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Department of Artificial Intelligence and Data Science

LAB MANUAL
Computer Laboratory-III
(BE)
Semester II

Prepared by:
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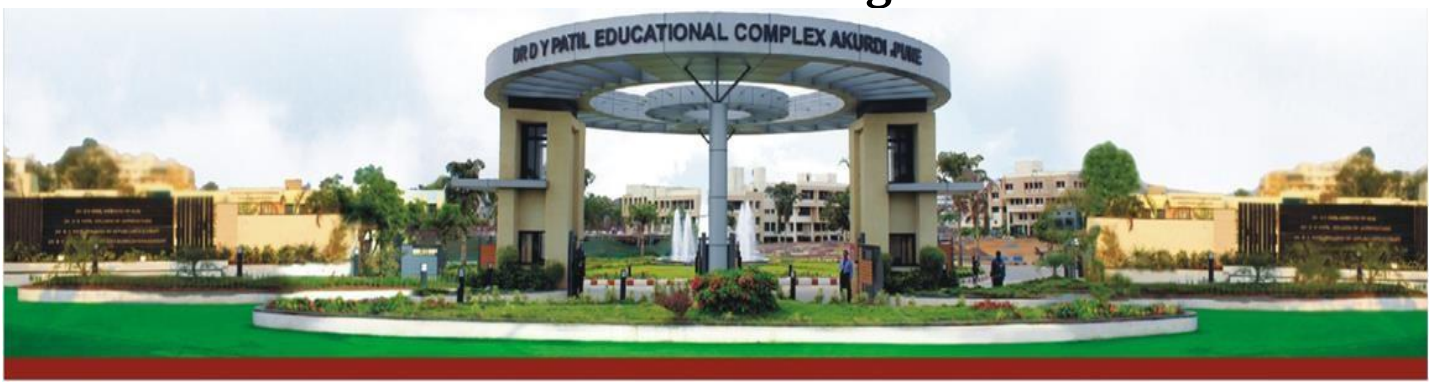


Computer Laboratory -III

Course Code	Course Name	Teaching Scheme (Hrs./ Week)	Credits
417530	Computer Laboratory-III: Computational Intelligence	2	2
417531	Computer Laboratory-III: Distributed Computing	2	2

Course Objectives:

 To understand the fundamentals of a distributed environment in complex application

 To introduce the concepts inspired by the human immune system and their application in problem-solving and optimization

 To make students aware about security issues and protection mechanisms for distributed environments

 Tofamiliarize with various evolutionary algorithms and optimization techniques inspired by natural evolution processes

Course Outcomes:

On completion of the course, learner will be able to–

CO1 : Apply the principles on which the internet and other distributed systems are based

CO2 :Understand and apply the basic theoretical concepts and algorithms of distributed systems in problem solving tools and techniques in area of software development to build mini projects

CO3 : Apply fuzzy logic techniques to model and solve problems

CO4 : Design and implement evolutionary algorithms to solve optimization and search problems in diverse domains

CO5: Design and implement artificial immune system algorithms to solve complex problems in different

Operating System recommended: Practical can be performed on suitable development platform

Table of Contents

Lab Assignment No.	1
Title	Problem Statement – Design a distributed application using RPC for remote computation where client submits an integer value to the server and server calculates factorial and returns the result to the client program
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Computational Intelligence
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 01

Title:-Design a distributed application using RPC for remote computation where client submits an integer value to the server and server calculates factorial and returns the result to the client

Objective:

1. Implement a distributed application using Remote Procedure Call (RPC) to allow a client to submit an integer value to the server.
2. Enable the server to calculate the factorial of the received integer and return the result to the client program.
3. Demonstrate the functionality and efficiency of RPC in remote computation tasks.

Outcome-

- Successfully implement an RPC-based client-server architecture for remote factorial calculation.
- Demonstrate the ease of implementing distributed applications using RPC.

Unit 1

Software Requirements -

- Python (3.x recommended)
- Jupyter Notebook or any Python IDE

Hardware Requirement

A machine with sufficient RAM and processing power for model training (8GB RAM recommended)

Prerequisites -

- Basic understanding of Python programming
- Familiarity with the concepts of RPC

What is RPC?

Remote Procedure Call (RPC) is an interprocess communication technique. The Full form of RPC is Remote Procedure Call. It is used for client-server applications. RPC mechanisms are used when a computer program causes a procedure or subroutine to execute in a different address space, which is coded as a normal procedure call without the programmer specifically coding the details for the remote interaction.

This procedure call also manages low-level transport protocol, such as User Datagram Protocol, Transmission Control Protocol/Internet Protocol etc. It is used for carrying the message data between programs.

Types of RPC

Three types of RPC are:

- Callback RPC
- Broadcast RPC
- Batch-mode RPC

Callback RPC

This type of RPC enables a P2P paradigm between participating processes. It helps a process to be both client and server services.

Functions of Callback RPC:

- Remotely processed interactive application problems
- Offers server with clients handle
- Callback makes the client process wait
- Manage callback deadlocks
- It facilitates a peer-to-Peer paradigm among participating processes.

Broadcast RPC

Broadcast RPC is a client's request, that is broadcast on the network, processed by all servers which have the method for processing that request.

Functions of Broadcast RPC:

- Allows you to specify that the client's request message has to be broadcasted.
- You can declare broadcast ports.
- It helps to reduce the load on the physical network

Batch-mode RPC

Batch-mode RPC helps to queue, separate RPC requests, in a transmission buffer, on the client-side, and then send them on a network in one batch to the server.

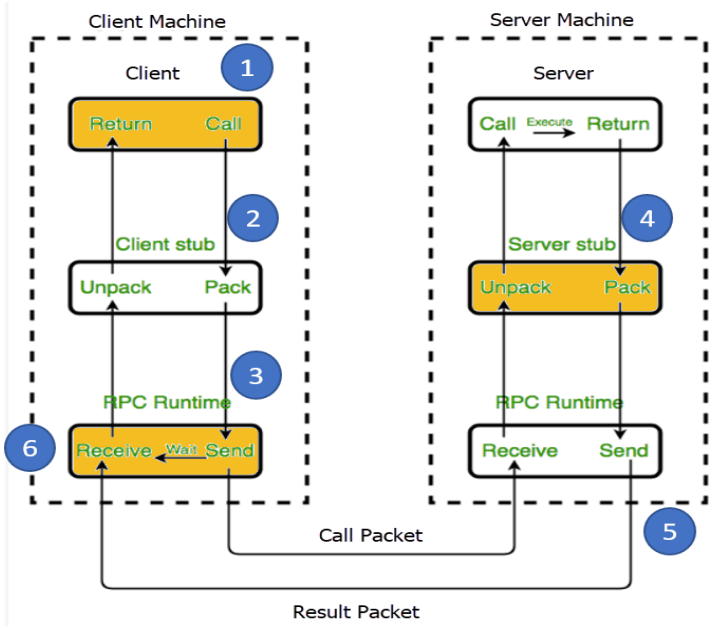
Functions of Batch-mode RPC:

- It minimizes overhead involved in sending a request as it sends them over the network in one batch to the server.
- This type of RPC protocol is only efficient for the application that needs lower call rates.
- It needs a reliable transmission protocol.

RPC Architecture

RPC architecture has mainly five components of the program:

1. **Client**
2. **Client Stub**
3. **RPC Runtime**
4. **Server Stub**
5. **Server**



How RPC Works?

Following steps take place during the RPC process:

Step 1) The client, the client stub, and one instance of RPC run time execute on the client machine.

Step 2) A client starts a client stub process by passing parameters in the usual way. The client stub stores within the client's own address space. It also asks the local RPC Runtime to send back to the server stub.

Step 3) In this stage, RPC accessed by the user by making regular Local Procedural Cal. RPC Runtime manages the transmission of messages between the network across client and server. It also performs the job of retransmission, acknowledgment, routing, and encryption.

Step 4) After completing the server procedure, it returns to the server stub, which packs (marshalls) the return values into a message. The server stub then sends a message back to the transport layer.

Step 5) In this step, the transport layer sends back the result message to the client transport layer, which returns back a message to the client stub.

Step 6) In this stage, the client stub demarshalls (unpack) the return parameters, in the resulting packet, and the execution process returns to the caller.

Characteristics of RPC

Here are the essential characteristics of RPC:

- The called procedure is in another process, which is likely to reside in another machine.
- The processes do not share address space.
- Parameters are passed only by values.
- RPC executes within the environment of the server process.
- It doesn't offer access to the calling procedure's environment.

Features of RPC

Here are the important features of RPC:

- Simple call syntax
- Offers known semantics
- Provide a well-defined interface
- It can communicate between processes on the same or different machines

Advantages of RPC

Here are Pros/benefits of RPC:

- RPC method helps clients to communicate with servers by the conventional use of procedure calls in high-level languages.
- RPC method is modeled on the local procedure call, but the called procedure is most likely to be executed in a different process and usually a different computer.
- RPC supports process and thread-oriented models.
- RPC makes the internal message passing mechanism hidden from the user.
- The effort needs to re-write and re-develop the code is minimum.
- Remote procedure calls can be used for the purpose of distributed and the local environment.
- It commits many of the protocol layers to improve performance.
- RPC provides abstraction. For example, the message-passing nature of network communication remains hidden from the user.

