KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

NAAC Accredited Grade B+

(Affiliated to University of Mumbai)

KALAMBOLI, 410 218 MAHARASHTRA

2024-2025

DEPARTMENT OF INFORMATION TECHNOLOGY

PRACTICAL BOOK

ON

BIG DATA ANALYTICS

Submitted to,

UNIVERSITY OF MUMBAI

BY

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Seat No:- 1312671

MASTER OF SCIENCE INFORMATION TECHNOLOGY

PART – I (SEMESTER - II)

(2024-2025)

KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

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KALAMBOLI, 410 218 MAHARASHTRA

CERTIFICATE

This is to certify that

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in M.sc.(Information Technolgy) during the academic year 20 - 20 as per the syllabus prescribed by the University of mumbai.

Prof. In Charge
Date:_____

Head of Deapartment
Date:_____

External Examiner
Date:_____

Principal Sign
Date:_____

College Stamp

INDEX

Practical 1

Aim: -Install, configure and run Hadoop and HDFS and explore HDFS on Windows

Code:

Steps to Install Hadoop :

1. Install Java JDK 1.8
2. Download Hadoop and extract and place under C drive
3. Set Path in Environment Variables
4. Config files under Hadoop directory
5. Create folder data node and name node under data directory
6. Edit HDFS and YARN files
7. Set Java Home environment in Hadoop environment
8. Setup Complete. Test by executing start-all.cmd

There are two ways to install Hadoop, i.e.

9. Single node
10. Multi node

Here, we use multi node cluster.

1. **Install Java**

11. – Java JDK Link to download (https://www.oracle.com/java/technologies/javase-jdk8-downloads.html)
12. – extract and install Java in C:\Java
13. – open cmd and type -> javac -version

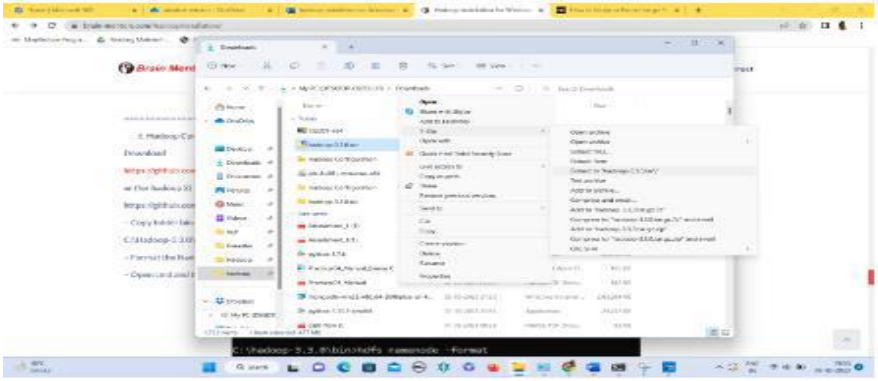
```
C:\Users>cd Beena

C:\Users\Beena>java -version
java version "1.8.0_361"
Java(TM) SE Runtime Environment (build 1.8.0_361-b09)
Java HotSpot(TM) 64-Bit Server VM (build 25.361-b09, mixed mode)
```

2. **Download Hadoop**

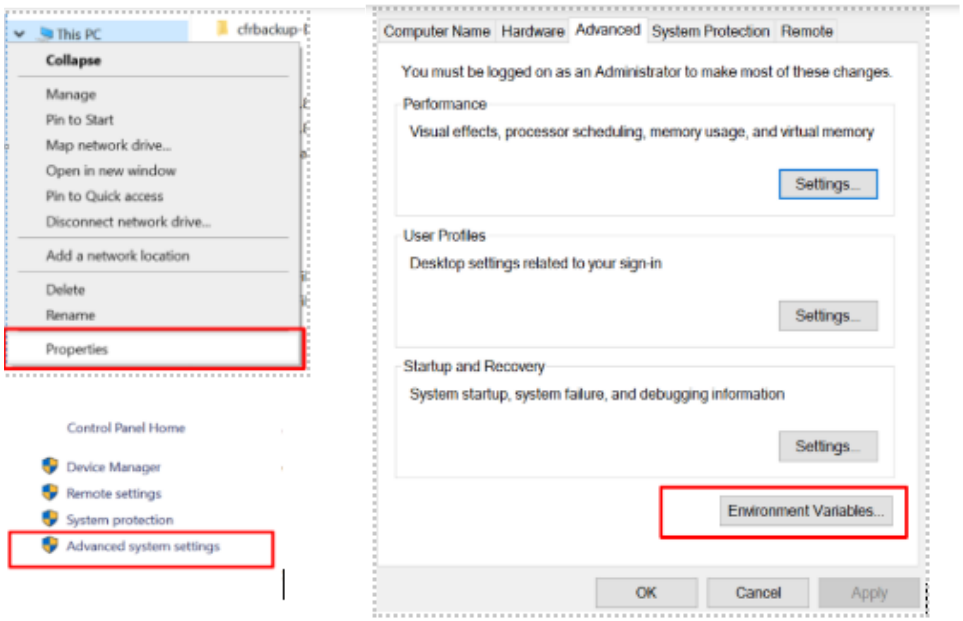
Link: https://www.apache.org/dyn/closer.cgi/hadoop/common/hadoop-3.3.0/hadoop-3.3.0.tar.gz

- right click .rar.gz file -> show more options -> 7-zip->and extract to C:\Hadoop-3.3.0\

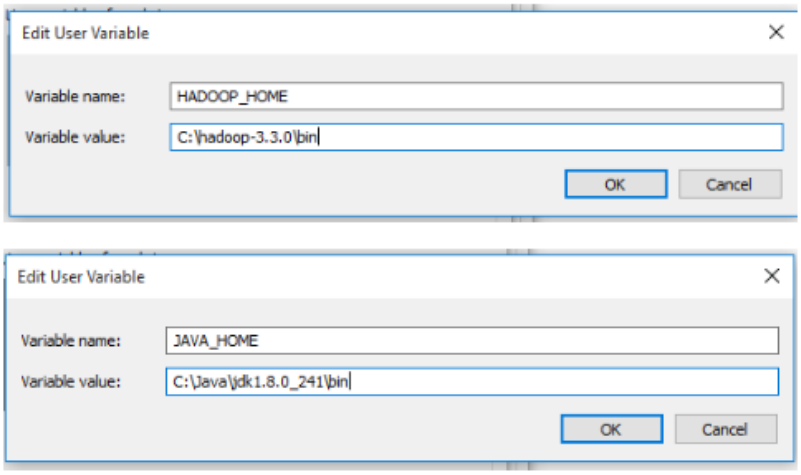


3. **Set the path JAVA_HOME Environment variable**

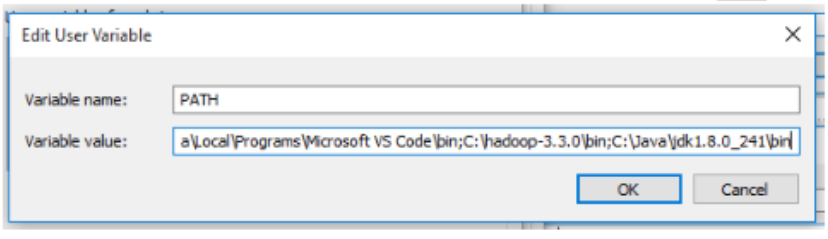
4. **Set the path HADOOP_HOME Environment variable**



Click on New to both user variables and system variables.



Click on user variable **-> path -> edit-> add path for Hadoop and java up to 'bin'**



Click Ok, Ok, Ok.

5.**Configurations**

Edit file -> **C:/Hadoop-3.3.0/etc/hadoop/core-site.xml**

paste the xml code in folder and save

==========

<configuration>

<property>

<name>fs.defaultFS</name>

<value>hdfs://localhost:9000</value>

</property>

</configuration>

==========

Rename "mapred-site.xml. Template" to "mapred-site.xml" and edit this file C:/Hadoop-3.3.0/etc/hadoop/mapred-site.xml, paste xml code and save this file.

==========

<configuration>

<property>

<name>mapreduce.framework.name</name>

<value>yarn</value>

</property>

</configuration>

==========

Create folder "data" under "C:\Hadoop-3.3.0"

Create folder "datanode" under "C:\Hadoop-3.3.0\data"

Create folder "namenode" under "C:\Hadoop-3.3.0\data"

==========

Edit file C:\Hadoop-3.3.0/etc/hadoop/hdfs-site.xml,

paste xml code and save this file.

<configuration>

<property>

<name>dfs.replication</name>

<value>1</value>

</property>

<property>

<name>dfs.namenode.name.dir</name>

<value>/hadoop-3.3.0/data/namenode</value>

</property>

<property>

<name>dfs.datanode.data.dir</name>

<value>/hadoop-3.3.0/data/datanode</value>

</property>

</configuration>

==========

Edit file C:/Hadoop-3.3.0/etc/hadoop/yarn-site.xml,

paste xml code and save this file.

<configuration>

</configuration>

==========

6. **Edit file C:/Hadoop-3.3.0/etc/hadoop/hadoop-env.cmd**

Find "JAVA_HOME=%JAVA_HOME%" and replace it as

set JAVA_HOME="C:\Java\jdk1.8.0_361"

==========

7. **Download "redistributable" package**

Download and run VC_redist.x64.exe: This is a "redistributable" package of the Visual C runtime code for 64-bit applications, from Microsoft. It contains certain shared code that every application written with Visual C expects to have available on the Windows computer it runs on.

==========

8. **Hadoop Configurations**

Download bin folder from

https://github.com/s911415/apache-hadoop-3.1.0-winutils

--- Copy the bin folder to c:\hadoop-3.3.0. Replace the existing bin folder.

==========

9. **copy "hadoop-yarn-server-timelineservice-3.0.3.jar" from ~\hadoop-3.0.3\share\hadoop\yarn\timelineservice to ~\hadoop-3.0.3\share\hadoop\yarn folder.**

==========

10. **Format the NameNode**

– Open cmd 'Run as Administrator' and type command "hdfs namenode –format"

```
Microsoft Windows [Version 10.0.22621.1265]
(c) Microsoft Corporation. All rights reserved.

C:\Windows\System32>cd\hadoop-3.3.0\bin

C:\hadoop-3.3.0\bin>hdfs namenode -format
```

```
2023-03-07 21:31:34,685 INFO namenode.FSImageFormatProtobuf: Saving image file C:\hadoop-3.3.0\data\namenode\current\fsi
mage.ckpt_0000000000000000000 using no compression
2023-03-07 21:31:34,844 INFO namenode.FSImageFormatProtobuf: Image file C:\hadoop-3.3.0\data\namenode\current\fsimage.ck
pt_0000000000000000000 of size 400 bytes saved in 0 seconds .
2023-03-07 21:31:34,860 INFO namenode.NNStorageRetentionManager: Going to retain 1 images with txid >= 0
2023-03-07 21:31:34,869 INFO namenode.FSImage: FSImageSaver clean checkpoint: txid=0 when meet shutdown.
2023-03-07 21:31:34,870 INFO namenode.NameNode: SHUTDOWN_MSG:
/************************************************************
SHUTDOWN_MSG: Shutting down NameNode at DESKTOP-OL8EULH/192.168.1.19
************************************************************/
```

