. End to end testing involves testing information flow across applications.

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**Exploratory Testing**

Exploratory testing is an informal type of testing conducted to learn the software at the same time looking for errors or application behaviour that seems non-obvious. Exploratory testing is usually done by testers but can be done by other stake holders as well like Business Analysts, developers, end users etc. who are interested in learning functions of the software and at the same time looking for errors or behaviour is seems non-obvious.

**Equivalence Partitioning**

Equivalence partitioning is also known as Equivalence Class Partitioning is a software testing technique and not a type of testing by itself. Equivalence partitioning technique is used in black box and grey box testing types. Equivalence partitioning classifies test data into Equivalence classes as positive Equivalence classes and negative Equivalence classes, such classification ensures both positive and negative conditions are tested.

**Functional Testing**

Functional testing is a formal type of testing performed by testers. Functional testing focuses on testing software against design document, Use cases and requirements document. Functional testing is a black box type of testing and does not require internal working of the software unlike white box testing.

**Fuzz Testing**

Fuzz testing or fuzzing is a software testing technique that involves testing with unexpected or random inputs. Software is monitored for failures or error messages that are presented due to the input errors.

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**GUI (Graphical User Interface) testing**

This type of software testing is aimed at testing the software GUI (Graphical User Interface) of the software meets the requirements as mentioned in the GUI mock-ups and Detailed designed documents. For e.g. checking the length and capacity of the input fields provided on the form, type of input field provided, e.g. some of the form fields can be displayed as dropdown box or a set of radio buttons. So GUI testing ensures GUI elements of the software are as per approved GUI mock-ups, detailed design documents and functional requirements.

Most of the functional test automation tools work on GUI capture and playback capabilities. This makes script recording faster at the same time increases the effort on script maintenance.

**Glass box Testing**

Glass box testing is another name for White box testing. Glass box testing is a testing method that involves testing individual statements, functions etc., Unit testing is one of the Glass box testing methods.

**Gorilla Testing**

This type of software testing is done by software testing team, has a scary name though? Objective of Gorilla Testing is to exercise one or few functionality thoroughly or exhaustively by having multiple people test the same functionality.

**Happy Path Testing**

Also known as Golden path testing, this type of testing focuses on selective execution of tests that do not exercise the software for negative or error conditions.

**Integration Testing**

Integration testing also known as met in short, in one of the important types of software testing. Once the individual units or components are tested by developers as working then testing team will run tests that will test the connectivity among these units/component or multiple units/components. There are different approaches for Integration testing namely, Top-down integration testing, Bottom-up integration testing and a combination of these two known as Sand witch testing

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**Interface Testing**

Software provides support for one or more interfaces like “Graphical user interface”, “Command Line Interface” or “Application programming interface” to interact with its users or other software. Interfaces serves as medium for software to accept input from user and provide result. Approach for interface testing depends on the type of the interface being testing like GUI or API

**Internationalization Testing**

Internationalization testing is a type of testing that is performed by software testing team to check the extent to which software can support Internationalization i.e., usage of different languages, different character sets, double byte characters etc., For e.g.: Gmail, is a web application that is used by people all over work with different languages, single by or multi byte character sets.

**Keyword-driven Testing**

Keyword driver testing is more of an automated software testing approach than a type of testing itself. Keyword driven testing is known as action driven testing or table driven testing.

**Load Testing**

Load testing is a type of non-functional testing; load testing is done to check the behaviour of the software under normal and over peak load conditions. Load testing is usually performed using automated testing tools. Load testing intends to find bottlenecks or issues that prevent software from performing as intended at its peak workloads.

**Localization Testing**

Localization testing a type of software testing performed by software testers, in this type of testing, software is expected to adapt to a particular locale, it should support a particular locale/language in terms of display, accepting input in that particular locale, display, font, date time, currency etc., related to a particular locale. For e.g. many web applications allow choice of locale like English, French, German or Japanese. So once locale is defined or set in the configuration of software, software is expected to work as expected with a set language/locale.