- RPC allows the usage of the applications in a distributed environment that is not only in the local environment.
- With RPC code, re-writing and re-developing effort is minimized.
- Process-oriented and thread-oriented models support by RPC.

Disadvantages of RPC

Here are the cons/drawbacks of using RPC:

- Remote Procedure Call Passes Parameters by values only and pointer values, which is not allowed.
- Remote procedure calling (and return) time (i.e., overheads) can be significantly lower than that for a local procedure.
- This mechanism is highly vulnerable to failure as it involves a communication system, another machine, and another process.
- RPC concept can be implemented in different ways, which is can't standard.
- Not offers any flexibility in RPC for hardware architecture as It is mostly interaction-based.
- The cost of the process is increased because of a remote procedure call.

RPC ArchitectureTo implement this in Python, we can use the **xmlrpc** library, which provides support for writing RPC servers and clients. The server program will create an XML-RPC server using **SimpleXMLRPCServer**, register a function to compute the factorial, and then start the server to listen for incoming requests. The client program will create an XML-RPC proxy object to communicate with the server, then call the remote procedure with the integer value as an argument to request the factorial calculation.

```
# Client-side code
import requests

def get_factorial(server_address, n):
    url = f"http://{server_address}/factorial"
    response = requests.post(url, json={"n": n})
```

```
    factorial = response.json()["factorial"]
    return factorial

if__name__== "__main__":
    server_address = "localhost:50051"  # Replace with your server's address and port
    n = int(input("Enter a non-negative integer: "))
    factorial = get_factorial(server_address, n)
    print(f"Factorial of {n} is {factorial}")

# Server-side code (using gRPC)
import grpc
import factorial_pb2
import factorial_pb2_grpc

class FactorialServicer(factorial_pb2_grpc.FactorialServiceServicer):
    def Calculate(self, request, context):
        n = request.n
        if n < 0:
            context.abort(grpc.status_code.INVALID_ARGUMENT, "n must be non-negative")
        factorial = 1
        for i in range(2, n + 1):
            factorial *= i
        return factorial_pb2.FactorialResponse(factorial=factorial)

def serve():
    server = grpc.server(concurrent=4)
    factorial_pb2_grpc.add_FactorialServiceServicer_to_server(FactorialServicer(), server)
    server.add_insecure_port("[::]:50051")  # Replace with your desired port
    server.start()
    server.wait_for_termination()
```

Conclusion:

Thus Implemented distributed application using RPC for remote computation where client submits an integer value to the server and server calculates factorial and returns the result to the client program

Lab Assignment No.	02
Title	Design a distributed application using RMI for remote computation where client submits two strings to the server and server returns the concatenation of the given strings
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III:Computational Intelligence
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 02

Title:- Distributed String Concatenation Application using RMI

Objective:

1. Develop a client-server application using Remote Method Invocation (RMI) for remote computation.
2. Enable the client to submit two strings to the server for concatenation.
3. Ensure that the server concatenates the given strings and returns the result to the client program.

Software Requirements -

- Jupyter Notebook, any Java IDE

Hardware Requirements -

- A machine with at least 8GB of RAM is recommended for model training.
- A multi-core CPU is suitable, and for faster training, a GPU (Graphics Processing Unit) is highly recommended.

Prerequisities -

- Basic understanding of Java programming

The **RMI** (Remote Method Invocation) is an API that provides a mechanism to create distributed application in java. The RMI allows an object to invoke methods on an object running in another JVM.

The RMI provides remote communication between the applications using two objects *stub* and *skeleton*.

Understanding stub and skeleton

RMI uses stub and skeleton object for communication with the remote object.

A **remote object** is an object whose method can be invoked from another JVM. Let's understand the stub and skeleton objects:

stub

The stub is an object, acts as a gateway for the client side. All the outgoing requests are routed through it. It resides at the client side and represents the remote object. When the caller invokes method on the stub object, it does the following tasks:

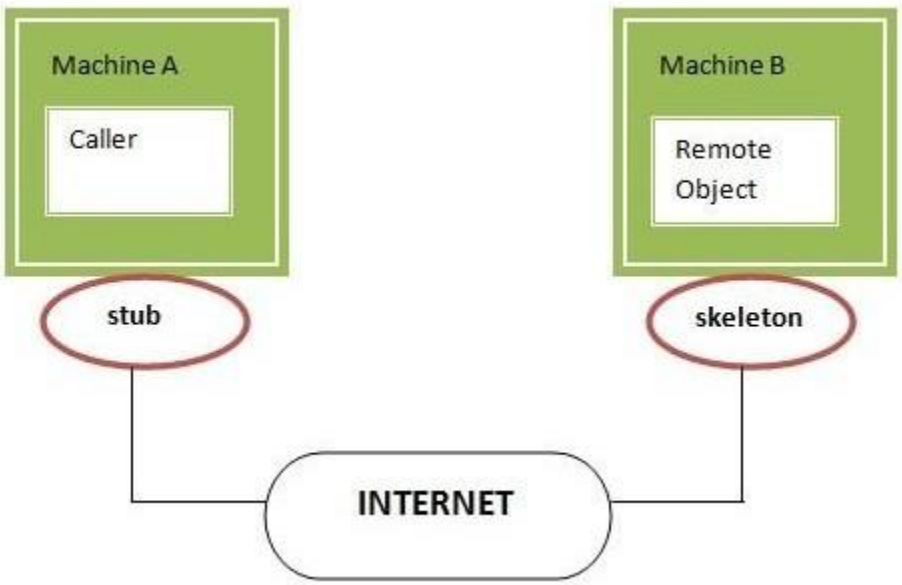
1. It initiates a connection with remote Virtual Machine (JVM),
2. It writes and transmits (marshals) the parameters to the remote Virtual Machine (JVM),

3. It waits for the result
4. It reads (unmarshals) the return value or exception, and
5. It finally, returns the value to the caller.

skeleton

The skeleton is an object, acts as a gateway for the server side object. All the incoming requests are routed through it. When the skeleton receives the incoming request, it does the following tasks:

1. It reads the parameter for the remote method
2. It invokes the method on the actual remote object, and
3. It writes and transmits (marshals) the result to the caller.In the Java 2 SDK, an stub protocol was introduced that eliminates the need for skeletons.



Understanding requirements for the distributed applications

If any application performs these tasks, it can be distributed application.

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1. The application need to locate the remote method
2. It need to provide the communication with the remote objects, and
3. The application need to load the class definitions for the objects.

The RMI application have all these features, so it is called the distributed application.

Java RMI Example

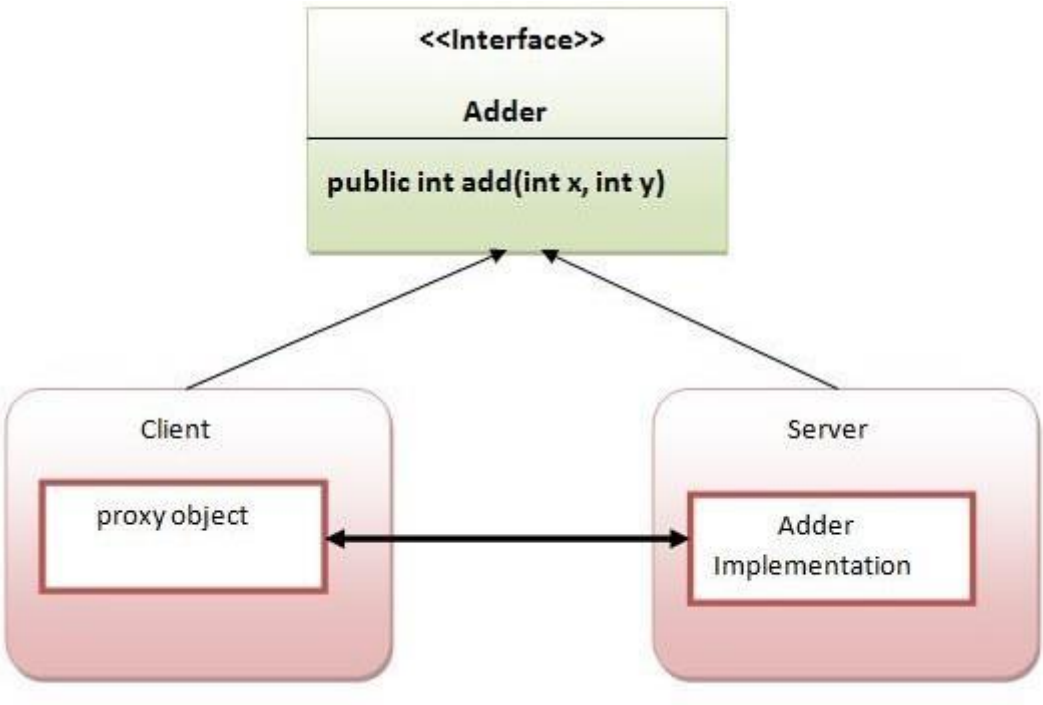
The is given the 6 steps to write the RMI program.

1. Create the remote interface
2. Provide the implementation of the remote interface
3. Compile the implementation class and create the stub and skeleton objects using the rmic tool
4. Start the registry service by rmiregistry tool
5. Create and start the remote application

6. Create and start the client application

RMI Example

In this example, we have followed all the 6 steps to create and run the rmi application. The client application need only two files, remote interface and client application. In the rmi application, both client and server interacts with the remote interface. The client application invokes methods on the proxy object, RMI sends the request to the remote JVM. The return value is sent back to the proxy object and then to the client application.