11. **Testing**

– Open cmd 'Run as Administrator' and change directory to C:\Hadoop-3.3.0\sbin

– type start-all.cmd

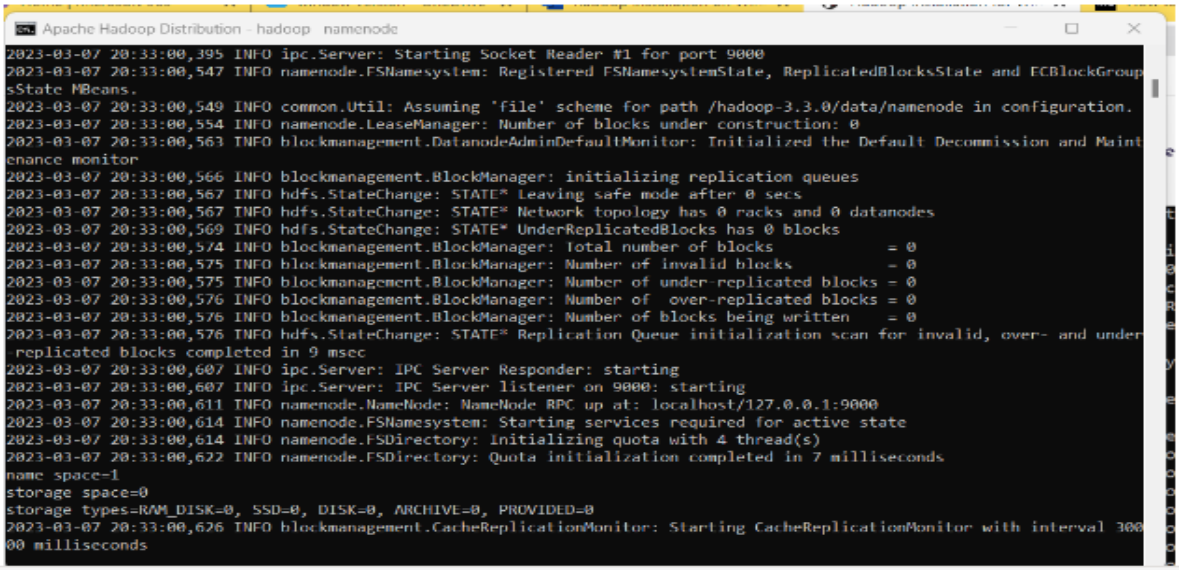
OR

- type start-dfs.cmd

– type start-yarn.cmd

```
C:\hadoop-3.3.0\sbin>start-all.cmd
This script is Deprecated. Instead use start-dfs.cmd and start-yarn.cmd
The filename, directory name, or volume label syntax is incorrect.
The filename, directory name, or volume label syntax is incorrect.
starting yarn daemons
The filename, directory name, or volume label syntax is incorrect.
```

– You will get 4 more running threads for Datanode, namenode, resource manager and node manager

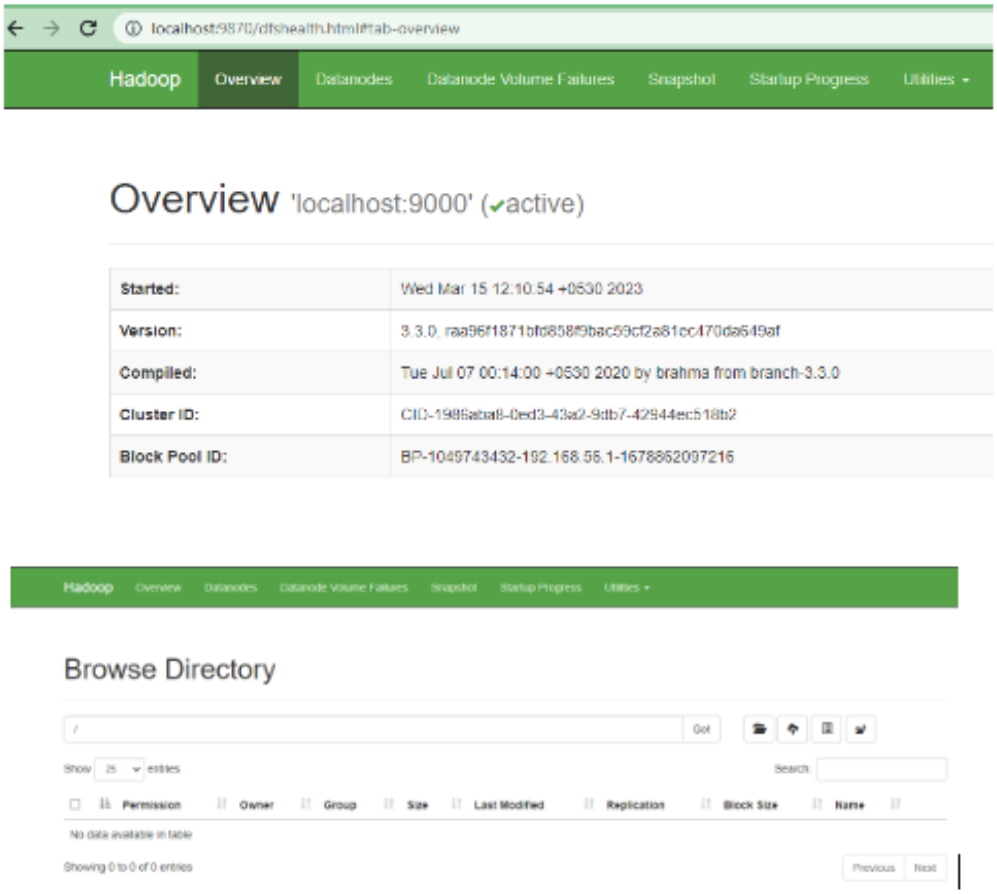


Output:

12. **Type JPS command to start-all.cmd command prompt, you will get following output.**

```
C:\hadoop-3.3.0\sbin>jps
5632 Jps
7572 DataNode
3752 ResourceManager
7992 NameNode
8028 NodeManager
```

13. **Run http://localhost:9870/ from any browser or http://localhost:50070/**



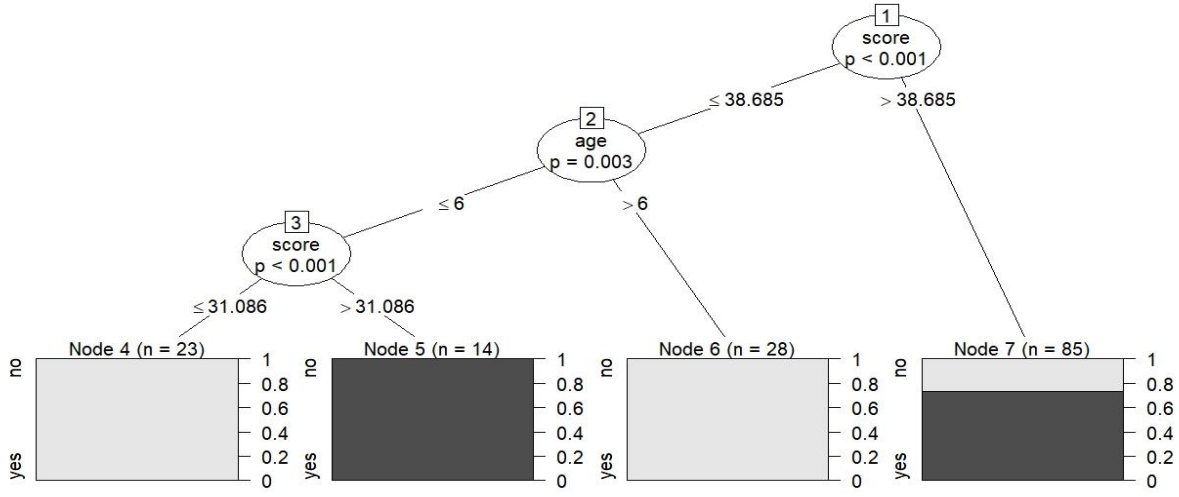
Practical 2

Aim: - Implement Decision tree classification techniques.

```
install.packages('datasets')
install.packages('caTools')
install.packages('party')
install.packages('dplyr')
install.packages('magrittr')
library(datasets)
library(caTools)
library(party)
library(dplyr)
library(magrittr)
data("readingSkills")
head(readingSkills)
sample_data = sample.split(readingSkills, SplitRatio = 0.8)
train_data <- subset(readingSkills, sample_data == TRUE)
test_data <- subset(readingSkills, sample_data == FALSE)
model<- ctree(nativeSpeaker ~ ., train_data)
plot(model)
```

Output:

```
Console   Terminal   Background Jobs
R 4.4.3 · ~/
> data("readingSkills")
> head(readingSkills)
  nativeSpeaker age shoeSize    score
1           yes   5 24.83189 32.29385
2           yes   6 25.95238 36.63105
3            no  11 30.42170 49.60593
4           yes   7 28.66450 40.28456
5           yes  11 31.88207 55.46085
6           yes  10 30.07843 52.83124
> sample_data = sample.split(readingSkills, SplitRatio = 0.8)
> train_data <- subset(readingSkills, sample_data == TRUE)
> test_data <- subset(readingSkills, sample_data == FALSE)
> model<- ctree(nativeSpeaker ~ ., train_data)
> plot(model)
>
```



Practical 3

Aim: - Implement SVM classification techniques.

```
#Code for installation of all necessary packages
install.packages("caret")
install.packages("ggplot2")
install.packages("GGally")
install.packages("psych")
install.packages("ggpubr")
install.packages("reshape")
# Code for importation of all necessary packages
library(caret)
library(ggplot2)
library(GGally)
library(psych)
library(ggpubr)
library(reshape)
# Code
df <- read.csv("C:/Users/DELL/Downloads/diabetes.csv")
head(df)
```

```
> # Code
> plot(model)
> df <- read.csv("C:/Users/DELL/Downloads/diabetes.csv")
> head(df)
  Pregnancies Glucose BloodPressure SkinThickness Insulin  BMI DiabetesPedigreeFunction Age Outcome
1           6     148            72            35       0 33.6                    0.627  50       1
2           1      85            66            29       0 26.6                    0.351  31       0
3           8     183            64             0       0 23.3                    0.672  32       1
4           1      89            66            23      94 28.1                    0.167  21       0
5           0     137            40            35     168 43.1                    2.288  33       1
6           5     116            74             0       0 25.6                    0.201  30       0
>
```

```
# Code
sum(is.na(df))
# Code
dim(df)
```

```
> # Code
> sum(is.na(df))
[1] 0
> # Code
> dim(df)
[1] 768   9
>
```

```
# Code
sapply(df, class)
# Code
summary(df) # to calculate the summary of our dataset
```

```
> summary(df) # to calculate the summary of our dataset
  Pregnancies       Glucose     BloodPressure   SkinThickness     Insulin         BMI
 Min.   : 0.00   Min.   :  0   Min.   :  0.0   Min.   : 0.0   Min.   :  0   Min.   : 0.0
 1st Qu.: 1.00   1st Qu.: 99   1st Qu.: 62.0   1st Qu.: 0.0   1st Qu.:  0   1st Qu.:27.3
 Median : 3.00   Median :117   Median : 72.0   Median :23.0   Median : 30   Median :32.0
 Mean   : 3.85   Mean   :121   Mean   : 69.1   Mean   :20.5   Mean   : 80   Mean   :32.0
 3rd Qu.: 6.00   3rd Qu.:140   3rd Qu.: 80.0   3rd Qu.:32.0   3rd Qu.:127   3rd Qu.:36.6
 Max.   :17.00   Max.   :199   Max.   :122.0   Max.   :99.0   Max.   :846   Max.   :67.1
 DiabetesPedigreeFunction      Age          Outcome
 Min.   :0.078            Min.   :21.0   Min.   :0.000
 1st Qu.:0.244            1st Qu.:24.0   1st Qu.:0.000
 Median :0.372            Median :29.0   Median :0.000
 Mean   :0.472            Mean   :33.2   Mean   :0.349
 3rd Qu.:0.626            3rd Qu.:41.0   3rd Qu.:1.000
 Max.   :2.420            Max.   :81.0   Max.   :1.000
> |
```