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**Negative Testing**

This type of software testing approach, which calls out the “attitude to break”, these are functional and non-functional tests that are intended to break the software by entering incorrect data like incorrect date, time or string or upload binary file when text files supposed to be upload or enter huge text string for input fields etc. It is also a positive test for an error condition.

**Non-functional testing**

Software are built to fulfil functional and non-functional requirements, non-functional requirements like performance, usability, localization etc., There are many types of testing like compatibility testing, compliance testing, localization testing, usability testing, volume testing etc., that are carried out for checking non-functional requirements.

**Pair Testing**

**It** is a software testing technique that can be done by software testers, developers or Business analysts (BA). As the name suggests, two people are paired together, one to test and other to monitor and record test results. Pair testing can also be performed in combination of tester-developer, tester-business analyst or developer-business analyst combination. Combining testers and developers in pair testing helps to detect defects faster, identify root cause, fix and test the fix.

**Performance Testing**

**It** is a type of software testing and part of performance engineering that is performed to check some of the quality attributes of software like Stability, reliability, availability. Performance testing is carried out by performance engineering team. Unlike Functional testing, Performance testing is done to check non-functional requirements. Performance testing checks how well software works in anticipated and peak workloads. There are different variations or sub types of performance like load testing, stress testing, volume testing, soak testing and configuration testing.

**Penetration Testing**

**It** is a type of security testing, also known as pen test in short. Penetration testing is done to tests how secure software and its environments (Hardware, Operating system and network) are when subject to attack by an external or internal intruder. Intruder can be a human/hacker or malicious programs.

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Pen test uses methods to forcibly intrude (by brute force attack) or by using a weakness (vulnerability) to gain access to a software or data or hardware with an intent to expose ways to steal, manipulate or corrupt data, software files or configuration. Penetration Testing is a way of ethical hacking, an experienced Penetration tester will use the same methods and tools that a hacker would use but the intention of Penetration tester is to identify vulnerability and get them fixed before a real hacker or malicious program exploits it.

**Regression Testing**

**It** is a type of software testing that is carried out by software testers as functional regression tests and developers as Unit regression tests. Objective of regression tests are to find defects that got introduced to defect fix (is) or introduction of new feature(s). Regression tests are ideal candidate for automation.

**Retesting**

**It** is a type of retesting that is carried out by software testers as a part of defect fix verification. For e.g. a tester is verifying a defect fix and let us say that there are 3 test cases failed due to this defect. Once tester verifies defect fix as resolved, test will retest or test the same functionality again by executing the test cases that were failed earlier.

**Risk based Testing**

It is a type of software testing and a different approach towards testinga software. In Risk based testing, requirements and functionality of software to be tested are prioritized as Critical, High, Medium and low. In this approach, all critical and high priority tests are tested and them followed by Medium. Low priority or low risk functionality are tested at the end or may not base on the time available for testing.

**Smoke testing**

**It** is a type of testing that is carried out by software testers to check if the new build provided by development team is stable enough i.e., major functionality is working as expected in order to carry out further or detailed testing. Smoke testing is intended to find “show stopper” defects that can prevent testers from testing the application in detail. Smoke testing carried out for a build is also known as build verification test.

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**Security Testing**

**It** is a type of software testing carried out by specialized team of software testers. Objective of security testing is to secure the software is to external or internal threats from humans and malicious programs. Security testing basically checks, how good is software’s authorization mechanism, how strong is authentication, how software maintains confidentiality of the data, how does the software maintain integrity of the data,

what is the availability of the software in an event of an attack on the software by hackers and malicious programs is for Security testing requires good knowledge of application, technology, networking, security testing tools. With increasing number of web applications necessarily of security testing has increased to a greater extent.

**Sanity Testing**

**It** is a type of testing that is carried out mostly by testers and in some projects by developers as well. Sanity testing is a quick evaluation of the software, environment, network, external systems are up & running, software environment as a whole is stable enough to proceed with extensive testing. Sanity tests are narrow and most of the time sanity tests are not documented.