1) create the remote interface

For creating the remote interface, extend the Remote interface and declare the RemoteException with all the methods of the remote interface. Here, we are creating a remote interface that extends the Remote interface. There is only one method named add() and it declares RemoteException.

```
1. import java.rmi.*;
2. public interface Adder extends Remote{
3. public int add(int x,int y)throws RemoteException;
4. }
```

2) Provide the implementation of the remote interface

Now provide the implementation of the remote interface. For providing the implementation of the Remote interface, we need to

- Either extend the UnicastRemoteObject class,
- or use the exportObject() method of the UnicastRemoteObject class

In case, you extend the UnicastRemoteObject class, you must define a constructor that declares

RemoteException.

```
1. import java.rmi.*;
2. import java.rmi.server.*;
3. public class AdderRemote extends UnicastRemoteObject implements Adder{
4. AdderRemote()throws RemoteException{
5. super();
6. }
7. public int add(int x,int y){return x+y;}
8. }
```

---

3) create the stub and skeleton objects using the rmic tool.

Next step is to create stub and skeleton objects using the rmi compiler. The rmic tool invokes the RMI compiler and creates stub and skeleton objects.

```
1. rmic AdderRemote
```

---

4) Start the registry service by the rmiregistry tool

Now start the registry service by using the rmiregistry tool. If you don't specify the port number, it uses a default port number. In this example, we are using the port number 5000.

```
1. rmiregistry 5000
```

---

5) Create and run the server application

Now rmi services need to be hosted in a server process. The Naming class provides methods to get and store the remote object.

Conclusion: Thus This application demonstrates the use of RMI to create a distributed application for string concatenation, where the server receives two strings from the client, concatenates them, and returns the result to the client.

Lab Assignment No.	03
Title	Design a distributed application using MapReduce under Hadoop for: a) Character counting in a given text file. b) Counting no. of occurrences of every word in a given text file.
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Computational Intelligence
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 03

Title:- Distributed Application using MapReduce for Text Analysis :

a) Character counting in a given text file.

b) Counting no. of occurrences of every word in a given text file.

Problem Statement:

Objective:

1. Implement a MapReduce program under Hadoop for character counting in a given text file.
2. Develop a MapReduce program under Hadoop for counting the number of occurrences of every word in a given text file.

Outcome-

1. Successfully count the number of characters in the given text file using MapReduce.
2. Count the occurrences of every word in the given text file using MapReduce.

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Software Requirement

- Python (3.x recommended)
- Jupyter Notebook or any Python IDE

Hardware Requirement

A machine with sufficient RAM and processing power for model training (8GB RAM recommended)

Prerequisities-

Counting the number of words in any language is a piece of cake like in C, C++, Python, Java, etc. MapReduce also uses Java but it is very easy if you know the syntax on how to write it.

It is the basic of MapReduce. You will first learn how to execute this code similar to “Hello World” program in other languages. So here are the steps which show how to write a MapReduce code for Word Count.

What is MapReduce?

MapReduce is a programming model and framework within the Hadoop ecosystem that enables efficient

processing of big data by automatically distributing and parallelizing the computation. It consists of two fundamental tasks: Map and Reduce.

In the Map phase, the input data is divided into smaller chunks and processed independently in parallel across multiple nodes in a distributed computing environment. Each chunk is transformed or "mapped" into key-value pairs by applying a user-defined function. The output of the Map phase is a set of intermediate key-value pairs.

The Reduce phase follows the Map phase. It gathers the intermediate key-value pairs generated by the Map tasks, performs data shuffling to group together pairs with the same key, and then applies a user-defined reduction function to aggregate and process the data. The output of the Reduce phase is the final result of the computation.

Map Reduce example allows for efficient processing of large-scale datasets by leveraging parallelism and distributing the workload across a cluster of machines. It simplifies the development of distributed data processing applications by abstracting away the complexities of parallelization, data distribution, and fault tolerance, making it an essential tool for big data processing in the Hadoop ecosystem.

Advantages of using MapReduce

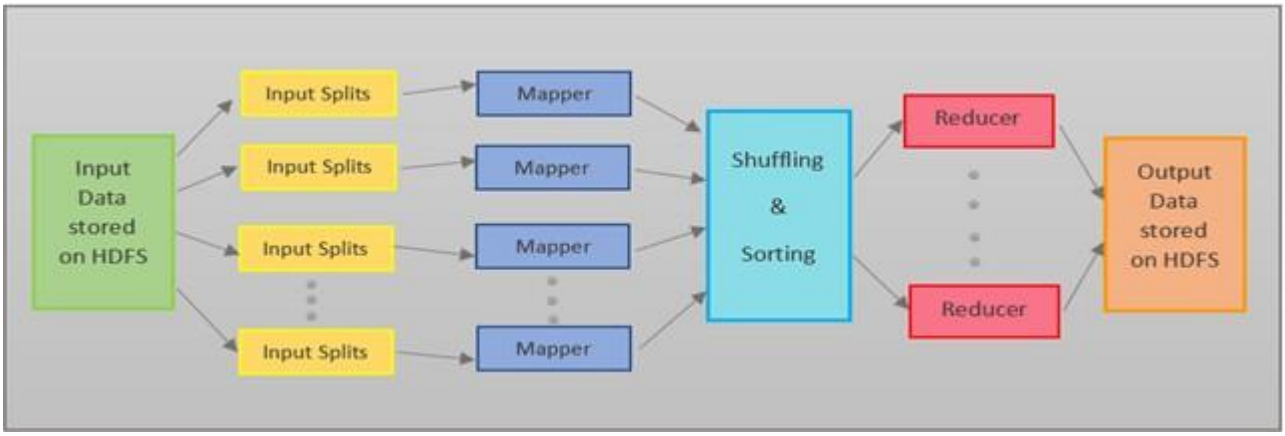
The advantages of using MapReduce are as follows:

- MapReduce can define mapper and reducer in several different languages using Hadoop streaming.
- MapReduce facilitates automatic parallelization and distribution, reducing the time required to run programs.
- MapReduce provides fault tolerance by re-executing, writing map output to a distributed file system, and restarting failed map or reducer tasks.
- Processing of data using MapReduce is a cost-effective solution.
- MapReduce processes large volumes of unstructured data very quickly.
- Using HDFS and HBase security, Map Reduce ensures data security by allowing only approved users to access data stored in the system.
- MapReduce programming utilizes a simple programming model to handle tasks more efficiently and quickly and is easy to learn.
- MapReduce is flexible and works with several Hadoop languages to handle and store data.

MapReduce Architecture

Map Reduce example process has the following phases:

1. Input Splits
2. Mapping
3. Shuffling
4. Sorting
5. Reducing



Input Splits

MapReduce splits the input into smaller chunks called input splits, representing a block of work with a single mapper task.

Mapping

The input data is processed and divided into smaller segments in the mapper phase, where the number of mappers is equal to the number of input splits. RecordReader produces a key-value pair of the input splits using TextFormat, which Reducer later uses as input. The mapper then processes these key-value pairs using coding logic to produce an output of the same form.

Shuffling

In the shuffling phase, the output of the mapper phase is passed to the reducer phase by removing duplicate values and grouping the values. The output remains in the form of keys and values in the mapper phase. Since shuffling can begin even before the mapper phase is complete, it saves time.