Code

```
a <- ggplot(data = df, aes(x = Pregnancies)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
b <- ggplot(data = df, aes(x = Glucose)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
c <- ggplot(data = df, aes(x = BloodPressure)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
d <- ggplot(data = df, aes(x = SkinThickness)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
e <- ggplot(data = df, aes(x = Insulin)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
f <- ggplot(data = df, aes(x = BMI)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
g <- ggplot(data = df, aes(x = DiabetesPedigreeFunction)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
  geom_density()
h <- ggplot(data = df, aes(x = Age)) +
  geom_histogram( color = "red", fill = "blue", alpha = 0.1) +geom_density()
ggarrange(a, b, c, d,e,f,g, h + rremove("x.text"),
          labels = c("a", "b", "c", "d","e", "f", "g", "h"),
          ncol = 3, nrow = 3)
```

```
Error fetching R version · ~/
> # Code
> a <- ggplot(data = df, aes(x = Pregnancies)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> b <- ggplot(data = df, aes(x = Glucose)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> c <- ggplot(data = df, aes(x = BloodPressure)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> d <- ggplot(data = df, aes(x = SkinThickness)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> e <- ggplot(data = df, aes(x = Insulin)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> f <- ggplot(data = df, aes(x = BMI)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> g <- ggplot(data = df, aes(x = DiabetesPedigreeFunction)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +
+   geom_density()
> h <- ggplot(data = df, aes(x = Age)) +
+   geom_histogram( color = "red", fill = "blue", alpha = 0.1) +geom_density()
> ggarrange(a, b, c, d,e,f,g, h + rremove("x.text"),
+           labels = c("a", "b", "c", "d","e", "f", "g", "h"),
+           ncol = 3, nrow = 3)
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
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`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
`stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
>
```
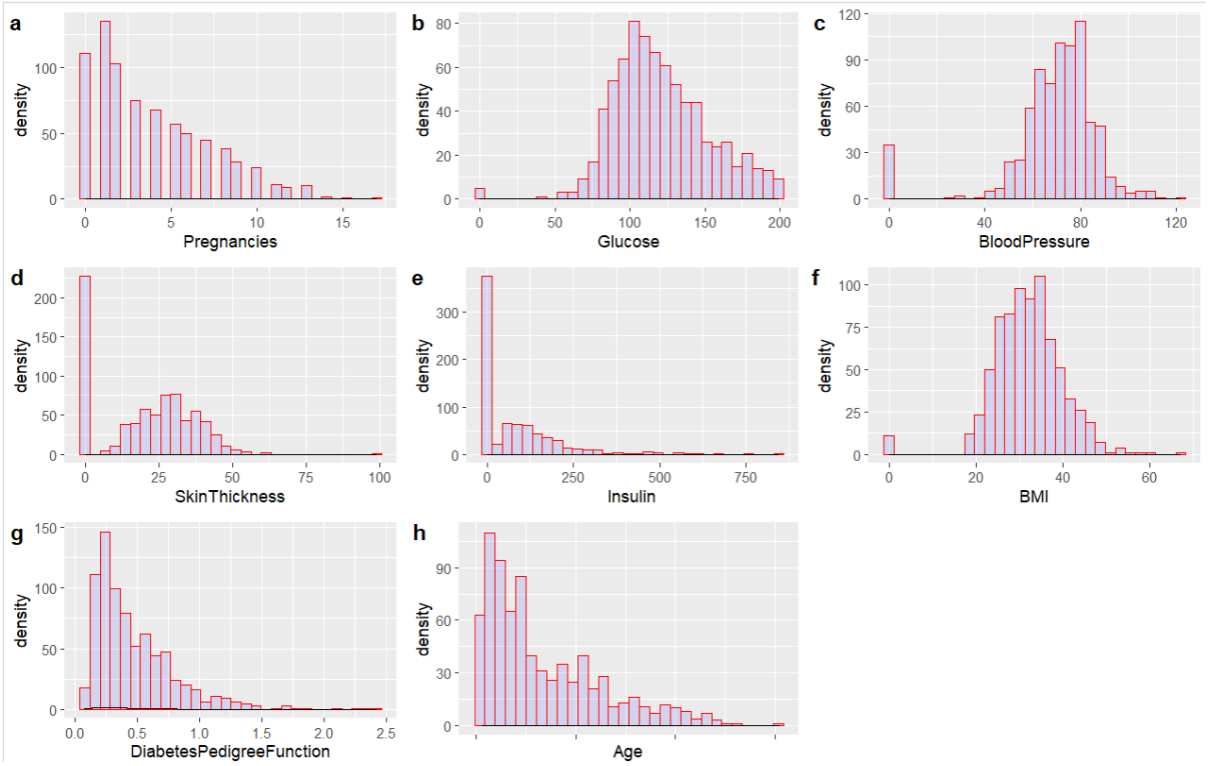
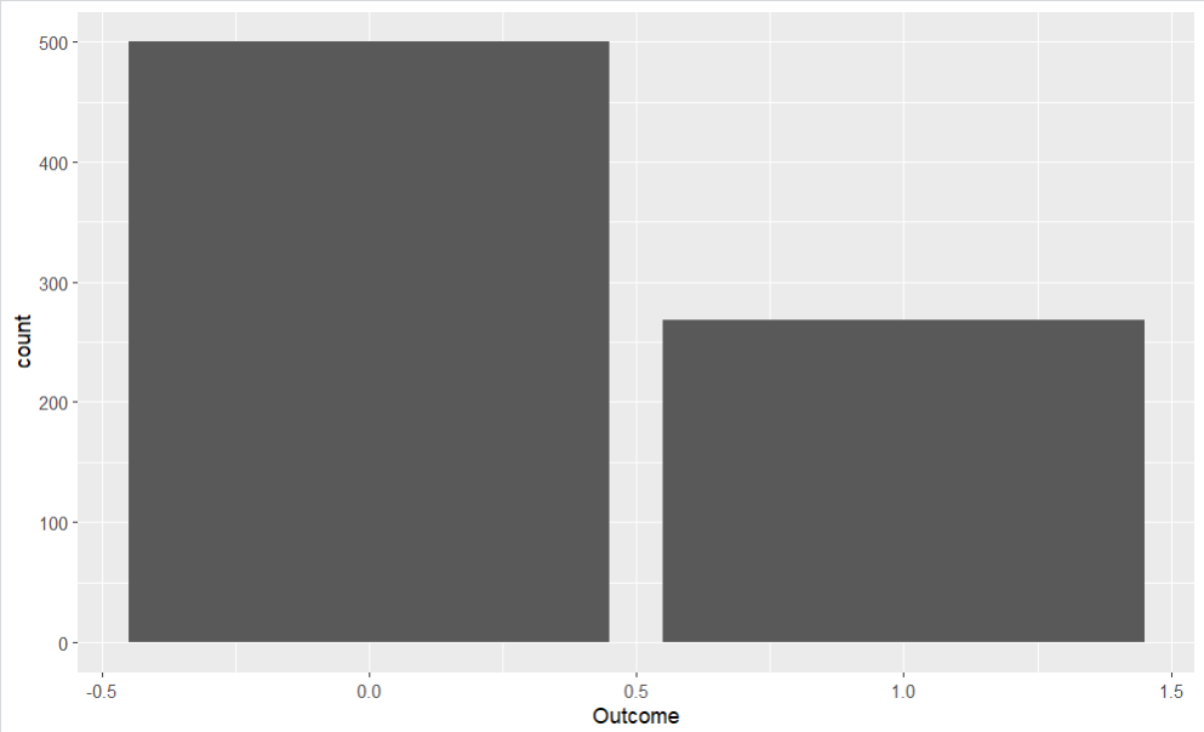
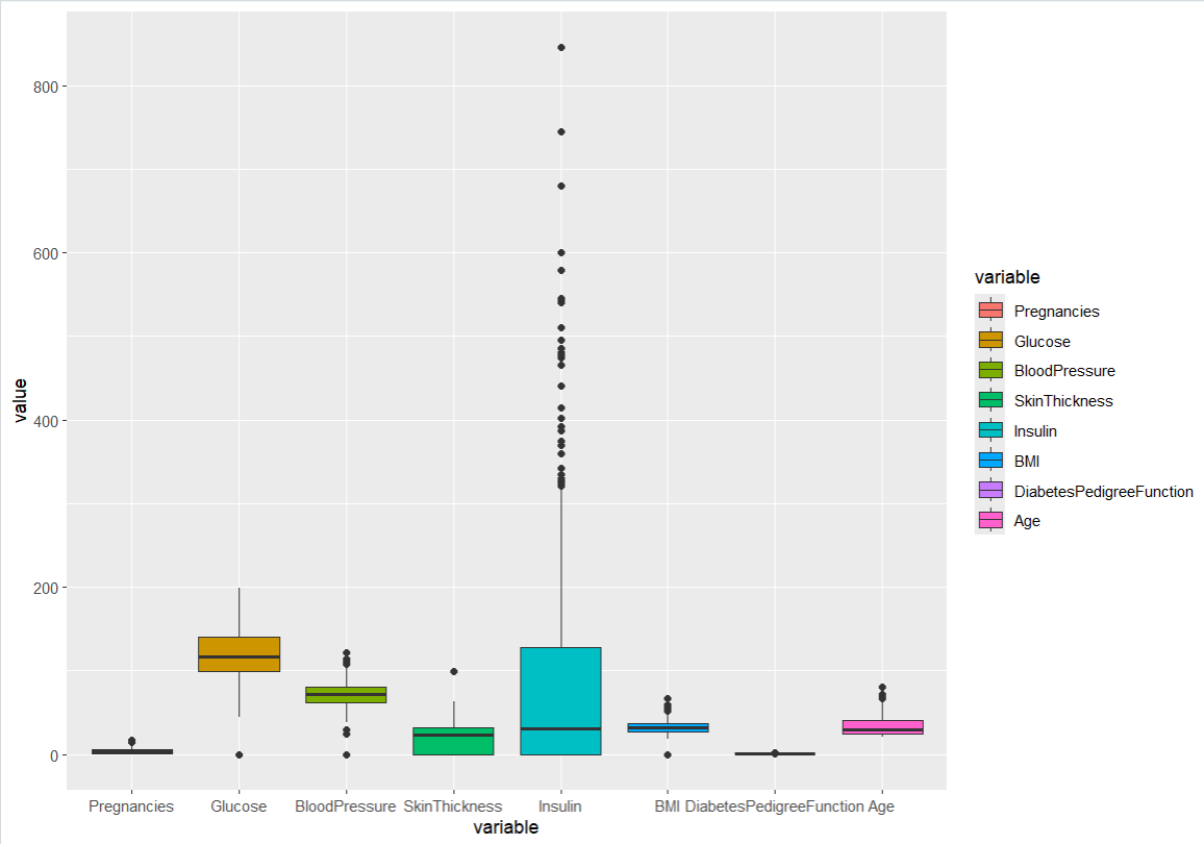



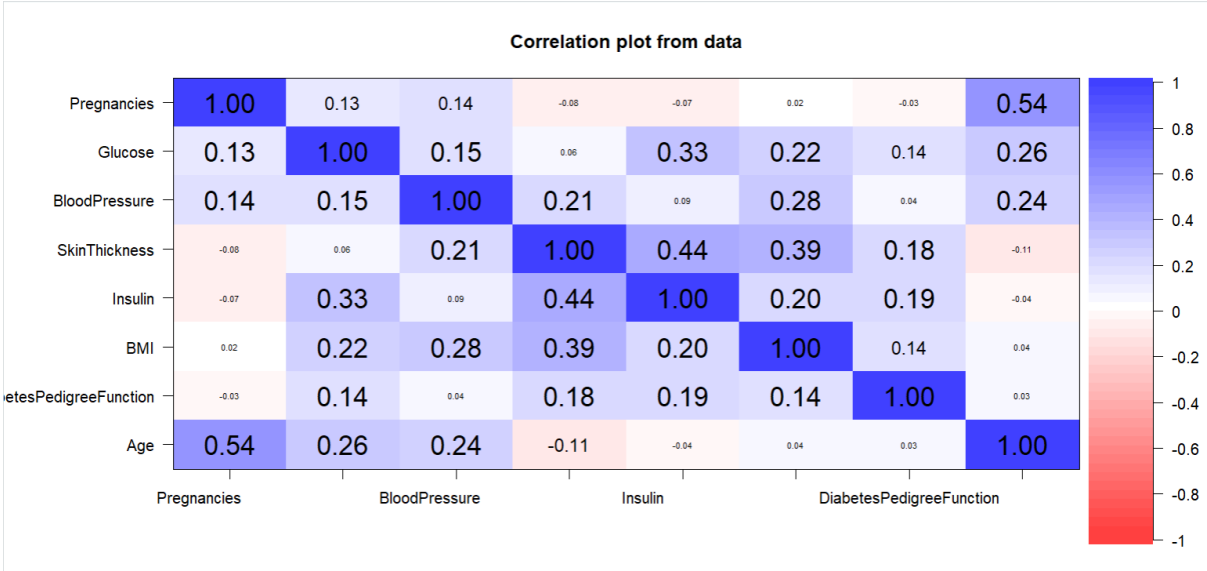
```
# Code
ggplot(data = df, aes(x =Outcome, fill = Outcome)) +
  geom_bar()
```




```
# Code to label our categorical variable as a factor
df$Outcome<- factor(df$Outcome,
                    levels = c(0, 1),
                    labels = c("Negative", "Positive"))
out <- subset(df,
              select = c(Pregnancies,Glucose,
                         BloodPressure,SkinThickness,
                         Insulin,BMI,
                         DiabetesPedigreeFunction,Age))
# Code for boxplot
ggplot(data = melt(out),
       aes(x=variable, y=value)) +
  geom_boxplot(aes(fill=variable))
```



corPlot(df[, 1:8])




```
cutoff <- createDataPartition(df$Outcome, p=0.85, list=FALSE)
# select 15% of the data for validation
testdf <- df[-cutoff,]
# use the remaining 85% of data to training and testing the models
traindf <- df[cutoff,]
# Code to train the SVM
set.seed(1234)
```