**Scalability Testing**

**It** is a non-functional test intended to test one of the software quality attributes i.e. “Scalability”. Scalability test is not focused on just one or few functionality of the software instead performance of software as a whole. Scalability testing is usually done by performance engineering team. Objective of scalability testing is to test the ability of the software to scale up with increased users, increased transactions, increase in database size etc., It is not necessary that software’s performance increases with increase in hardware configuration, scalability tests helps to find out how much more workload the software can support with expanding user base, transactions, data storage etc.,

**Stability Testing**

**It** is a non-functional test intended to test one of the software quality attributes i.e. “Stability”. Stability testing focuses on testing how stable software is when it is subject to loads at acceptable levels, peak loads, loads generated in spikes, with more volumes of data to be processed.

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Scalability testing will involve performing different types of performance tests like load testing, stress testing, spike testing, soak testing, spike testing etc

**Static Testing**

is a form of testing where in approaches like reviews, walkthroughs are employed to evaluate the correctness of the deliverable. In static testing software code is not executed instead it is reviewed for syntax, commenting, naming convention, size of the functions and methods etc. Static testing usually has check lists against which deliverables are evaluated.

Static testing can be applied for requirements, designs, and test cases by using approaches like reviews or walkthroughs.

**Stress Testing**

is a type of performance testing, in which software is subjected to peak loads and even to a break point to observe how the software would behave at breakpoint. Stress testing also tests the behaviour of the software with insufficient resources like CPU, Memory, Network bandwidth, Disk space etc. Stress testing enables to check some of the quality attributes like robustness and reliability.

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**SAMPLE CODE**

# Libraries

import pandas as pd

import warnings

import numpy as np

# Packages

from sklearn import metrics

from sklearn.model\_selection import train\_test\_split

from keras.models import Sequential

from keras.layers import Dense

from keras.layers import LSTM

from keras.layers import Dropout

from sklearn.linear\_model import LinearRegression

import matplotlib.pyplot as plt

data=pd.read\_csv("traffic.csv")

print("<----Dataset----->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

print(data.head(20))

print()

warnings.filterwarnings("ignore")

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print("<------Preprocessing------->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

data1=(data.isnull().sum())

print(data1)

print()

print("<------Remove Unwanted Column------>")

data=data.drop(["DateTime"],axis=1)

print(data.head(20))

print()

# Splitting the data into features and target sets

print("<--------Data Splitting--------->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

#Splitting the values into x and y

x=data.drop("Vehicles",axis=1)

y=data["Vehicles"]

print("Data Splitted into x and y")

print("X Label Dataset")

print(x.head(20))

print("Y Label Dataset")

print(y.head(20))

print()

print("<--------Data Splitting--------->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

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# splitting the data into the training and test set.

x\_train,x\_test,y\_train,y\_test=train\_test\_split(x,y,test\_size=0.25,random\_state=1)

print()

x1\_train=np.expand\_dims(x\_train, axis=2)

y1\_train=np.expand\_dims(y\_train,axis=1)

x1\_test=np.expand\_dims(x\_test,axis=2)

print("Algorithm implemntation")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

print("LSTM")

model = Sequential()

model.add(LSTM(units=50, return\_sequences=True, input\_shape=(x1\_train.shape[1], 1)))

model.add(Dropout(0.2))

model.add(LSTM(units=50, return\_sequences=True))

model.add(Dropout(0.2))

model.add(LSTM(units=50, return\_sequences=True))

model.add(Dropout(0.2))

model.add(LSTM(units=50))

model.add(Dropout(0.2))

model.add(Dense(units = 1))

model.compile(optimizer = 'adam', loss = 'mae', metrics=['accuracy'])

model.fit(x1\_train, y1\_train, epochs = 10, batch\_size = 32)

predictions = model.predict(x1\_test)

print()

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print("Classification Report")

print("Results of sklearn.metrics:")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*)

mae = metrics.mean\_absolute\_error(y\_test,predictions)

mse = metrics.mean\_squared\_error(y\_test,predictions)

rmse = np.sqrt(mse) #mse\*\*(0.5)

r2 = metrics.r2\_score(y\_test,predictions)

print("MAE:",mae)

print("MSE:", mse)

print("RMSE:", rmse)

print("R-Squared:", r2)

print()

print("Linear Regression")

regressor = LinearRegression()

regressor.fit(x\_train, y\_train) #training the algorithm

#To retrieve the intercept:

print(regressor.intercept\_)