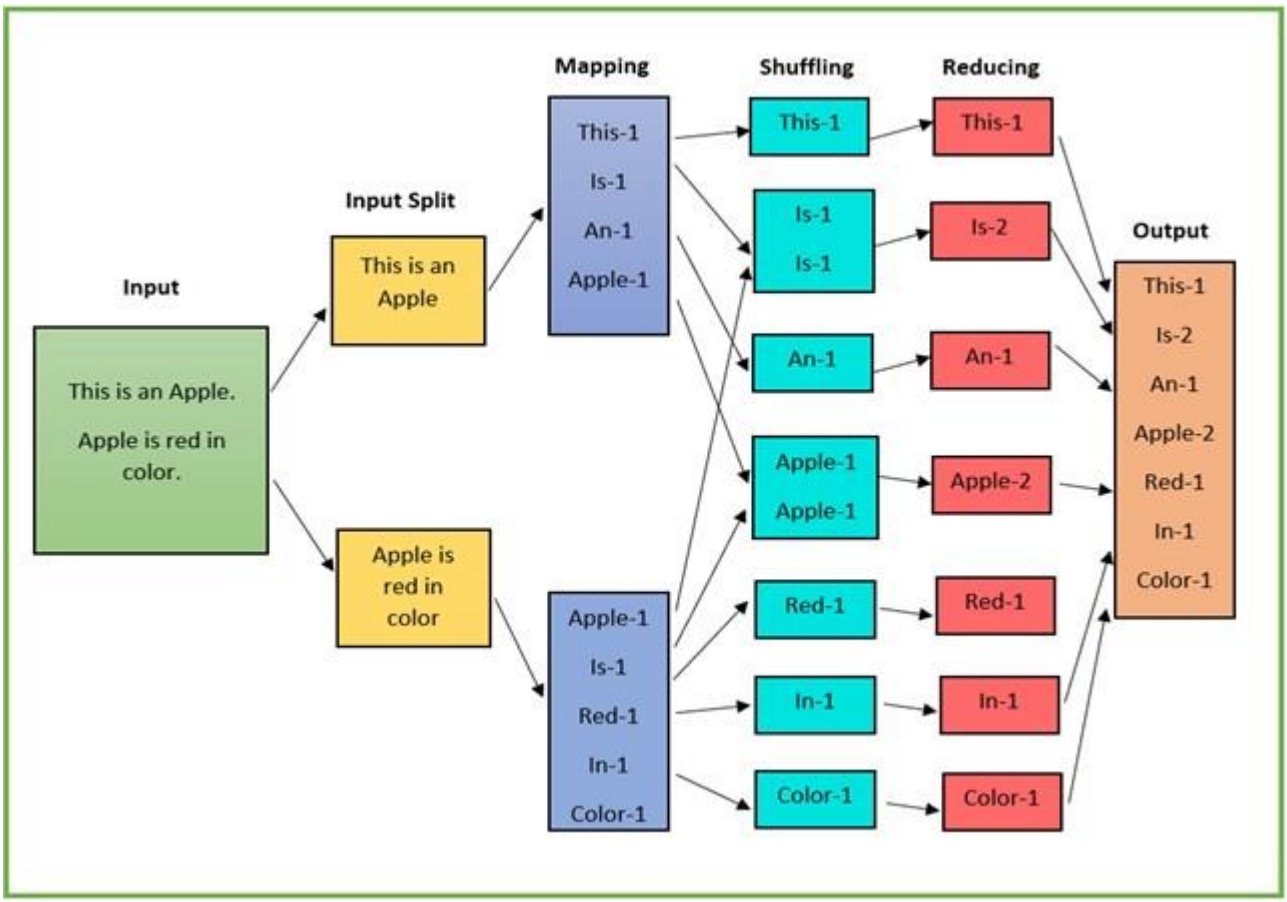
Sorting

Sorting is performed simultaneously with shuffling. The Sorting phase involves merging and sorting the output generated by the mapper. The intermediate key-value pairs are sorted by key before starting the reducer phase, and the values can take any order. Sorting by value is done by secondary sorting.

Reducing

In the reducer phase, the intermediate values from the shuffling phase are reduced to produce a single output value that summarizes the entire dataset. HDFS is then used to store the final output.

Here's an Map Reduce example to count the frequency of each word in an input text. The text is, "This is an apple. Apple is red in color."



- The input data is divided into multiple segments, then processed in parallel to reduce processing time. In this case, the input data will be divided into two input splits so that work can be distributed over all the map nodes.
- The Mapper counts the number of times each word occurs from input splits in the form of key-value pairs where the key is the word, and the value is the frequency.
- For the first input split, it generates 4 key-value pairs: This, 1; is, 1; an, 1; apple, 1; and for the second, it generates 5 key-value pairs: Apple, 1; is, 1; red, 1; in, 1; color.
- It is followed by the shuffle phase, in which the values are grouped by keys in the form of key-value pairs. Here we get a total of 6 groups of key-value pairs.
- The same reducer is used for all key-value pairs with the same key.
- All the words present in the data are combined into a single output in the reducer phase. The output shows the frequency of each word.
- Here in the example, we get the final output of key-value pairs as This, 1; is, 2; an, 1; apple, 2; red, 1; in, 1; color, 1.
- The record writer writes the output key-value pairs from the reducer into the output files, and the final output data is by default stored on HDFS.

Limitations of MapReduce

Map Reduce example also faces some limitations, and they are as follows:

- MapReduce is a low-level programming model which involves a lot of writing code.
- The batch-based processing nature of MapReduce makes it unsuitable for real-time processing.
- It does not support data pipelining or overlapping of Map and Reduce phases.
- Task initialization, coordination, monitoring, and scheduling take up a large chunk of MapReduce's execution time and reduce its performance.
- MapReduce cannot cache the intermediate data in memory, thereby diminishing Hadoop's performance.

Conclusion: Thus designed Distributed Application using MapReduce for Text Analysis.

https://www.geeksforgeeks.org/how-to-execute-character-count-program-in-mapreduce-hadoop/

Lab Assignment No.	04
Title	Design and implement a CNN for Image Classification a) Select a suitable image classification dataset (medical imaging, agricultural, etc.). b) Optimized with different hyper-parameters including learning rate, filter size, no. of layers, optimizers, dropouts, etc
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-IV: Deep Learning
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 04

Title:-

Design and implement Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relations by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.

Problem Statement: Design and implement Union, Intersection, Complement, and Difference operations on fuzzy sets. Create fuzzy relations by the Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.

Objective:

1. To implement Union, Intersection, Complement, and Difference operations on fuzzy sets.
2. To create fuzzy relations using the Cartesian product of fuzzy sets and perform max-min composition on fuzzy relations.
3. To demonstrate the application of these operations in fuzzy logic.

Outcome-

1. Successfully implement Union, Intersection, Complement, and Difference operations on fuzzy sets.
2. Create fuzzy relations using the Cartesian product of fuzzy sets and perform max-min composition on fuzzy relations.

Software Requirement

- Python (3.x recommended)
- Jupyter Notebook or any Python IDE

Hardware Requirement

A machine with sufficient RAM and processing power for model training (8GB RAM recommended)

Prerequisities-

What is Fuzzy Set ?

Fuzzy refers to something that is unclear or vague . Hence, Fuzzy Set is a Set where every key is associated with value, which is between 0 to 1 based on the certainty .This value is often called as degree of membership. Fuzzy Set is denoted with a Tilde Sign on top of the normal Set notation.

Operations on Fuzzy Set with Code :

1. Union :

Operations on Fuzzy Set with Code :

1. Union : Consider 2 Fuzzy Sets denoted by A and B, then let's consider Y be the Union of them, then for every member of A and B, Y will be:

degree_of_membership(Y)= max(degree_of_membership(A), degree_of_membership(B))

EXAMPLE :

```
# Example to Demonstrate the

# Union of Two Fuzzy Sets

A = dict()

B = dict()

Y = dict()

A = {"a": 0.2, "b": 0.3, "c": 0.6, "d": 0.6}

B = {"a": 0.9, "b": 0.9, "c": 0.4, "d": 0.5}

print('The First Fuzzy Set is :', A)

print('The Second Fuzzy Set is :', B)

for A_key, B_key in zip(A, B):

        A_value = A[A_key]

        B_value = B[B_key]


        if A_value > B_value:

                Y[A_key] = A_value

        else:

                Y[B_key] = B_value

print('Fuzzy Set Union is :', Y)
```

Output

The First Fuzzy Set is : {'a': 0.2, 'b': 0.3, 'c': 0.6, 'd': 0.6}

The Second Fuzzy Set is : {'a': 0.9, 'b': 0.9, 'c': 0.4, 'd': 0.5}

Fuzzy Set Union is : {'a': 0.9, 'b': 0.9, 'c': 0.6, 'd': 0.6}

2. Intersection :

Consider 2 Fuzzy Sets denoted by A and B, then let's consider Y be the Intersection of them, then for every member of A and B, Y will be:

degree_of_membership(Y)= min(degree_of_membership(A), degree_of_membership(B))

EXAMPLE :

```
# Example to Demonstrate

# Intersection of Two Fuzzy Sets

A = dict()

B = dict()

Y = dict()

A = {"a": 0.2, "b": 0.3, "c": 0.6, "d": 0.6}

B = {"a": 0.9, "b": 0.9, "c": 0.4, "d": 0.5}

print('The First Fuzzy Set is :', A)

print('The Second Fuzzy Set is :', B)

for A_key, B_key in zip(A, B):

        A_value = A[A_key]

        B_value = B[B_key]

        if A_value < B_value:

                Y[A_key] = A_value

        else:

                Y[B_key] = B_value
```

```
print('Fuzzy Set Intersection is :', Y)
```

Output

The First Fuzzy Set is : {'a': 0.2, 'b': 0.3, 'c': 0.6, 'd': 0.6}

The Second Fuzzy Set is : {'a': 0.9, 'b': 0.9, 'c': 0.4, 'd': 0.5}

Fuzzy Set Intersection is : {'a': 0.2, 'b': 0.3, 'c': 0.4, 'd': 0.5}

3. Complement :

Consider a Fuzzy Sets denoted by A , then let's consider Y be the Complement of it, then for every member of A , Y will be:

degree_of_membership(Y)= 1 - degree_of_membership(A)

EXAMPLE :

```
# Example to Demonstrate the

# Difference Between Two Fuzzy Sets

A = dict()

Y = dict()

A = {"a": 0.2, "b": 0.3, "c": 0.6, "d": 0.6}

print('The Fuzzy Set is :', A)

for A_key in A:

Y[A_key]= 1-A[A_key]

print('Fuzzy Set Complement is :', Y)
```

Output

The Fuzzy Set is : {'a': 0.2, 'b': 0.3, 'c': 0.6, 'd': 0.6}

Fuzzy Set Complement is : {'a': 0.8, 'b': 0.7, 'c': 0.4, 'd': 0.4}

4.Difference :

Consider 2 Fuzzy Sets denoted by A and B, then let's consider Y be the Intersection of them, then for every member of A and B, Y will be:

degree_of_membership(Y)= min(degree_of_membership(A), 1- degree_of_membership(B))