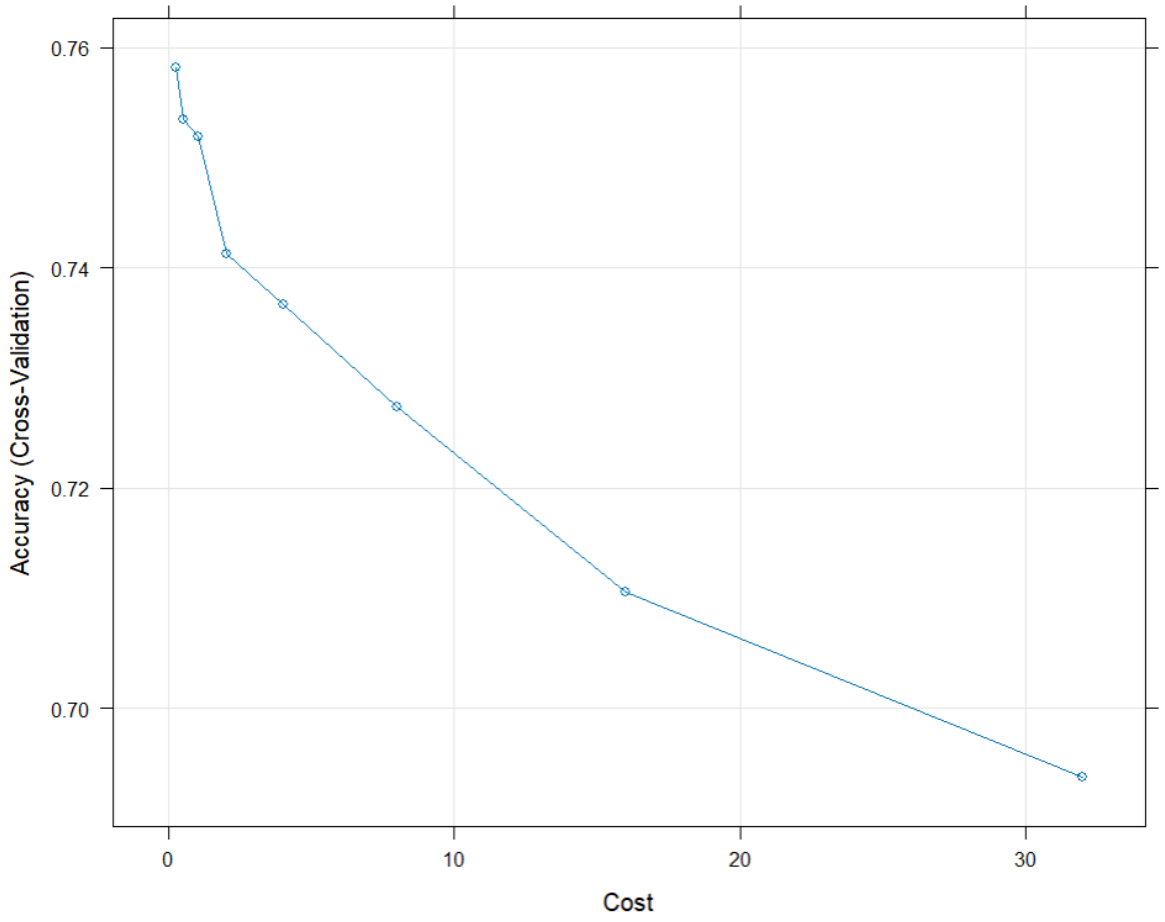
```
# set the 10 fold cross validation with AU
# to pick for us what we call the best model
control <- trainControl(method="cv",number=10, classProbs = TRUE)
metric <- "Accuracy"
model <- train(Outcome ~., data = traindf, method = "svmRadial",
          tuneLength = 8,preProc = c("center","scale"),
          metric=metric, trControl=control)
# Code for model summary
model
```

Console | Terminal | Background Jobs

Error fetching R version · ~/

```
> cutoff <- createDataPartition(df$Outcome, p=0.85, list=FALSE)
> # select 15% of the data for validation
> testdf <- df[-cutoff,]
> # use the remaining 85% of data to training and testing the models
> traindf <- df[cutoff,]
> # Code to train the SVM
> set.seed(1234)
> # set the 10 fold cross validation with AU
> # to pick for us what we call the best model
> control <- trainControl(method="cv",number=10, classProbs = TRUE)
> metric <- "Accuracy"
> model <- train(Outcome ~., data = traindf, method = "svmRadial",
+                tuneLength = 8,preProc = c("center","scale"),
+                metric=metric, trControl=control)
> # Code for model summary
> model
Support Vector Machines with Radial Basis Function Kernel

653 samples
  8 predictor
  2 classes: 'Negative', 'Positive'

Pre-processing: centered (8), scaled (8)
Resampling: Cross-Validated (10 fold)
Summary of sample sizes: 587, 588, 587, 588, 587, 589, ...
Resampling results across tuning parameters:

  C      Accuracy  Kappa
   0.25  0.758     0.448
   0.50  0.753     0.432
   1.00  0.752     0.423
   2.00  0.741     0.395
   4.00  0.737     0.385
   8.00  0.727     0.364
  16.00  0.711     0.311
  32.00  0.694     0.259

Tuning parameter 'sigma' was held constant at a value of 0.119
Accuracy was used to select the optimal model using the largest value.
The final values used for the model were sigma = 0.119 and C = 0.25.
```

# Code
plot(model)



Practical 4

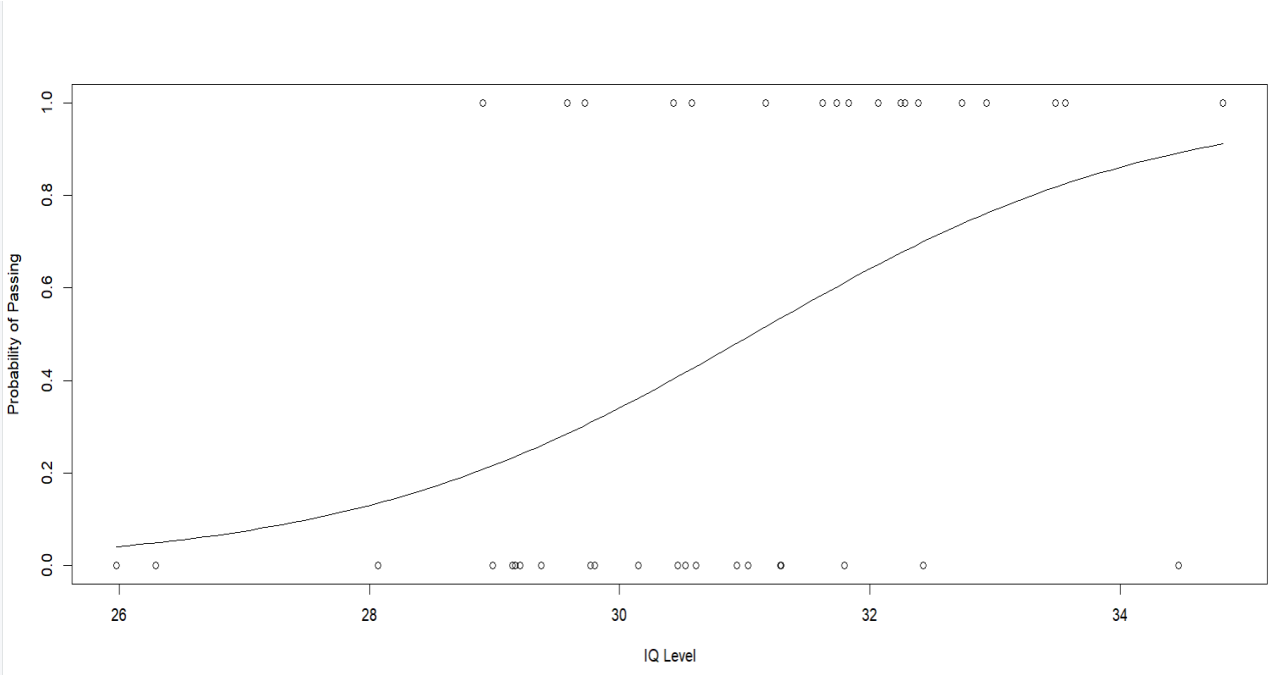
Aim: - Implement of REGRESSION MODLE.

```
# Generate random IQ values with mean = 30 and sd =2
IQ <- rnorm(40, 30, 2)
# Sorting IQ level in ascending order
IQ <- sort(IQ)
# Generate vector with pass and fail values of 40 students
result <- c(0, 0, 0, 1, 0, 0, 0, 0, 0, 1,
        1, 0, 0, 0, 1, 1, 0, 0, 1, 0,
        0, 0, 1, 0, 0, 1, 1, 0, 1, 1,
        1, 1, 1, 0, 1, 1, 1, 1, 0, 1)
# Data Frame
df <- as.data.frame(cbind(IQ, result))
# Print data frame
print(df)
```

Error fetching R version · ~/

```
> # Code
> plot(model)
> # Generate random IQ values with mean = 30 and sd =2
> IQ <- rnorm(40, 30, 2)
> # Sorting IQ level in ascending order
> IQ <- sort(IQ)
> # Generate vector with pass and fail values of 40 students
> result <- c(0, 0, 0, 1, 0, 0, 0, 0, 0, 1,
+             1, 0, 0, 0, 1, 1, 0, 0, 1, 0,
+             0, 0, 1, 0, 0, 1, 1, 0, 1, 1,
+             1, 1, 1, 0, 1, 1, 1, 1, 0, 1)
> # Data Frame
> df <- as.data.frame(cbind(IQ, result))
> # Print data frame
> print(df)
      IQ result
1  26.0      0
2  26.3      0
3  28.1      0
4  28.9      1
5  29.0      0
6  29.1      0
7  29.2      0
8  29.2      0
9  29.4      0
10 29.6      1
11 29.7      1
12 29.8      0
13 29.8      0
14 30.2      0
15 30.4      1
16 30.4      1
17 30.5      0
18 30.5      0
19 30.6      1
20 30.6      0
21 30.9      0
22 31.0      0
23 31.2      1
```

```
# Plotting IQ on x-axis and result on y-axis
plot(IQ, result, xlab = "IQ Level",
    ylab = "Probability of Passing")
# Create a logistic model
g = glm(result~IQ, family=binomial, df)
# Create a curve based on prediction using the regression model
curve(predict(g, data.frame(IQ=x), type="resp"), add=TRUE)
# Based on fit to the regression model
points(IQ, fitted(g), pch=30)
```




```
# Summary of the regression model
summary(g)
```

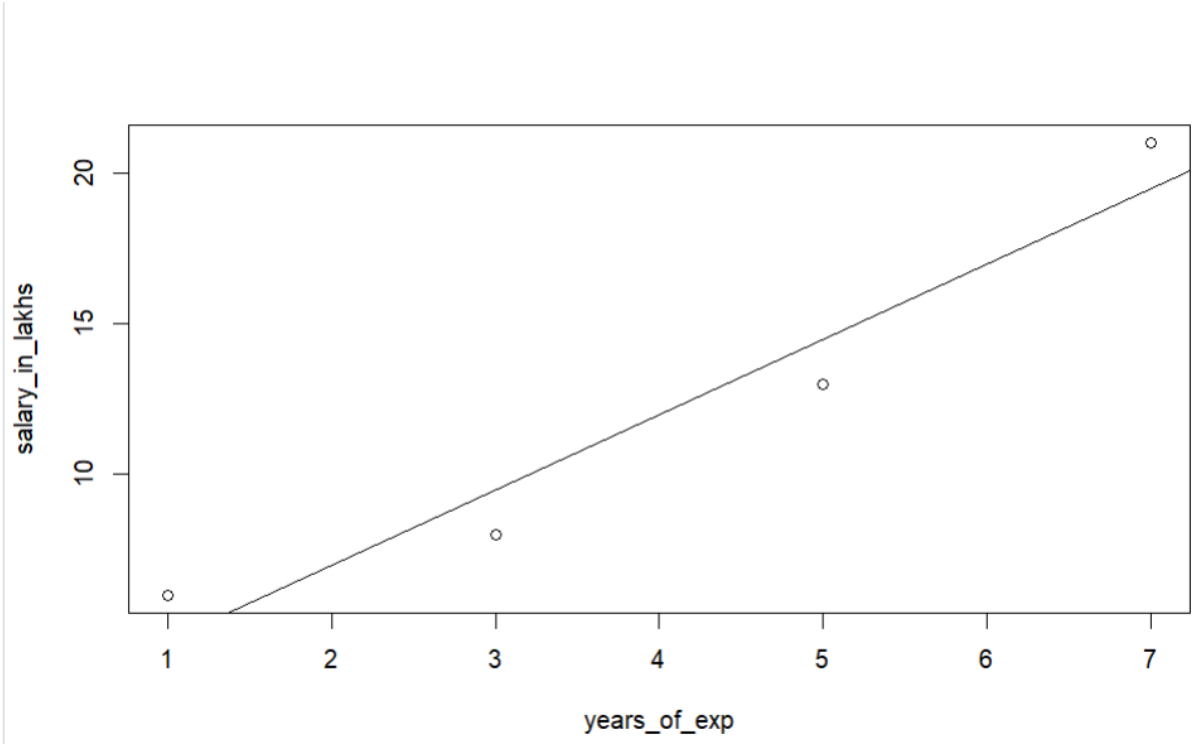
```
> summary(g)

Call:
glm(formula = result ~ IQ, family = binomial, data = df)

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -19.252      7.624   -2.53    0.012 *
IQ             0.620      0.246    2.52    0.012 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 55.352  on 39  degrees of freedom
Residual deviance: 46.336  on 38  degrees of freedom
AIC: 50.34

Number of Fisher Scoring iterations: 4
```