#For retrieving the slope:

print(regressor.coef\_)

y\_pred = regressor.predict(x\_test)

print("Classification Report")

print("Results of sklearn.metrics:")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

mae1 = metrics.mean\_absolute\_error(y\_test,y\_pred)

mse1 = metrics.mean\_squared\_error(y\_test,y\_pred)

rmse1 = np.sqrt(mse1) #mse\*\*(0.5)

r2 = metrics.r2\_score(y\_test,y\_pred)

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print()

print("MAE:",mae1)

print("MSE:", mse1)

print("RMSE:", rmse1)

print("R-Squared:", r2)

print("<------Prediction Status-------->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

data12=np.array([1,20151102221]).reshape(1,-1)

predictions=regressor.predict(data12)

abs(predictions)

if predictions>=20:

print("Traffic Network ")

else:

print("Normal Network")

print()

print("<-------Comparision Graph------->")

print("\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*")

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#Comparision Graph b/w two algo

vals=[mse,mse1]

inds=range(len(vals))

labels=["LSTM ","Linear Regression" ]

fig,ax = plt.subplots()

rects = ax.bar(inds, vals)

ax.set\_xticks([ind for ind in inds])

ax.set\_xticklabels(labels)

plt.title('Comparison graph For LSTM & Regression')

plt.show()

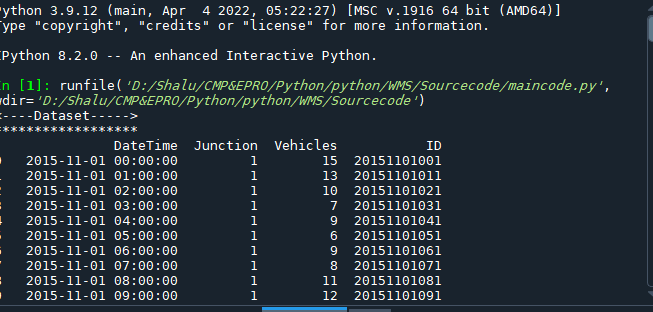
import pickle

filename = 'traffic.pkl'

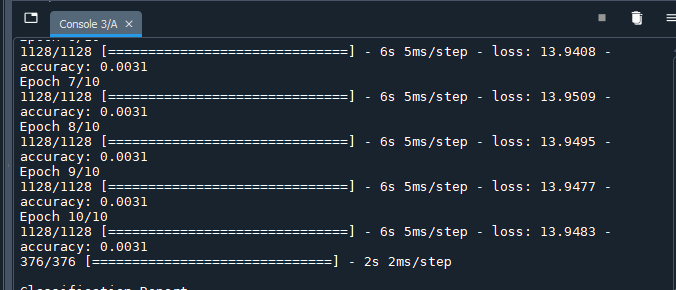
pickle.dump(regressor, open(filename, 'wb'))

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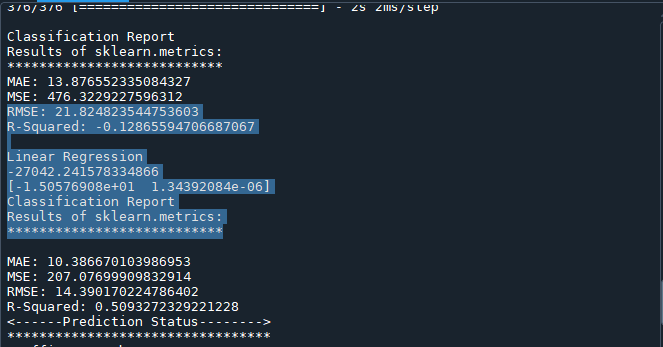
**10. OUTPUT SCREENSHOTS**