EXAMPLE :

```
# Example to Demonstrate the

# Difference Between Two Fuzzy Sets

A = dict()

B = dict()

Y = dict()

A = {"a": 0.2, "b": 0.3, "c": 0.6, "d": 0.6}

B = {"a": 0.9, "b": 0.9, "c": 0.4, "d": 0.5}

print('The First Fuzzy Set is :', A)

print('The Second Fuzzy Set is :', B)

for A_key, B_key in zip(A, B):

        A_value = A[A_key]

        B_value = B[B_key]

        B_value = 1 - B_value

        if A_value < B_value:

                Y[A_key] = A_value

        else:

                Y[B_key] = B_value

print('Fuzzy Set Difference is :', Y)
```

Conclusion: Fuzzy logic provides a powerful framework for dealing with uncertainty and imprecision in data. By implementing operations on fuzzy sets and relations, we can model complex relationships and make more flexible decisions in various applications such as control systems, artificial intelligence, and pattern recognition. The Union, Intersection, Complement, and Difference operations allow us to manipulate fuzzy sets, while fuzzy relations and max-min composition enable us to represent and combine fuzzy relationships between sets. These operations and techniques expand the capabilities of traditional logic and set theory, offering a more nuanced approach to handling vague and ambiguous information

Lab Assignment No.	05
Title	Optimization of genetic algorithm parameter in hybrid genetic algorithm-neural network modelling: Application to spray drying of coconut milk.
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III: Computational Intelligence
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 05

Title: Design and implement Optimization of genetic algorithm parameter in hybrid genetic algorithm-neural network modelling: Application to spray drying of coconut milk.

Problem Statement: Design and implement the spray drying process of coconut milk involves complex interactions of multiple parameters that affect the quality of the dried product.

Prerequisite:

Basics of Python

Software Requirements: Jupyter

Hardware Requirements:

PIV, 2GB RAM, 500 GB HDD

Learning Objectives:

1. To optimize the parameters of the genetic algorithm in a hybrid genetic algorithm-neural network model for the spray drying process of coconut milk.
2. To improve the accuracy and efficiency of the modeling process by tuning the genetic algorithm parameters.
3. To demonstrate the effectiveness of the optimized hybrid model in predicting the quality of the dried coconut milk.

Outcomes:

1. Identification of the optimal parameters for the genetic algorithm in the hybrid model.
2. Improved prediction accuracy and efficiency of the hybrid model compared to traditional modeling approaches.

Theory: Modeling complex processes like spray drying coconut milk presents a multi-faceted challenge. Nonlinear relationships and numerous influential factors demand sophisticated methods beyond traditional linear models. While Artificial Neural Networks (ANNs) excel in capturing such nonlinearities, they can be prone to initialization issues and require substantial data for optimal performance. Genetic Algorithms (GAs), on the other hand, adeptly navigate global optimization landscapes but can be computationally expensive. This research explores the intriguing avenue of optimizing GA parameters in a hybrid GA-NN approach to model spray drying, aiming to synergistically leverage the strengths of both techniques while mitigating their limitations.

Our endeavor is driven by three key objectives:

1. Fine-tuning GA Parameters: We seek to identify a set of GA parameters that efficiently navigate the solution space, ultimately leading to optimized network weights for modeling spray drying. Population size, crossover rate, and mutation rate are prominent parameters we intend to carefully calibrate.

2. Elevating Model Accuracy: Our ambition is to develop a model that surpasses the accuracy of both standalone ANNs and GA-NN models using unoptimized parameters. This enhanced model should faithfully represent the intricate dynamics of the spray drying process, offering superior predictive capabilities.

3. Striking a Balance: Achieving high accuracy is commendable, but it shouldn't come at the expense of exorbitant computational costs. We delve into the interplay between accuracy and computation time, striving to find GA parameter settings that strike a favorable balance between thorough exploration and focused exploitation, minimizing execution time without compromising model efficacy.

Through this endeavor, we aspire to achieve two significant outcomes:

1. A Champion Model: The culmination of our efforts will be a meticulously optimized GA-NN model capable of precisely predicting spray drying performance based on diverse input parameters. This model should stand out from its peers, demonstrating superior accuracy and robustness.

2. Performance Benchmarking: We will meticulously quantify the model's improved accuracy and the reduction in computational cost compared to alternative approaches. This comparative analysis will illuminate the effectiveness of our optimization strategy, providing valuable insights and paving the way for further advancements.

The optimization process typically involves the following steps:

Parameter Initialization: Initialize the genetic algorithm parameters, including population size, crossover rate, mutation rate, and selection strategy.

Fitness Evaluation: Evaluate the fitness of each individual in the population using the NN model. The fitness function is usually based on the error between predicted and actual drying parameters.

Selection: Select individuals from the population based on their fitness scores to form the next generation.

Crossover and Mutation: Apply crossover and mutation operators to create offspring for the next generation.

Replacement: Replace the current population with the new generation of individuals.

Termination: Repeat the process until a termination condition is met, such as reaching a maximum number of generations or achieving a desired level of convergence.

By optimizing the genetic algorithm parameters in the hybrid GA-NN model, we expect to improve the accuracy of predicting the quality of dried coconut milk powder. This optimized model can provide valuable insights for optimizing the spray drying process and enhancing the quality of the final product.

Here's an example of how you can optimize the genetic algorithm parameters in a hybrid GA-NN model for predicting the quality of dried coconut milk powder using Python. This example uses the **genetic_algorithm** library for the genetic algorithm part and **scikit-learn** for the neural network part. Please note that this is a simplified example for demonstration purposes and may require further customization for your specific application.

```
import numpy as np
from genetic_algorithm import GeneticAlgorithm
from sklearn.neural_network import MLPRegressor
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error

# Sample data (features and target)
X = np.random.rand(100, 5)  # Example features
y = np.random.rand(100)     # Example target

# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Define the neural network model
nn_model = MLPRegressor(hidden_layer_sizes=(100, 50), activation='relu', solver='adam', random_state=42)

# Define the fitness function for the genetic algorithm
def fitness_function(params):
    # Unpack genetic algorithm parameters
    population_size, crossover_rate, mutation_rate = params

    # Create the genetic algorithm object
    ga = GeneticAlgorithm(population_size=population_size, crossover_rate=crossover_rate,
mutation_rate=mutation_rate)

    # Train the neural network model
    nn_model.fit(X_train, y_train)

    # Evaluate the model
    y_pred = nn_model.predict(X_test)
    mse = mean_squared_error(y_test, y_pred)

    return mse

# Define the parameter ranges for the genetic algorithm
parameter_ranges = {
```

```
    'population_size': (50, 100),
    'crossover_rate': (0.6, 0.9),
    'mutation_rate': (0.01, 0.1)
}

# Create the genetic algorithm object
ga = GeneticAlgorithm(fitness_function, parameter_ranges)

# Optimize the genetic algorithm parameters
best_params = ga.optimize()

print("Best Parameters:", best_params)
```

Conclusion: Thus Designed and Optimization of genetic algorithm parameter in hybrid genetic algorithm-neural network modelling: Application to spray drying of coconut milk.

Lab Assignment No.	06
Title	Implementation of Clonal selection algorithm using Python.
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III: Computational Intelligence
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 06

Problem Statement: Implementation of Clonal selection algorithm using Python

Objective:

1. To implement the clonal selection algorithm in Python for solving optimization problems.
2. To apply the algorithm to a specific optimization problem and compare its performance with other optimization algorithms.
3. To analyze the effectiveness and efficiency of the clonal selection algorithm in finding optimal solutions.

Title:- The Clonal Selection Algorithm (CSA) is a computational optimization technique inspired by the clonal selection process in the immune system.

Outcomes:

1. Implementation of the clonal selection algorithm in Python, including the main algorithmic steps such as cloning, mutation, and selection.
2. Evaluation of the algorithm's performance in terms of convergence speed and solution quality compared to other optimization algorithms.

Theory

The Clonal Selection Algorithm (CSA) is a bio-inspired optimization algorithm that is based on the clonal selection process of B cells in the immune system. The algorithm was first proposed by de Castro and Timmis in 2002 as a way to solve complex optimization problems. The CSA mimics the behavior of the immune system by using an iterative process of selection, cloning, and mutation to evolve a population of candidate solutions towards an optimal solution.

Key Concepts:

1. **Antibody Representation:** In the CSA, candidate solutions, called antibodies, are represented as vectors in a multidimensional search space. Each dimension of the vector corresponds to a possible solution to the optimization problem.
2. **Affinity Maturation:** Affinity maturation is the process by which antibodies with higher affinities to the target antigen are selected and cloned. In the context of the CSA, affinity represents the fitness of an antibody, i.e., how well it solves the optimization problem.
3. **Cloning:** Cloning is the process of creating multiple copies of high-affinity antibodies. In the CSA, antibodies are cloned based on their affinity, with higher-affinity antibodies being cloned more frequently.
4. **Mutation:** Mutation introduces diversity into the population by randomly perturbing the cloned antibodies. This helps to explore new regions of the search space and avoid local optima.
5. **Selection:** Selection is the process of choosing antibodies to form the next generation based on their affinity. Higher-affinity antibodies are more likely to be selected, while lower-affinity antibodies may be discarded.