Practical 5

Aim:- Implement of Simple Linear regression.

```
years_of_exp = c(7,5,1,3)
salary_in_lakhs = c(21,13,6,8)
#employee.data = data.frame(satisfaction_score, years_of_exp, salary_in_lakhs)
employee.data = data.frame(years_of_exp, salary_in_lakhs)
employee.data
# Estimation of the salary of an employee, based on his year of experience and satisfaction score in
#his company.
model <- lm(salary_in_lakhs ~ years_of_exp, data = employee.data)
summary(model)
# The formula of Regression becomes
# Y = 2 + 2.5*year_of_Exp
# Visualization of Regression
plot(salary_in_lakhs ~ years_of_exp, data = employee.data)
abline(model)
```

```
> years_of_exp = c(7,5,1,3)
> salary_in_lakhs = c(21,13,6,8)
> #employee.data = data.frame(satisfaction_score, years_of_exp, salary_in_lakhs)
> employee.data = data.frame(years_of_exp, salary_in_lakhs)
> employee.data
  years_of_exp salary_in_lakhs
1            7              21
2            5              13
3            1               6
4            3               8
> # Estimation of the salary of an employee, based on his year of experience and satis
faction score in his company.
> model <- lm(salary_in_lakhs ~ years_of_exp, data = employee.data)
> summary(model)

Call:
lm(formula = salary_in_lakhs ~ years_of_exp, data = employee.data)

Residuals:
   1    2    3    4
 1.5 -1.5  1.5 -1.5

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)     2.000      2.174    0.92    0.455
years_of_exp    2.500      0.474    5.27    0.034 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.12 on 2 degrees of freedom
Multiple R-squared:  0.933,     Adjusted R-squared:  0.899
F-statistic: 27.8 on 1 and 2 DF,  p-value: 0.0342

> # The formula of Regression becomes
> # Y = 2 + 2.5*year_of_Exp
> # Visualization of Regression
> plot(salary_in_lakhs ~ years_of_exp, data = employee.data)
> abline(model)
```


salary_in_lakhs
10
15
20
1
2
3
4
5
6
7
years_of_exp

Practical 6

Aim:- Implement of Multiple Linear Regression.

```
# Importing the dataset
dataset = read.csv('C:/Users/DELL/Downloads/1000_Companies.csv')
# Encoding categorical data
dataset$State = factor(dataset$State,
                       levels = c('New York', 'California', 'Florida'),
                       labels = c(1, 2, 3))
dataset$State
# Splitting the dataset into the Training set and Test set
install.packages('caTools')
library(caTools)
set.seed(123)
split = sample.split(dataset$Profit, SplitRatio = 0.8)
training_set = subset(dataset, split == TRUE)
test_set = subset(dataset, split == FALSE)
# Feature Scaling
# training_set = scale(training_set)
# test_set = scale(test_set)
# Fitting Multiple Linear Regression to the Training set
regressor = lm(formula = Profit ~ .,
               data = training_set)
# Predicting the Test set results
y_pred = predict(regressor, newdata = test_set)
regressor
```

```
> library(caTools)
> set.seed(123)
> split = sample.split(dataset$Profit, SplitRatio = 0.8)
> training_set = subset(dataset, split == TRUE)
> test_set = subset(dataset, split == FALSE)
> # Feature Scaling
> # training_set = scale(training_set)
> # test_set = scale(test_set)
> # Fitting Multiple Linear Regression to the Training set
> regressor = lm(formula = Profit ~ .,
+                data = training_set)
> # Predicting the Test set results
> y_pred = predict(regressor, newdata = test_set)
> regressor

Call:
lm(formula = Profit ~ ., data = training_set)

Coefficients:
    (Intercept)        R.D.Spend   Administration  Marketing.Spend
      -7.12e+04         5.95e-01         1.06e+00         5.61e-02
         State2           State3
      -1.66e+02        -9.73e+02

> |
```

Practical 7

Aim:- Implement of Logistic regression.

```
install.packages("ISLR")
library(ISLR)
#load dataset
data <- ISLR::Default
print (head(ISLR::Default))
#view summary of dataset
summary(data)
#find total observations in dataset
nrow(data)
#Create Training and Test Samples
#split the dataset into a training set to train the model on and a testing set to test the model
set.seed(1)
#Use 70% of dataset as training set and remaining 30% as testing set
sample <- sample(c(TRUE, FALSE), nrow(data), replace=TRUE, prob=c(0.7,0.3))
print (sample)
train <- data[sample, ]
test <- data[!sample, ]
nrow(train)
nrow(test)
# Fit the Logistic Regression Model
# use the glm (general linear model) function and specify family="binomial"
#so that R fits a logistic regression model to the dataset
model <- glm(default~student+balance+income, family="binomial", data=train)
#view model summary
summary(model)
#Model Diagnostics
install.packages("InformationValue")
library(InformationValue)
predicted <- predict(model, test, type="response")
confusionMatrix(test$default, predicted)
```

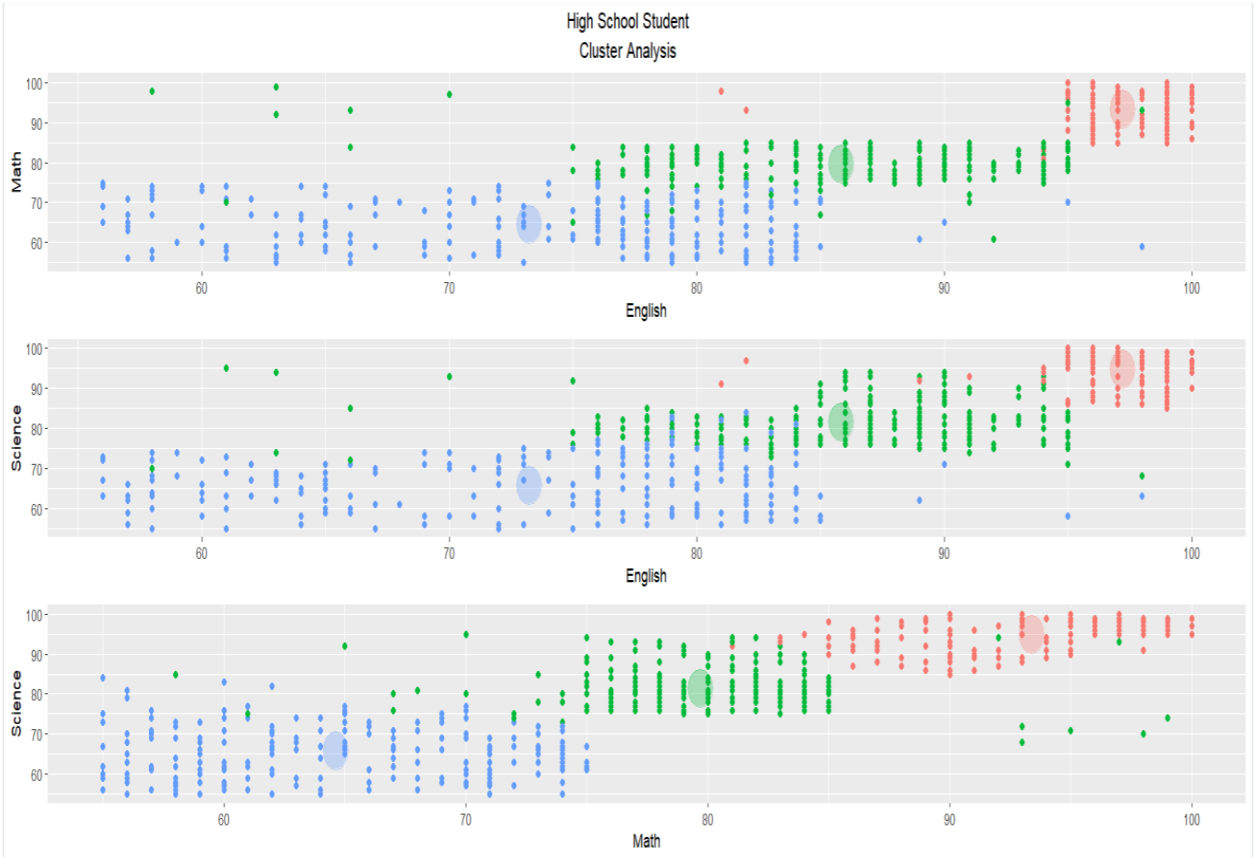
```
> predicted <- predict(model, test, type="response")
> confusionMatrix(test$default, predicted)
    No Yes
0 2912  64
1   21  39
> plotROC(test$default, predicted)
```

Practical 8

Aim:- Read a datafile grades_km_input.csv and apply k-means clustering.

```
# install required packages
install.packages("plyr")
install.packages("ggplot2")
install.packages("cluster")
install.packages("lattice")
install.packages("grid")
install.packages("gridExtra")
# Load the package
library(plyr)
library(ggplot2)
library(cluster)
library(lattice)
library(grid)
library(gridExtra)
# A data frame is a two-dimensional array-like structure in which each column contains values of one variable and each row contains one set of values from each column.
grade_input=as.data.frame(read.csv("C:/Users/DELL/Downloads/grades_km_input.csv"))
kmdata_orig=as.matrix(grade_input[, c ("Student","English","Math","Science")])
kmdata=kmdata_orig[,2:4]
kmdata[1:10,]
# the k-means algorithm is used to identify clusters for k = 1, 2, .. . , 15. For each value of k, the WSS is calculated.
wss=numeric(15)
# the option n start=25 specifies that the k-means algorithm will be repeated 25 times, each starting with k random initial centroids
for(k in 1:15)wss[k]=sum(kmeans(kmdata,centers=k,nstart=25)$withinss)
plot(1:15,wss,type="b",xlab="Number of Clusters",ylab="Within sum of square")
#As can be seen, the WSS is greatly reduced when k increases from one to two. Another substantial
#reduction in WSS occurs at k = 3. However, the improvement in WSS is fairly linear fork > 3.
km = kmeans(kmdata,3,nstart=25)
km
c( wss[3] , sum(km$withinss))
df=as.data.frame(kmdata_orig[,2:4])
df$cluster=factor(km$cluster)
centers=as.data.frame(km$centers)
g1=ggplot(data=df, aes(x=English, y=Math, color=cluster )) +
  geom_point() + theme(legend.position="right") +
  geom_point(data=centers,aes(x=English,y=Math, color=as.factor(c(1,2,3))),size=10, alpha=.3,
          show.legend =FALSE)
g2=ggplot(data=df, aes(x=English, y=Science, color=cluster )) +
  geom_point () +geom_point(data=centers,aes(x=English,y=Science,
                                color=as.factor(c(1,2,3))),size=10, alpha=.3, show.legend=FALSE)
g3 = ggplot(data=df, aes(x=Math, y=Science, color=cluster )) +
  geom_point () + geom_point(data=centers,aes(x=Math,y=Science,
```

```
                                color=as.factor(c(1,2,3))),size=10, alpha=.3, show.legend=FALSE)
tmp=ggplot_gtable(ggplot_build(g1))
grid.arrange(arrangeGrob(g1 + theme(legend.position="none"),g2 +
                         theme(legend.position="none"),g3 + theme(legend.position="none"),top ="High
School Student
Cluster Analysis" ,ncol=1))
```