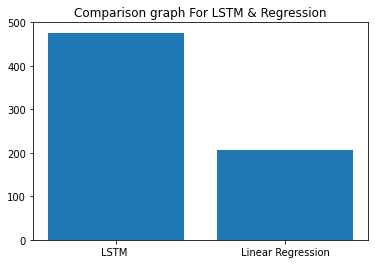


**OUTPUT SCREENSHOTS**



**OUTPUT SCREENSHOTS**





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**12. CONCLUSION**

In Conclusion challenges for these systems are security and privacy. Anomaly detection is an important data analysis task as one of the approaches for CPSs security. As different anomaly detection methods are presented, it is difficult to compare the advantages and disadvantages of these techniques. Finally, in this chapter Machine Learning (ML) methods for detection of anomalies are presented through a case study which demonstrates the effectiveness of machine learning techniques at classifying False Data Injection (FDI) attacks

**FUTURE ENCHANCEMENT**

In Future model based on Deep Learning model using CNN Algorithm

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**12. BIBLIOGRAPHY**

## **Features of Python**

### **Simple**

Python is a simple and minimalistic language. Reading a good Python program feels almost like reading English, although very strict English! This pseudo-code nature of Python is one of its greatest strengths. It allows you to concentrate on the solution to the problem rather than the language itself.

**Easy to Learn**

As you will see, Python is extremely easy to get started with. Python has an extraordinarily simple syntax, as already mentioned.

### **Free and Open Source**

Python is an example of a FLOSS (Free/Libré and Open Source Software). In simple terms, you can freely distribute copies of this software, read its source code, make changes to it, and use pieces of it in new free programs. FLOSS is based on the concept of a community which shares knowledge. This is one of the reasons why Python is so good - it has been created and is constantly improved by a community who just want to see a better Python.

### **High-level Language**

When you write programs in Python, you never need to bother about the low-level details such as managing the memory used by your program, etc.

**Portable**

Due to its open-source nature, Python has been ported to (i.e. changed to make it work on) many platforms. All your Python programs can work on any of these platforms without requiring any changes at all if you are careful enough to avoid any system-dependent features.

You can use Python on GNU/Linux, Windows, FreeBSD, Macintosh, Solaris, OS/2, Amiga, AROS, AS/400, BeOS, OS/390, and # -\*- coding: utf-8 -\*-

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z/OS, Palm OS, QNX, VMS, Psion, Acorn RISC OS, VxWorks, PlayStation, Sharp Zaurus, Windows CE and PocketPC!

You can even use a platform like [Kivy](http://kivy.org) to create games for your computer and for iPhone, iPad, and Android.

### **Interpreted**

This requires a bit of explanation.

A program written in a compiled language like C or C++ is converted from the source language i.e. C or C++ into a language that is spoken by your computer (binary code i.e. 0s and 1s) using a compiler with various flags and options. When you run the program, the linker/loader software copies the program from hard disk to memory and starts running it.Python, on the other hand, does not need compilation to binary. You just run the program directly from the source code. Internally, Python converts the source code into an intermediate form called byte codes and then translates this into the native language of your computer and then runs it. All this, actually, makes using Python much easier since you don't have to worry about compiling the program, making sure that the proper libraries are linked and loaded, etc. This also makes your Python programs much more portable, since you can just copy your Python program onto another computer and it just works!

### **Object Oriented**

Python supports procedure-oriented programming as well as object-oriented programming. In procedure-oriented languages, the program is built around procedures or functions which are nothing but reusable pieces of programs. In object-oriented languages, the program is built around objects which combine data and functionality. Python has a very powerful but simplistic way of doing OOP, especially when compared to big languages like C++ or Java.

### **Extensible**

If you need a critical piece of code to run very fast or want to have some piece of algorithm not to be open, you can code that part of your program in C or C++ and then use it from your Python program.

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### **Embeddable**

You can embed Python within your C/C++ programs to give scripting capabilities for your program's users.

### **Extensive Libraries**

The Python Standard Library is huge indeed. It can help you do various things involving regular expressions, documentation generation, unit testing, threading, databases, web browsers, CGI, FTP, email, XML, XML-RPC, HTML, WAV files, cryptography, GUI (graphical user interfaces), and other system-dependent stuff. Remember, all this is always available wherever Python is installed. This is called the Batteries Included philosophy of Python.

Besides the standard library, there are various other high-quality libraries which you can find at the [Python Package Index](http://pypi.python.org/pypi).

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