Algorithm Steps:

1. **Initialization:** Initialize a population of antibodies randomly or using a heuristic method.
2. **Affinity Calculation:** Calculate the affinity of each antibody in the population based on its fitness in solving the optimization problem.
3. **Clonal Selection:** Select antibodies for cloning based on their affinity, with higher-affinity antibodies being cloned more.
4. **Cloning:** Create multiple copies of selected antibodies based on their affinity.
5. **Mutation:** Perturb the cloned antibodies to introduce diversity into the population.
6. **Selection:** Select antibodies for the next generation based on their affinity.
7. **Repeat:** Repeat steps 3-6 for a specified number of iterations or until a convergence criteria is met.

Termination: The algorithm terminates when a stopping criterion is met, such as a maximum number of iterations or the convergence of the population towards an optimal solution.

Python Implementation:
Below is a basic implementation of the Clonal Selection Algorithm in Python:

```
# Pseudocode for Clonal Selection Algorithm
def clonal_selection_algorithm(population_size, mutation_rate, num_iterations):
    # Initialize population of antibodies
    antibodies = initialize_population(population_size)

    for _ in range(num_iterations):
        # Calculate affinity of antibodies
        calculate_affinity(antibodies)

        # Select antibodies for cloning
        selected_antibodies = select_antibodies_for_cloning(antibodies)

        # Clone selected antibodies
        cloned_antibodies = clone_antibodies(selected_antibodies)

        # Mutate cloned antibodies
        mutated_antibodies = mutate_antibodies(cloned_antibodies, mutation_rate)

        # Select antibodies for next generation
        antibodies = select_next_generation(antibodies, mutated_antibodies)

    # Return best antibody
    return best_antibody(antibodies)
```

This implementation is a basic framework for the Clonal Selection Algorithm and can be customized for specific optimization problems by defining appropriate functions for initialization, affinity calculation, selection, cloning, mutation, and selection of the next generation.

Conclusion: Thus designed and implemented of Clonal selection algorithm using Python

Lab Assignment No.	07
Title	To apply the artificial immune pattern recognition to perform a task of structure damage Classification .
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Distributed System
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 07

Title: To apply the artificial immune pattern recognition to perform a task of structure damage Classification .

Problem Statement: Develop an artificial immune pattern recognition system for the task of structural damage classification.

Prerequisite:

Basics of Python

Software Requirements: Jupyter Notebook or any Python IDE

Required Python libraries (scikit-learn, numpy, matplotlib)

Hardware Requirements:

PIV, 2GB RAM, 500 GB HDD

Learning Objectives:

1. Design a robust algorithm capable of identifying patterns indicative of structural damage within complex datasets.
2. Implement a scalable solution that can accurately classify various types and extents of structural damage with high efficiency.

Outcomes:

After completion of this assignment students are able to understand how to The developed system will enable automated and accurate identification of structural damage, aiding in timely maintenance and ensuring safety.

Theory:

Introduction to AIS:

- Briefly discuss the biological immune system and its key functions.
- Introduce the concept of AIS and its principles for pattern recognition.
- Explain the analogy between antigens (foreign invaders) and damage patterns, and antibodies (immune cells) and damage detectors.

2. Setting Up the AIS Model:

- Divide the students into groups and assign each group a specific damage type (e.g., crack, corrosion).
- Provide each group with a training dataset containing features of healthy and damaged structures related to their assigned damage type.
- Guide students through the process of encoding the data into a format suitable for the AIS algorithm (e.g., binary strings representing feature values).
- Introduce the chosen AIS algorithm and its key parameters (e.g., population size, mutation rate).
- Assist students in implementing the algorithm using the provided library or framework.

3. Training and Testing the Model:

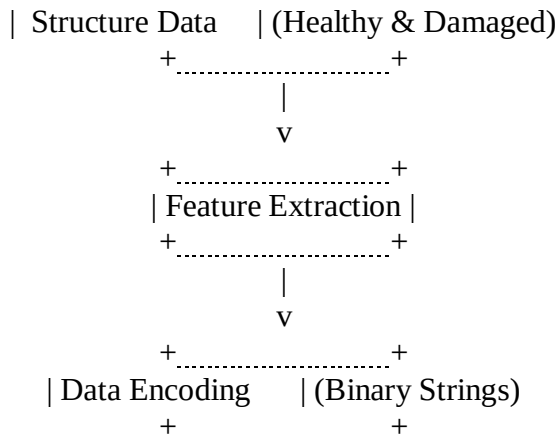
- Run the AIS algorithm on the training data for each group.
- Explain the selection, mutation, and cloning processes within the algorithm.
- Observe how the "antibodies" (damage detectors) evolve over generations to better recognize the assigned damage pattern.
- Once training is complete, test the model with unseen data containing both healthy and damaged structures.
- Evaluate the performance of the AIS model based on its accuracy in detecting the assigned damage type.

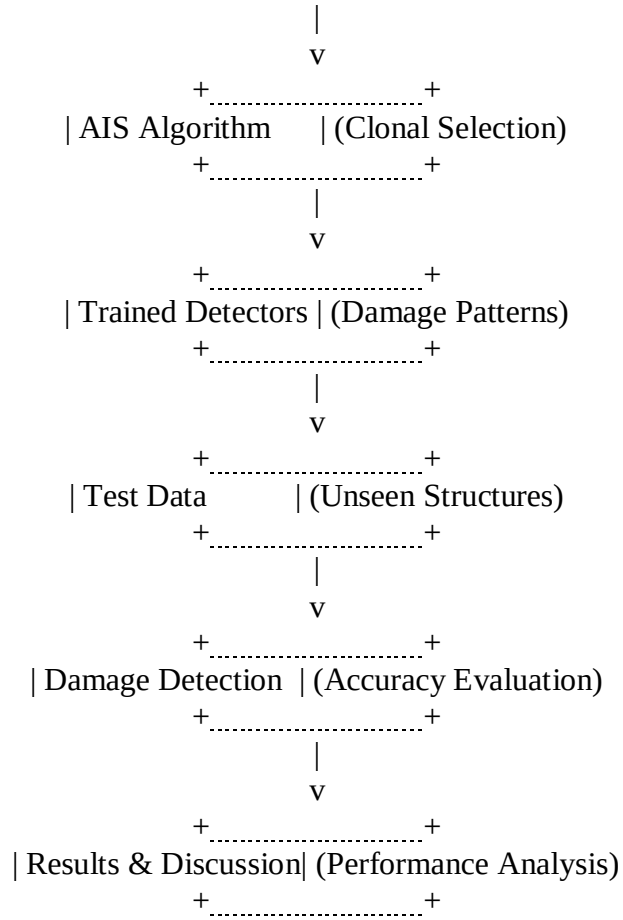
4. Analysis and Discussion:

- Each group presents their results and discusses the performance of their AIS model.
- Compare the effectiveness of different damage detection algorithms or parameter settings across groups.
- Discuss the advantages and limitations of using AIS for damage detection.
- Explore potential applications of AIS in real-world engineering scenarios.

5. Diagram:

A simplified diagram illustrating the key steps of the lab experiment:





Note: This is a general outline and can be adapted based on the specific AIS algorithm, chosen damage types, and available resources.

This code represents a process flow for a damage detection system using an AIS algorithm.

1. Structure Data: Represents the input data for the system, which includes information about healthy and damaged structures.
2. Feature Extraction: Extracts relevant features from the input data to be used in the detection process.
3. Data Encoding: Converts the extracted features into binary strings for processing by the AIS algorithm.
4. AIS Algorithm: Utilizes a Clonal Selection algorithm to detect damage patterns in the encoded data.
5. Trained Detectors: Represents the detectors that have been trained to recognize specific damage patterns.
6. Test Data: Contains unseen structures that will be used to test the performance of the detection system.

7. Damage Detection: Evaluates the accuracy of the detection system in identifying damage in the test data.
8. Results & Discussion: Analyzes the performance of the system and discusses the results obtained from the damage detection process.

CODE:

```
import numpy as np


# Generate dummy data for demonstration purposes (replace this with your actual data)
def generate_dummy_data(samples=100, features=10):
    data = np.random.rand(samples, features)
    labels = np.random.randint(0, 2, size=samples)
    return data, labels


# Define the AIRS algorithm
class AIRS:
    def__init_(self, num_detectors=10, hypermutation_rate=0.1):
        self.num_detectors = num_detectors
        self.hypermutation_rate = hypermutation_rate


    def train(self, X, y):
        self.detectors = X[np.random.choice(len(X), self.num_detectors, replace=False)]


    def predict(self, X):
        predictions = []
        for sample in X:
            distances = np.linalg.norm(self.detectors - sample, axis=1)
            prediction = int(np.argmin(distances))
            predictions.append(prediction)
```

```
    return predictions

# Generate dummy data
data, labels = generate_dummy_data()

# Split data into training and testing sets
split_ratio = 0.8
split_index = int(split_ratio * len(data))
train_data, test_data = data[:split_index], data[split_index:]
train_labels, test_labels = labels[:split_index], labels[split_index:]

# Initialize and train AIRS
airs = AIRS(num_detectors=10, hypermutation_rate=0.1)
airs.train(train_data, train_labels)

# Test AIRS on the test set
predictions = airs.predict(test_data)

# Evaluate accuracy
accuracy = np.mean(predictions == test_labels)
print(f"Accuracy: {accuracy}")
```

```
# Evaluate accuracy
accuracy = np.mean(predictions == test_labels)
print(f"Accuracy: {accuracy}")
```

```
Accuracy: 0.05
```

Conclusion: - This way, Implemented the artificial immune pattern recognition to perform a task of structure damage Classification .