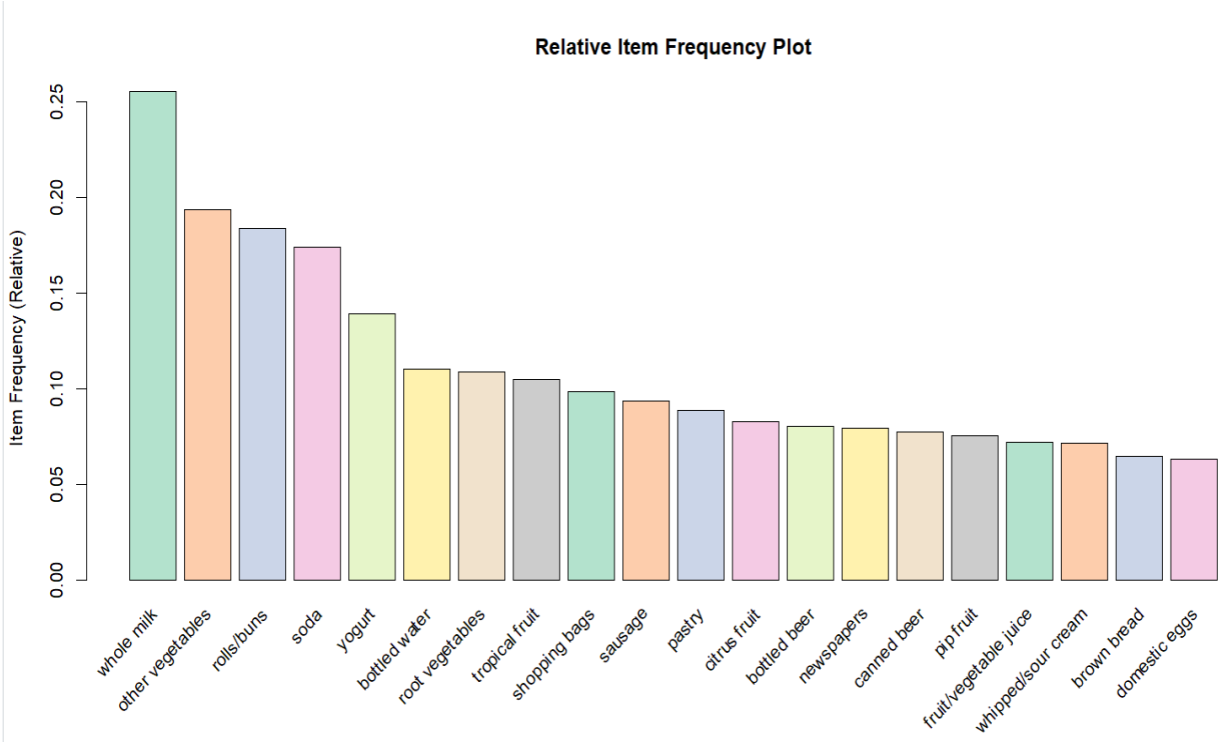


Practical 9

Aim:- Perform Apriori algorithm using Groceries dataset from the R rules package.

```
install.packages("arules")
install.packages("arulesViz")
install.packages("RColorBrewer")
# Loading Libraries
library(arules)
library(arulesViz)
library(RColorBrewer)
# import dataset
data(Groceries)
Groceries
summary(Groceries)
class(Groceries)
# using apriori() function
rules = apriori(Groceries, parameter = list(supp = 0.02, conf = 0.2))
summary (rules)
# using inspect() function
inspect(rules[1:10])
# using itemFrequencyPlot() function
arules::itemFrequencyPlot(Groceries, topN = 20,
                          col = brewer.pal(8, 'Pastel2'),
                          main = 'Relative Item Frequency Plot',
                          type = "relative",
                          ylab = "Item Frequency (Relative)")
itemsets = apriori(Groceries, parameter = list(minlen=2, maxlen=2,support=0.02, target="frequent
itemsets"))
summary(itemsets)
# using inspect() function
inspect(itemsets[1:10])
itemsets_3 = apriori(Groceries, parameter = list(minlen=3, maxlen=3,support=0.02, target="frequent
itemsets"))
summary(itemsets_3)
# using inspect() function
inspect(itemsets_3)
```

```
R 4.4.3 · ~/
> summary(itemsets_3)
set of 2 itemsets

most frequent items:
other vegetables       whole milk  root vegetables           yogurt
               2                2                1                1
     frankfurter          (Other)
               0                0

element (itemset/transaction) length distribution:sizes
3
2

   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      3       3       3       3       3       3

summary of quality measures:
    support           count
 Min.   :0.0223   Min.   :219
 1st Qu.:0.0225   1st Qu.:221
 Median :0.0227   Median :224
 Mean   :0.0227   Mean   :224
 3rd Qu.:0.0230   3rd Qu.:226
 Max.   :0.0232   Max.   :228

includes transaction ID lists: FALSE

mining info:
      data ntransactions support confidence
 Groceries          9835    0.02          1
                                                                                                    call
 apriori(data = Groceries, parameter = list(minlen = 3, maxlen = 3, support = 0.02, target = "frequent itemsets"))
> # using inspect() function
> inspect(itemsets_3)
    items                                          support count
[1] {root vegetables, other vegetables, whole milk} 0.0232  228
[2] {other vegetables, whole milk, yogurt}          0.0223  219
```



KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

NAAC Accredited Grade B+

(Affiliated to University of Mumbai)

KALAMBOLI, 410 218 MAHARASHTRA

2024-2025

DEPARTMENT OF INFORMATION TECHNOLOGY

PRACTICAL BOOK

ON

MODERN NETWORKING

Submitted to,

UNIVERSITY OF MUMBAI

BY

MAHESH TANAJI CHAVAN

Seat No:- 1312671

MASTER OF SCIENCE INFORMATION TECHNOLOGY

PART – I (SEMESTER - II)

(2024-2025)

KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

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KALAMBOLI, 410 218 MAHARASHTRA

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_____

in M.sc.(Information Technolgy) during the academic year 20 - 20 as per the syllabus prescribed by the University of mumbai.

Prof. In Charge
Date:_____

Head of Deapartment
Date:_____

External Examiner
Date:_____

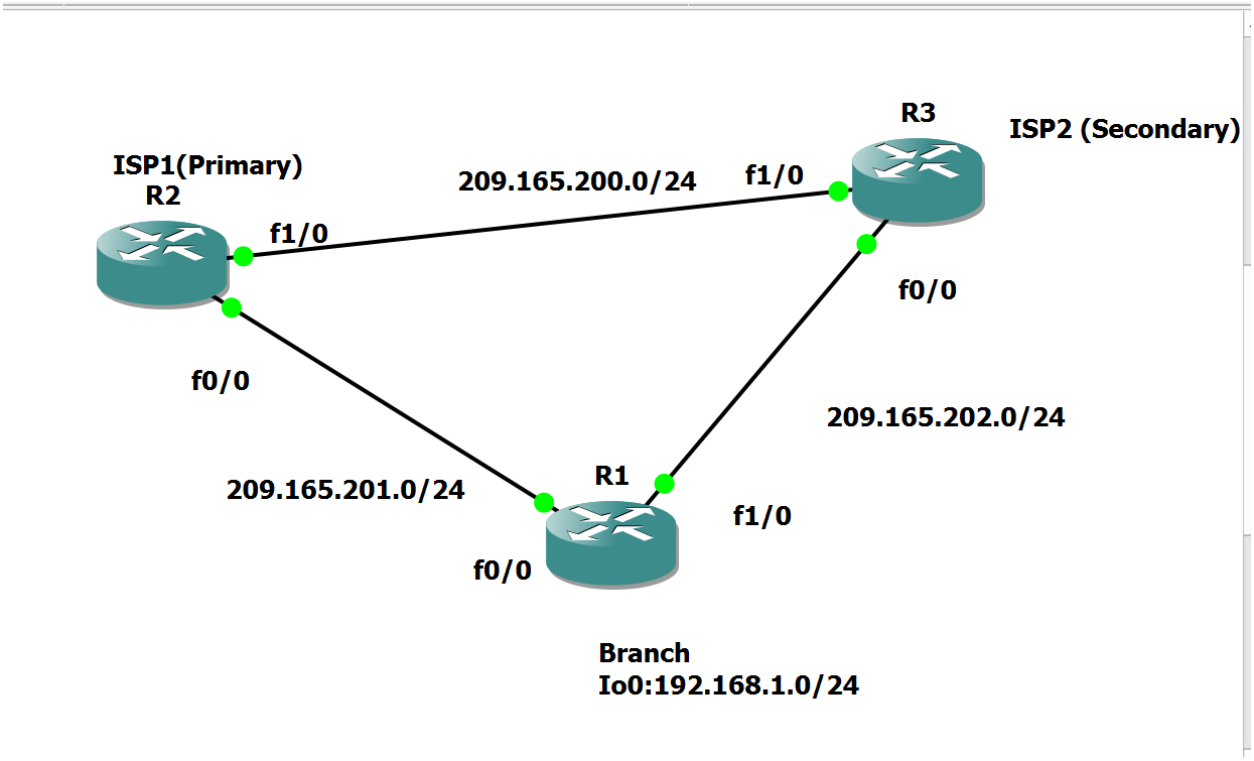
Principal Sign
Date:_____

College Stamp

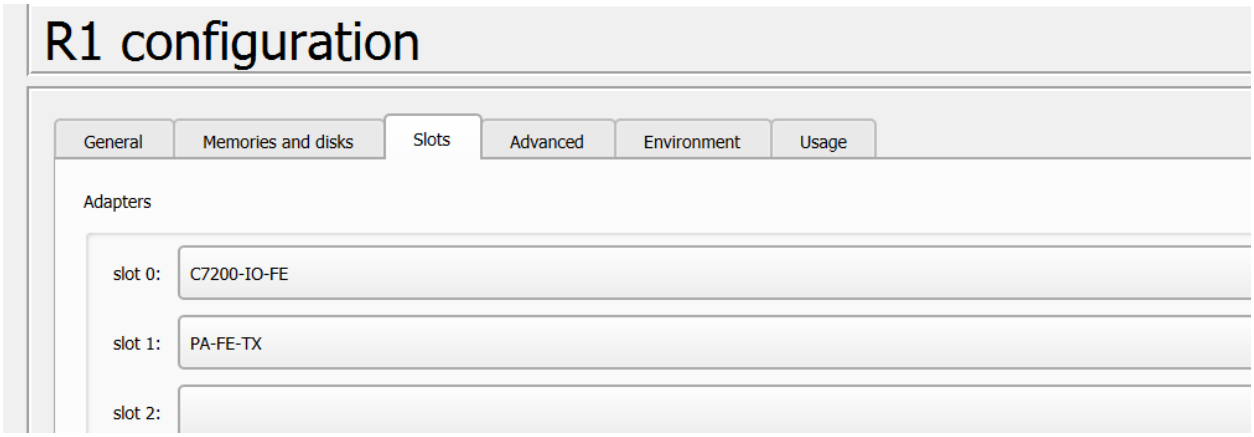
INDEX

Practical No: 1

Configure IP SLA tracking and path control topology.