Lab Assignment No.	8
Title	Implement DEAP (Distributed Evolutionary Algorithms) using Python
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Distributed System
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 08

Title: Implement DEAP (Distributed Evolutionary Algorithms) using Python

Problem Statement:. Develop a distributed evolutionary algorithm using DEAP (Distributed Evolutionary Algorithms in Python) to optimize a complex problem that requires intensive computational resources.

Prerequisite:

Basics of Python

Software Requirements: Jupyter

Hardware Requirements:

PIV, 2GB RAM, 500 GB HDD

Learning Objectives:

1. Implement a scalable and efficient distributed evolutionary algorithm using DEAP to solve the optimization problem.
2. Improve the optimization process by leveraging parallel processing capabilities and distributing the workload across multiple nodes.

Outcomes:

After completion of this assignment students are able to understand how to developed distributed evolutionary algorithm will significantly reduce the optimization time and enable the solution of larger and more complex optimization problems.

Theory:

DEAP (Distributed Evolutionary Algorithms in Python) is a framework for building and analyzing distributed evolutionary algorithms. It provides tools for implementing genetic algorithms and other evolutionary computation techniques in a flexible and easy-to-use manner. DEAP allows users to parallelize their evolutionary algorithms across multiple processors or computers, making it suitable for tackling complex optimization problems that require significant computational resources.

DEAP provides a wide range of tools and functionalities to facilitate the implementation and experimentation of evolutionary algorithms. Some key features of DEAP include:

1. **Genetic Operators:** DEAP provides a set of standard genetic operators such as crossover, mutation, and selection, which can be easily customized and combined to suit the problem being solved.

2. **Fitness Evaluation:** DEAP allows users to define custom fitness functions to evaluate the quality of candidate solutions.
3. **Population Management:** DEAP provides tools for managing populations of candidate solutions, including initialization methods and selection strategies.
4. **Statistics and Logging:** DEAP includes utilities for tracking and logging the evolution of candidate solutions over time, including statistics such as average fitness and best fitness.
5. **Parallelization:** DEAP supports parallelization of evolutionary algorithms, allowing users to take advantage of multi-core processors and distributed computing environments to speed up optimization tasks.
6. **Integration:** DEAP can be easily integrated with other Python libraries and frameworks, making it a versatile tool for a wide range of optimization problems.

Overall, DEAP provides a convenient and efficient way to implement evolutionary algorithms in Python, making it a popular choice for researchers and practitioners working in the field of evolutionary computation.

Use and Applications:

- DEAP is used to solve optimization problems where traditional methods may be impractical or inefficient.
- It is commonly used in various fields such as engineering, biology, finance, and data science for optimization tasks.
- Applications include parameter optimization, feature selection, function optimization, and more.

Implementation Using Python:

To implement DEAP in Python, first, install the DEAP package using pip:

```
import random
from deap import base, creator, tools, algorithms

# Define the evaluation function (minimize a simple mathematical function)
def eval_func(individual):
```

```
    # Example evaluation function (minimize a quadratic function)
    return sum(x ** 2 for x in individual),

# DEAP setup
creator.create("FitnessMin", base.Fitness, weights=(-1.0,))
creator.create("Individual", list, fitness=creator.FitnessMin)

toolbox = base.Toolbox()

# Define attributes and individuals
toolbox.register("attr_float", random.uniform, -5.0, 5.0)  # Example: Float values between -5 and 5
toolbox.register("individual", tools.initRepeat, creator.Individual, toolbox.attr_float, n=3)  # Example: 3-dimensional individual
toolbox.register("population", tools.initRepeat, list, toolbox.individual)

# Evaluation function and genetic operators
toolbox.register("evaluate", eval_func)
toolbox.register("mate", tools.cxBlend, alpha=0.5)
toolbox.register("mutate", tools.mutGaussian, mu=0, sigma=1, indpb=0.2)
toolbox.register("select", tools.selTournament, tournsize=3)

# Create population
population = toolbox.population(n=50)

# Genetic Algorithm parameters
generations = 20

# Run the algorithm
for gen in range(generations):
    offspring = algorithms.varAnd(population, toolbox, cxpb=0.5, mutpb=0.1)
```

```
    fits = toolbox.map(toolbox.evaluate, offspring)
    for fit, ind in zip(fits, offspring):
        ind.fitness.values = fit

    population = toolbox.select(offspring, k=len(population))

# Get the best individual after generations
best_ind = tools.selBest(population, k=1)[0]
best_fitness = best_ind.fitness.values[0]

print("Best individual:", best_ind)
print("Best fitness:", best_fitness)
```

```
Best individual: [-0.0002592913968913620 4, -0.007494927037045774, -0.00031377093359364716]
Best fitness: 5.6339615517909845e-05
```

USE JUPYTER NOTEBOOK

Conclusion:- This way DEAP (Distributed Evolutionary Algorithms) using Python is done.

Lab Assignment No.	09
Title	Python Implementation of Ant Colony Optimization for the Traveling Salesman Problem
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Distributed System
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 09

Title: - Python Implementation of Ant Colony Optimization for the Traveling Salesman Problem

Problem Statement: - To find the shortest route for a salesman to visit a set of cities exactly once and return to the original city, the task is to implement Ant Colony Optimization for the Traveling Salesman Problem using Python.

Prerequisite: - Basics of Python

Software Requirements: - Jupyter Notebook or any Python IDE

Required Python libraries: - (numpy)

Hardware Requirements: - PIV, 2GB RAM, 500 GB HDD

Learning Objectives: -

1. Understand the concept of the Traveling Salesman Problem and its significance in optimization.

2. Implement the Ant Colony Optimization algorithm to find an approximate solution to the Traveling Salesman Problem using Python.

Outcomes: -

After completion of this assignment students are able to understand how to apply metaheuristic algorithms like Ant Colony Optimization to solve real-world optimization problems efficiently.

Theory: -

- **Traveling Salesman Problem (TSP):**

The Traveling Salesman Problem (TSP) is a classic optimization problem in computer science and operations research. It involves finding the shortest possible route that visits a set of cities exactly once and returns to the starting city. Mathematically, given a list of cities and the distances between each pair of cities, the objective is to find the shortest possible tour that visits each city exactly once and returns to the starting city.

- **Ant Colony Optimization (ACO):**

Ant Colony Optimization (ACO) is a metaheuristic algorithm that is inspired by the foraging behavior of real ants. In nature, ants communicate with each other through pheromone trails, which they deposit on the ground as they move. Ants tend to follow paths with stronger pheromone trails, and over time, these trails are reinforced by more ants, leading to the emergence of efficient routes between food sources and the ant colony.

- **Basic Concepts of ACO:**

- Ants: In ACO, artificial ants are used to construct candidate solutions to the optimization problem. Each ant builds a solution by iteratively selecting the next city to visit based on a combination of pheromone trails and heuristic information.

- Pheromone Trails: Pheromone trails represent the artificial analog of the pheromone trails laid by real ants. They are used to guide the ants' exploration of the solution space. Initially, pheromone trails are assigned equal probabilities for all edges. As ants construct solutions, they deposit pheromone on the edges they traverse, with the amount of pheromone proportional to the quality of the solution.

- **Heuristic Information**: In addition to pheromone trails, ants also use heuristic information to guide their decision-making process. Heuristic information typically reflects the desirability of visiting a particular city based on factors such as the distance between cities or the attractiveness of the city.

- **Algorithm Steps:**

The basic steps of the Ant Colony Optimization algorithm for solving the TSP can be summarized as follows:

- **Initialization:** Initialize the pheromone trails and optionally the heuristic information.

- **Ant Movement**: Each ant constructs a solution by iteratively selecting the next city to visit based on a combination of pheromone trails and heuristic information.

- **Pheromone Update:** After all ants have constructed solutions, update the pheromone trails based on the quality of the solutions.

- **Termination:** Repeat the ant movement and pheromone update steps for a predefined number of iterations or until convergence criteria are met.

- **Convergence and Solution Quality:**

- ACO iteratively refines the solution space by updating the pheromone trails based on the quality of the solutions constructed by the ants.

- Over time, the pheromone trails converge towards the optimal solution, as ants tend to prefer paths with stronger pheromone trails.

- The quality of the final solution obtained by ACO depends on various factors such as the number of ants, the exploration-exploitation balance, and the pheromone evaporation rate.

By implementing Ant Colony Optimization for the Traveling Salesman Problem in Python, we can explore the behavior of artificial ants and their ability to find approximate solutions to combinatorial optimization problems efficiently. This practical exercise not only provides insights into the workings of metaheuristic algorithms but also equips us with valuable tools for solving real-world optimization challenges.

Code:-

```
import numpy as np


class AntColony:
    def __init__(self, distances, n_ants, n_best, n_iterations, decay, alpha=1, beta=1):
        self.distances = distances
        self.pheromone = np.ones(self.distances.shape) / len(distances)
        self.all_inds = range(len(distances))
        self.n_ants = n_ants
        self.n_best = n_best
        self.n_iterations = n_iterations
        self.decay = decay
        self.alpha = alpha
```

```
    self.beta = beta

def run(self):
    shortest_path = None
    shortest_path_length = np.inf
    for i in range(self.n_iterations):
        all_paths = self.gen_all_paths()
        self.spread_pheromone(all_paths, self.n_best, shortest_path, shortest_path_length)
        shortest_path, shortest_path_length = self.get_shortest(all_paths)
        self.pheromone *= self.decay

    return shortest_path, shortest_path_length

def spread_pheromone(self, all_paths, n_best, shortest_path, shortest_path_length):
    sorted_paths = sorted(all_paths, key=lambda x: x[1])
    for path, dist in sorted_paths[:n_best]:
        for move in path:
            self.pheromone[move] += 1.0 / self.distances[move]

def gen_path_dist(self, path):
    total_dist = 0
    for ele in path:
        total_dist += self.distances[ele]
    return total_dist

def gen_all_paths(self):
    all_paths = []
    for i in range(self.n_ants):
        path = self.gen_path(0)
        all_paths.append((path, self.gen_path_dist(path)))
    return all_paths

def gen_path(self, start):
    path = []
    visited = set()
```

```
        visited.add(start)
        prev = start
        for i in range(len(self.distances) - 1):
            move = self.pick_move(self.pheromone[prev], self.distances[prev], visited)
            path.append((prev, move))
            prev = move
            visited.add(move)
        path.append((prev, start))  # going back to where we started
        return path

    def pick_move(self, pheromone, dist, visited):
        pheromone = np.copy(pheromone)
        pheromone[list(visited)] = 0

        row = pheromone ** self.alpha * ((1.0 / dist) ** self.beta)

        norm_row = row / row.sum()
        move = np.random.choice(self.all_inds, 1, p=norm_row)[0]
        return move

    def get_shortest(self, all_paths):
        best_path = None
        best_path_length = np.inf
        for path, dist in all_paths:
            if dist < best_path_length:
                best_path_length = dist
                best_path = path
        return best_path, best_path_length

if __name__ == '__main__':
    # Define the distance matrix
    distances = np.array([[np.inf, 10, 15, 20],
                          [10, np.inf, 35, 25],
                          [15, 35, np.inf, 30],
                          [20, 25, 30, np.inf]])
```

```
# Initialize the Ant Colony Optimization algorithm
ant_colony = AntColony(distances, n_ants=3, n_best=2, n_iterations=100, decay=0.95)

# Run the algorithm
shortest_path, shortest_path_length = ant_colony.run()

print("Shortest Path:", shortest_path)
print("Shortest Path Length:", shortest_path_length)
```

Output:-

```
Shortest Path: [(0, 1), (1, 3), (3, 2), (2, 0)]
Shortest Path Length: 80.0
```

Conclusion: - In conclusion, implementing Ant Colony Optimization for the Traveling Salesman Problem in Python offers a powerful approach to approximate solutions efficiently, demonstrating the effectiveness of metaheuristic algorithms in solving combinatorial optimization problems.

Lab Assignment No.	10
Title	Create and Art with Neural style transfer on given image using deep learning
Roll No.	
Class	BE
Date of Completion	
Subject	Computer Laboratory-III-Distributed System
Assessment Marks	
Assessor's Sign	

ASSIGNMENT No: 10

Title: - Create and Art with Neural style transfer on given image using deep learning.

Problem Statement: - To create an artwork using neural style transfer on a given image utilizing deep learning in distributed computing, aiming to generate a visually captivating piece that merges reality with AI-generated dreamscapes.

Prerequisite: - Basics of Python

Software Requirements: - TensorFlow or PyTorch framework, CUDA Toolkit for GPU acceleration, Image processing software for pre- and post-processing

Required Python libraries: - - TensorFlow or PyTorch, NumPy, OpenCV, Matplotlib

Hardware Requirements: - PIV, 2GB RAM, 500 GB HDD

Learning Objectives: -
1. Gain practical experience in implementing neural style transfer using deep learning frameworks.
2. Understand the significance of distributed computing for accelerating complex deep learning tasks.

Outcomes: -
After completion of this assignment students are able to develop proficiency in applying neural style transfer to transform images into visually striking artworks.

Theory:
Neural Style Transfer (NST) is a technique in deep learning that combines the content of one image with the style of another image to create visually appealing artworks. The process involves optimizing the pixels of a given content image to simultaneously match the content features of a content image and the style features of a style image. This optimization is achieved by minimizing a specific loss function.

1. **Content Representation:**
- The content of an image is captured by the high-level features extracted from a pre-trained convolutional neural network (CNN). Common choices for the network include VGG, ResNet, or Inception.
- The content loss is calculated as the mean squared error (MSE) between the feature maps of the content image and the generated image at a particular layer of the CNN.

2. **Style Representation:**
- The style of an image refers to its texture, colors, and visual patterns, which are captured by the correlations between different feature maps across various layers of the CNN.
- The style loss is computed as the Gram matrix of the feature maps at each chosen layer. The Gram matrix represents the correlations between the feature maps, capturing the texture and style information of the image.

3. **Total Variation Loss:**
- To ensure smoothness and continuity in the generated image, a total variation loss term is often added to the optimization function. This loss encourages neighboring pixels to have similar values, reducing noise and artifacts in the final output.

4. **Optimization Process:**
- The optimization process aims to minimize the combined loss function, which consists of the content loss, style loss, and total variation loss. This is typically achieved using gradient descent or its variants.
- By iteratively updating the pixel values of the generated image, NST seeks to find an image that preserves the content of the content image while adopting the style of the style image.

5. **Layer Selection and Weighting:**
- The choice of layers for computing the content and style losses, as well as their respective weights in the overall loss function, significantly impact the final result. Lower layers capture low-level features (e.g., edges), while higher layers capture more abstract features (e.g., textures).
- Experimentation with different layer combinations and weights allows for fine-tuning the style transfer process to achieve desired artistic effects.

In summary, neural style transfer harnesses the power of deep convolutional neural networks to blend the content and style of two images, resulting in visually appealing artworks that combine the content of one image with the stylistic characteristics of another. By optimizing a loss function that balances content preservation, style transfer, and image smoothness, NST offers a versatile tool for creative expression and artistic manipulation of digital imagery.

Code:-

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.applications import vgg19
from tensorflow.keras.preprocessing import image as keras_image
from tensorflow.keras import backend as K
import numpy as np
import matplotlib.pyplot as plt

# Function to load and preprocess an image
def load_and_preprocess_image(image_path, img_height, img_width):
    img = keras_image.load_img(image_path, target_size=(img_height, img_width))
    img = keras_image.img_to_array(img)
    img = np.expand_dims(img, axis=0)
    img = vgg19.preprocess_input(img)
    return img

# Function to convert a tensor into a valid image
def tensor_to_image(tensor):
    tensor = tensor * 255
    tensor = np.clip(tensor, 0, 255).astype('uint8')
```

```
    return tensor[0]

# Define paths to style and content images using raw string (r-prefix) or escaped backslashes
style_image_path =  r'content_image.jpg'
content_image_path = r'style_image.jpg'
# Constants for image dimensions
img_height = 400
img_width = 400

# Load style and content images
style_image = load_and_preprocess_image(style_image_path, img_height, img_width)
content_image = load_and_preprocess_image(content_image_path, img_height, img_width)

import tensorflow as tf

def style_loss(style_targets, style_outputs):
    loss = tf.zeros(shape=())  # Initialize loss tensor
    num_layers = len(style_targets)  # Number of style layers

    for i in range(num_layers):
        target_features = style_targets[i]
        output_features = style_outputs[i]

        # Compute Gram matrices for target and output features
        target_gram_matrix = gram_matrix(target_features)
        output_gram_matrix = gram_matrix(output_features)

        # Compute mean squared difference between Gram matrices
        layer_loss = tf.reduce_mean(tf.square(target_gram_matrix - output_gram_matrix))

        # Accumulate layer loss
        loss += layer_loss

    # Average loss across all style layers
    total_loss = loss / float(num_layers)

    return total_loss

def gram_matrix(tensor):
    # Get shape of the tensor (batch_size, height, width, channels)
    batch_size, height, width, channels = tensor.get_shape().as_list()

    # Reshape tensor to combine batch_size and spatial dimensions
    reshaped_tensor = tf.reshape(tensor, [batch_size * height * width, channels])

    # Compute Gram matrix: A^T * A where A is the reshaped tensor
    gram = tf.matmul(reshaped_tensor, reshaped_tensor, transpose_a=True)

    # Normalize Gram matrix by the number of elements
    num_elements = tf.cast(batch_size * height * width * channels, tf.float32)
```

```
    gram /= num_elements

    return gram
# Use tf.Variable to create a trainable image (initialized with content image)
generated_image = tf.Variable(content_image, dtype=tf.float32)

# Optimizer and training loop
optimizer = tf.optimizers.Adam(learning_rate=0.02, beta_1=0.99, epsilon=1e-1)


# Convert the final generated image tensor to a valid image
final_image = tensor_to_image(generated_image.numpy())

# Display the final stylized image
plt.imshow(final_image)
plt.axis('off')
plt.show()
```

Output:-

Conclusion: - In conclusion, neural style transfer offers a powerful and versatile technique for seamlessly blending content and style, paving the way for innovative artistic expression in digital imagery.