Take 3 routers -> Configure -> slots -> PA-FE_TX



Task 1: Configure IP SLA using GNS3

On router 1 console:

R1#conf t

R1(config)#interface f0/0

R1(config-if)#ip add 209.165.201.1 255.255.255.0

R1(config-if)#no sh

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface f0/0
R1(config-if)#ip add 209.165.201.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

R1(config-if) # interface f1/0

R1(config-if) # ip add 209.165.202.1 255.255.255.0

R1(config-if) # no sh

```
R1(config)#interface f1/0
R1(config-if)#ip add 209.165.202.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

R1(config-if) # int lo0

R1(config-if) # ip add 192.168.1.1 255.255.255.0

R1(config-if) # no sh

```
R1(config-if)#int lo0
R1(config-if)#ip add 192.168.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

R1(config-if) # do sh ip int br | include up

```
R1(config-if)#do sh ip int br | include up
FastEthernet0/0        209.165.201.1   YES manual up                    up
FastEthernet1/0        209.165.202.1   YES manual up                    up
Loopback0              192.168.1.1     YES manual up                    up
R1(config-if)#
```

On router 2 console:

R2 # conf t

R2(config) # int f0/0

R2(config-if) # ip add 209.165.201.2 255.255.255.0

R2(config-if) # no sh

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int f0/0
R2(config-if)#ip add 209.165.201.2 255.255.255.0
R2(config-if)#no sh
```

R2(config-if) # int f1/0

R2(config-if) # ip add 209.165.200.2 255.255.255.0

R2(config-if) # no sh

```
R2(config-if)#int f1/0
R2(config-if)#ip add 209.165.200.2 255.255.255.0
R2(config-if)#no sh
R2(config-if)#
```

R2(config-if) # do sh ip int br | include up

```
R2(config-if)#do sh ip int br | include up
FastEthernet0/0        209.165.201.2   YES manual up                    up
FastEthernet1/0        209.165.200.2   YES manual up                    up
R2(config-if)#
```

On router 3 console:

R3 # conf t

R3(config) # int f0/0

R3(config-if) # ip add 209.165.202.3 255.255.255.0

R3(config-if) # no sh

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#int f0/0
R3(config-if)#ip add 209.165.202.3 255.255.255.0
R3(config-if)#no sh
```

R3(config) # int f1/0

R3(config-if) # ip add 209.165.200.3 255.255.255.0

R3(config-if) # no sh

```
R3(config-if)#int f1/0
R3(config-if)#ip add 209.165.200.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

R3(config-if) # do sh ip int br | include up

```
R3(config-if)#do sh ip int br | include up
FastEthernet0/0        209.165.202.3   YES manual up                    up
FastEthernet1/0        209.165.200.3   YES manual up                    up
R3(config-if)#
```

Task 2: Configure static routing on branch router and dynamic routing using eigrp

On router 1 console:

R1 # conf t

R1(config) # ip route 0.0.0.0 0.0.0.0 209.165.201.2

R1(config) #

```
R1(config-if)#ip route 0.0.0.0 0.0.0.0 209.165.201.2
R1(config)#
```

On router 2 console :

R2(config) # router eigrp 1

R2(config-router) # network 209.165.200.0 0.0.0.255

R2(config-router) # network 209.165.201.0 0.0.0.255

R2(config-router) # no auto-summary

```
R2(config-if)#router eigrp 1
R2(config-router)#network 209.165.200.0 0.0.0.255
R2(config-router)#network 209.165.201.0 0.0.0.255
R2(config-router)#no auto-summary
R2(config-router)#
```

On router 3 console :

R3(config) # router eigrp 1

R3(config-router) # network 209.165.200.0 0.0.0.255

R3(config-router) # network 209.165.202.0 0.0.0.255

R3(config-router) # no auto-summary

```
R3(config)#router eigrp 1
R3(config-router)#network 209.165.200.0 0.0.0.255
R3(config-router)#network 209.165.202.0 0.0.0.255
R3(config-router)#no auto-summary
R3(config-router)#
```

On router 2 console :

R2(config-router) # exit

R2(config) # ip route 192.168.1.0 255.255.255.0 209.165.201.1

```
R2(config-router)#
R2(config-router)#exit
R2(config)#ip route 192.168.1.0 255.255.255.0 209.165.201.1
R2(config)#
```

On router 3 console

R3(config-router) # exit

R3(config) # ip route 192.168.1.0 255.255.255.0 209.165.202.1

```
R3(config-router)#
R3(config-router)#exit
R3(config)#ip route 192.168.1.0 255.255.255.0 209.165.202.1
R3(config)#
```

Ping other routers

R1(config) # do ping 209.165.200.3

R3(config) # do ping 209.165.201.1

```
R1(config)#do ping 209.165.200.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.200.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/23/40 ms
R1(config)#
```

```
R3(config)#do ping 209.165.201.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 209.165.201.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/21/28 ms
R3(config)#
```

Ping other routers

R2(config) # do ping 192.168.1.1

R3(config) # do ping 192.168.1.1

```
R2(config)#do ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/60/132 ms
R2(config)#
```

```
R3(config)#do ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/11/16 ms
R3(config)#
```

Give hostname

R1(config) # hostname r1-branch

R2(config) # hostname r2-isp1

R3(config) # hostname r3-isp2

```
R1(config)#
R1(config)#hostname r1-branch
r1-branch(config)#
```

```
R2(config)#
R2(config)#hostname r2-isp1
r2-isp1(config)#
```

```
R3(config)#
R3(config)#hostname r3-isp2
r3-isp2(config)#
```

Task 3: Configure IP SLA probes at branch router

On router 1 console

r1-branch(config) # ip sla 11

r1-branch(config-ip-sla) # icmp-echo 209.165.201.2

r1-branch(config-ip-sla-echo) # frequency 10

r1-branch(config-ip-sla-echo) # exit

r1-branch(config) #

r1-branch(config) # ip sla schedule 11 life forever start-time now

r1-branch(config) #

r1-branch(config) # do sh ip sla configuration 11

```
r1-branch(config)#ip sla 11
r1-branch(config-ip-sla)# icmp-echo 209.165.201.2
r1-branch(config-ip-sla-echo)#frequency 10
r1-branch(config-ip-sla-echo)#exit
r1-branch(config)#
r1-branch(config)#ip sla schedule 11 life forever start-time now
r1-branch(config)#
```

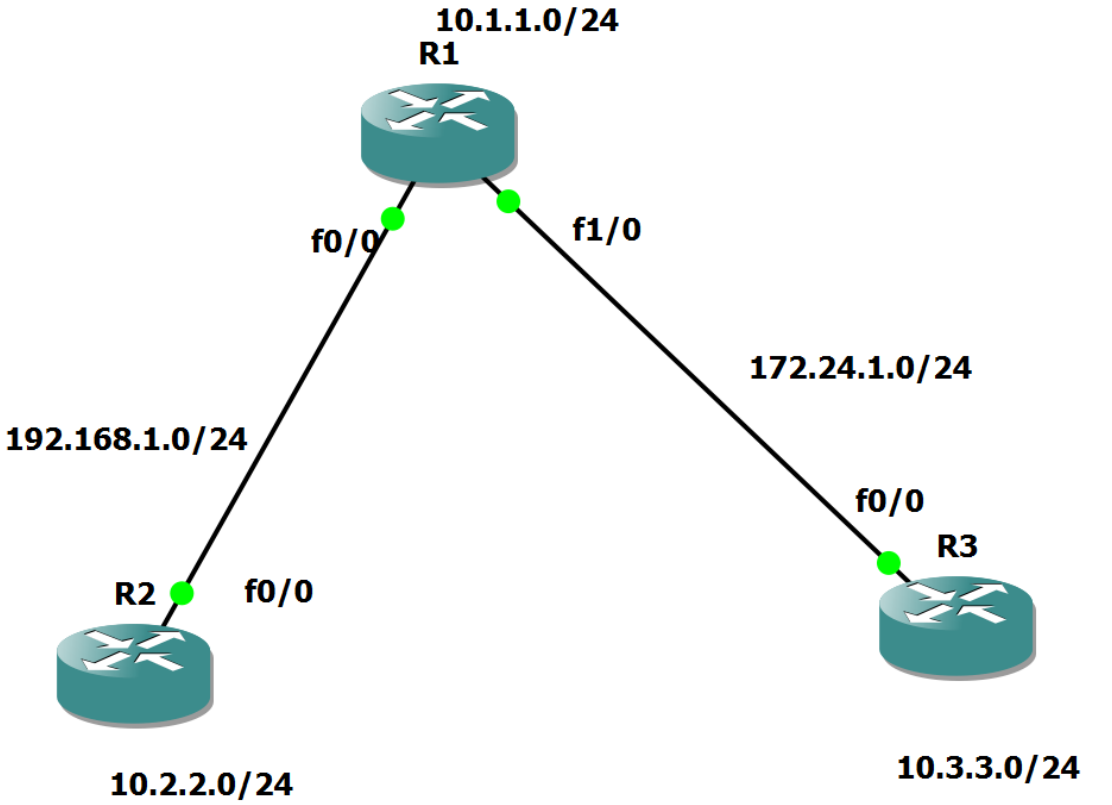
```
r1-branch(config)#do sh ip sla configuration 11
IP SLAs Infrastructure Engine-III
Entry number: 11
Owner:
Tag:
Operation timeout (milliseconds): 5000
Type of operation to perform: icmp-echo
Target address/Source address: 209.165.201.2/0.0.0.0
Type Of Service parameter: 0x0
Request size (ARR data portion): 28
Verify data: No
Vrf Name:
Schedule:
   Operation frequency (seconds): 10  (not considered if randomly scheduled)
   Next Scheduled Start Time: Start Time already passed
   Group Scheduled : FALSE
   Randomly Scheduled : FALSE
   Life (seconds): Forever
   Entry Ageout (seconds): never
   Recurring (Starting Everyday): FALSE
   Status of entry (SNMP RowStatus): Active
Threshold (milliseconds): 5000
Distribution Statistics:
   Number of statistic hours kept: 2
   Number of statistic distribution buckets kept: 1
   Statistic distribution interval (milliseconds): 20
Enhanced History:

r1-branch(config)#ip sla 11
Entry already running and cannot be modified
        (only can delete (no) and start over)
        (check to see if the probe has finished exiting)

r1-branch(config)#
```

Practical No: 2

Implementation of BGP using AS PATH attribute.



On Router console type following commands one by one.

R1 Console

R1(config)#conf t

R1(config)#int f0/0

R1(config-if)#ip add 192.168.1.1 255.255.255.0

R1(config-if)#no sh

R1(config-if)#int f1/0

R1(config-if)#ip add 172.24.1.1 255.255.255.0

R1(config-if)#no sh

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int f0/0
R1(config-if)#ip add 192.168.1.1 255.255.255.0
R1(config-if)#no sh
```

```
R1(config-if)#int f1/0
R1(config-if)#ip add 172.24.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

R2 Console :

R2#conf t

Enter configuration commands, one per line. End with CNTL/Z.

R2(config)#int f0/0

R2(config-if)#ip add 192.168.1.2 255.255.255.0

R2(config-if)#no sh

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int f0/0
R2(config-if)#ip add 192.168.1.2 255.255.255.0
R2(config-if)#no sh
R2(config-if)#
```

R3 Console :

R3#conf t

Enter configuration commands, one per line. End with CNTL/Z.

R3(config)#int f0/0

R3(config-if)#ip add 172.24.1.3 255.255.255.0

R3(config-if)#no sh

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#int f0/0
R3(config-if)#ip add 172.24.1.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

To add loopback address ,On Router console type following commands one by one.

R1 Console:

R1#conf t

R1(config)#int lo0

R1(config-if)#ip add 10.1.1.1 255.255.255.0

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int lo0
R1(config-if)#ip add 10.1.1.1 255.255.255.0
R1(config-if)#
```

R2 Console :

R2#conf t

R2(config)#int lo0

R2(config-if)#ip add 10.2.2.2 255.255.255.0

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int lo0
R2(config-if)#ip add 10.2.2.2 255.255.255.0
R2(config-if)#
R2(config-if)#
```

R3 Console :

R3#conf t

R3(config)#int lo0

R3(config-if)#ip add 10.3.3.3 255.255.255.0

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#int lo0
R3(config-if)#ip add 10.3.3.3 255.255.255.0
R3(config-if)#
```

To add bgp protocol, On Router console type following commands one by one.

R1 Console:

R1(config-if)#router bgp 100

R1(config-router)#neighbor 192.168.1.2 remote-as 200

R1(config-router)#neighbor 172.24.1.3 remote-as 300

R1(config-router)#network 10.1.1.0 mask 255.255.255.0

```
R1(config-if)#router bgp 100
R1(config-router)#neighbor 192.168.1.2 remote-as 200
R1(config-router)#neighbor 172.24.1.3 remote-as 300
R1(config-router)#network 10.1.1.0 mask 255.255.255.0
R1(config-router)#
```

R2 Console :

R2(config-if)#router bgp 200

R2(config-router)#neighbor 192.168.1.1 remote-as 100

R2(config-router)#network 10.2.2.0 mask 255.255.255.0

```
R2(config-if)#router bgp 200
R2(config-router)#neighbor 192.168.1.1 remote-as 100
R2(config-router)#network 10.2.2.0 mask 255.255.255.0
R2(config-router)#
```

R3 Console :

R3(config-if)#router bgp 300

R3(config-router)#neighbor 172.24.1.1 remote-as 100

R3(config-router)#network 10.3.3.0 mask 255.255.255.0

R3(config-router)#

```
R3(config-if)#router bgp 300
R3(config-router)#neighbor 172.24.1.1 remote-as 100
R3(config-router)#network 10.3.3.0 mask 255.255.255.0
R3(config-router)#
```

To show ip route type following command in each router console

R3#conf t

R3(config)#do sh ip route

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
B        10.1.1.0/24 [20/0] via 172.24.1.1, 00:00:48
B        10.2.2.0/24 [20/0] via 172.24.1.1, 00:00:48
C        10.3.3.0/24 is directly connected, Loopback0
L        10.3.3.3/32 is directly connected, Loopback0
      172.24.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.24.1.0/24 is directly connected, FastEthernet0/0
L        172.24.1.3/32 is directly connected, FastEthernet0/0
R3(config)#
```

To verify output type following commands: (OUTPUT)

R2(config-router)#do ping 10.3.3.3 source lo0

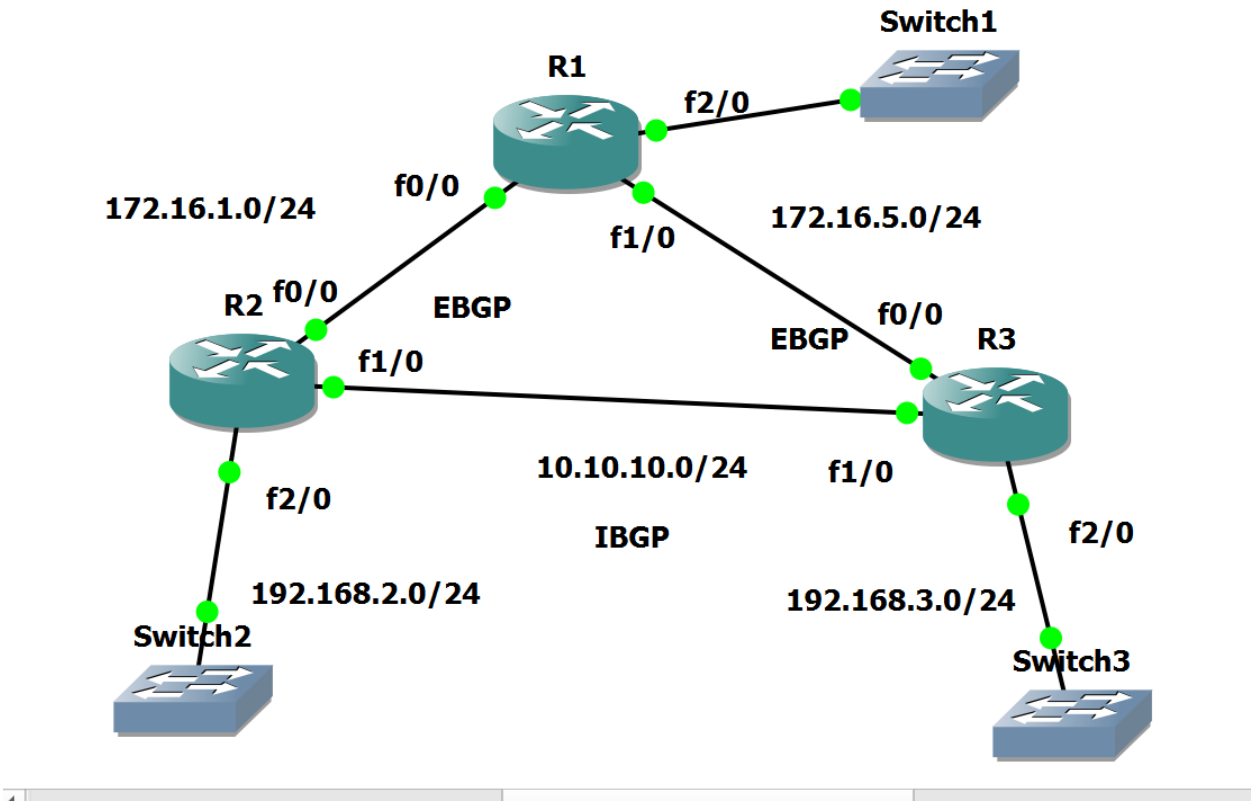
```
R2(config)#router bgp 200
R2(config-router)#do ping 10.3.3.3 source lo0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 10.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/43/48 ms
R2(config-router)#
```

R3(config)#do ping 10.2.2.2 source lo0

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#do ping 10.2.2.2 source lo0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 10.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/40/44 ms
R3(config)#
```

Practical No: 3

Configure IGBP and EBGP Sessions



Step 1: Configure IP addresses on the given routers

On Router R1:

R1 # conf t

R1(config) # int f2/0

R1(config-if) # ip add 192.168.1.1 255.255.255.0

R1(config-if) # no sh

R1(config-if) #

R1(config-if) # int f0/0

R1(config-if) # ip add 172.16.1.1 255.255.255.0

R1(config-if) # no sh

R1(config-if) #

R1(config-if) # int f1/0

R1(config-if) # ip add 172.16.5.1 255.255.255.0

R1(config-if) # no sh

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int f2/0
R1(config-if)#ip add 192.168.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

```
R1(config-if)#int f0/0
R1(config-if)#ip add 172.16.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

```
R1(config-if)#int f1/0
R1(config-if)#ip add 172.16.5.1 255.255.255.0
R1(config-if)#no sh
```

On Router R2:

R2 # conf t

R2(config) # int f1/0

R2(config-if) # ip add 10.10.10.2 255.255.255.0

R2(config-if) # no sh

R2(config-if) #

R2(config-if) # int f2/0

R2(config-if) # ip add 192.168.2.2 255.255.255.0

R2(config-if) # no sh

R2(config-if) #

R2(config-if) # int f0/0

R2(config-if) # ip add 172.16.1.2 255.255.255.0

R2(config-if) # no sh

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#int f1/0
R2(config-if)#ip add 10.10.10.2 255.255.255.0
R2(config-if)#no sh
R2(config-if)#
```

```
R2(config-if)#int f2/0
R2(config-if)#ip add 192.168.2.2 255.255.255.0
R2(config-if)#no sh
R2(config-if)#
```

```
R2(config-if)#int f0/0
R2(config-if)#ip add 172.16.1.2 255.255.255.0
R2(config-if)#no sh
R2(config-if)#
```

On Router 3:

R3 # conf t

Enter configuration commands, one per line. End with CNTL/Z.

R3(config) # int f1/0

R3(config-if) # ip add 10.10.10.3 255.255.255.0

R3(config-if) # no sh

R3(config-if) # int f2/0

R3(config-if) # ip add 192.168.3.3 255.255.255.0

R3(config-if) # no sh

R3(config-if) # int f0/0

R3(config-if) # ip add 172.16.5.3 255.255.255.0

R3(config-if) # no sh

```
R3(config)#int f1/0
R3(config-if)#ip add 10.10.10.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

```
R3(config-if)#int f2/0
R3(config-if)#ip add 192.168.3.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

```
R3(config-if)#int f0/0
R3(config-if)#ip add 172.16.5.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

On all routers:

do sh ip int br | include up

```
R1(config-if)#
R1(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.1.1      YES manual up                    up
FastEthernet1/0        172.16.5.1      YES manual up                    up
FastEthernet2/0        192.168.1.1     YES manual up                    up
R1(config-if)#
```

```
R2(config-if)#
R2(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.1.2      YES manual up                    up
FastEthernet1/0        10.10.10.2      YES manual up                    up
FastEthernet2/0        192.168.2.2     YES manual up                    up
R2(config-if)#
```

```
R3(config-if)#
R3(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.5.3      YES manual up                    up
FastEthernet1/0        10.10.10.3      YES manual up                    up
FastEthernet2/0        192.168.3.3     YES manual up                    up
R3(config-if)#
```

Step 2: Configure IRP in autonomous system 65200

On Router R2:

R2(config-if) # router ospf 1

R2(config-router) # network 10.10.10.0 0.0.0.255 area 0

R2(config-router) # network 192.168.2.0 0.0.0.255 area 1

```
R2(config-if)#router ospf 1
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#network 192.168.2.0 0.0.0.255 area 1
R2(config-router)#
```

On Router R3:

R3(config-if) # router ospf 1

R3(config-router) # network 10.10.10.0 0.0.0.255 area 0

R3(config-router) # network 192.168.3.0 0.0.0.255 area 2

```
R3(config-if)#router ospf 1
R3(config-router)#network 10.10.10.0 0.0.0.255 area 0
R3(config-router)#network 192.168.3.0 0.0.0.255 area 2
R3(config-router)#
```

Step 3: IBGP & EBGP configuration:

On Router R1:

R1(config) # router bgp 65100

R1(config-router) # network 192.168.1.0

R1(config-router) # network 172.16.1.0 mask 255.255.255.0

R1(config-router) # network 172.16.5.0 mask 255.255.255.0

R1(config-router) # neighbor 172.16.1.2 remote-as 65200

R1(config-router) # neighbor 172.16.5.3 remote-as 65200

R1(config-router) # do sh ip route

```
R1(config-if)#
R1(config-if)#router bgp 65100
R1(config-router)#network 192.168.1.0
R1(config-router)#network 172.16.1.0 mask 255.255.255.0
R1(config-router)#network 172.16.5.0 mask 255.255.255.0
R1(config-router)#neighbor 172.16.1.2 remote-as 65200
R1(config-router)#neighbor 172.16.5.3 remote-as 65200
R1(config-router)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks
C        172.16.1.0/24 is directly connected, FastEthernet0/0
L        172.16.1.1/32 is directly connected, FastEthernet0/0
C        172.16.5.0/24 is directly connected, FastEthernet1/0
L        172.16.5.1/32 is directly connected, FastEthernet1/0
      192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.1.0/24 is directly connected, FastEthernet2/0
L        192.168.1.1/32 is directly connected, FastEthernet2/0
R1(config-router)#
```

On Router R2:

R2(config-router) # router bgp 65200

R2(config-router) # redistribute ospf 1

R2(config-router) # network 172.16.1.0 mask 255.255.255.0

R2(config-router) # neighbor 172.16.1.1 remote-as 65100

R2(config-router) # neighbor 10.10.10.3 remote-as 65200

R2(config-router) # do sh ip route

```
R2(config-router)#router bgp 65200
R2(config-router)#redistribute ospf 1
R2(config-router)#network 172.16.1.0 mask 255.255.255.0
R2(config-router)#neighbor 172.16.1.1 remote-as 65100
R2(config-router)#
*Apr 23 23:47:14.803: %BGP-5-ADJCHANGE: neighbor 172.16.1.1 Up
R2(config-router)#neighbor 10.10.10.3 remote-as 65200
R2(config-router)#
```

```
R2(config-router)#neighbor 172.16.1.1 remote-as 65100
R2(config-router)#neighbor 10.10.10.3 remote-as 65200
R2(config-router)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.10.10.0/24 is directly connected, FastEthernet1/0
L        10.10.10.2/32 is directly connected, FastEthernet1/0
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
C        172.16.1.0/24 is directly connected, FastEthernet0/0
L        172.16.1.2/32 is directly connected, FastEthernet0/0
B        172.16.5.0/24 [20/0] via 172.16.1.1, 00:02:47
B     192.168.1.0/24 [20/0] via 172.16.1.1, 00:02:47
      192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.2.0/24 is directly connected, FastEthernet2/0
L        192.168.2.2/32 is directly connected, FastEthernet2/0
 --More--
```

On Router R3:

R3(config-router) #

R3(config-router) # router bgp 65200

R3(config-router) # redistribute ospf 1

R3(config-router) # network 172.16.5.0 mask 255.255.255.0

R3(config-router) # neighbor 172.16.5.1 remote-as 65100

R3(config-router) # neighbor 10.10.10.2 remote-as 65200

R3(config-router) # do sh ip route

```
R3(config-router)#router bgp 65200
R3(config-router)#redistribute ospf 1
R3(config-router)#network 172.16.5.0 mask 255.255.255.0
R3(config-router)#neighbor 172.16.5.1 remote-as 65100
```

```
R3(config-router)#do sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C        10.10.10.0/24 is directly connected, FastEthernet1/0
L        10.10.10.3/32 is directly connected, FastEthernet1/0
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
B        172.16.1.0/24 [200/0] via 10.10.10.2, 00:00:16
C        172.16.5.0/24 is directly connected, FastEthernet0/0
L        172.16.5.3/32 is directly connected, FastEthernet0/0
B     192.168.1.0/24 [20/0] via 172.16.5.1, 00:00:27
O IA  192.168.2.0/24 [110/2] via 10.10.10.2, 00:09:00, FastEthernet1/0
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.3.0/24 is directly connected, FastEthernet2/0
 --More--
```

On Router R1:

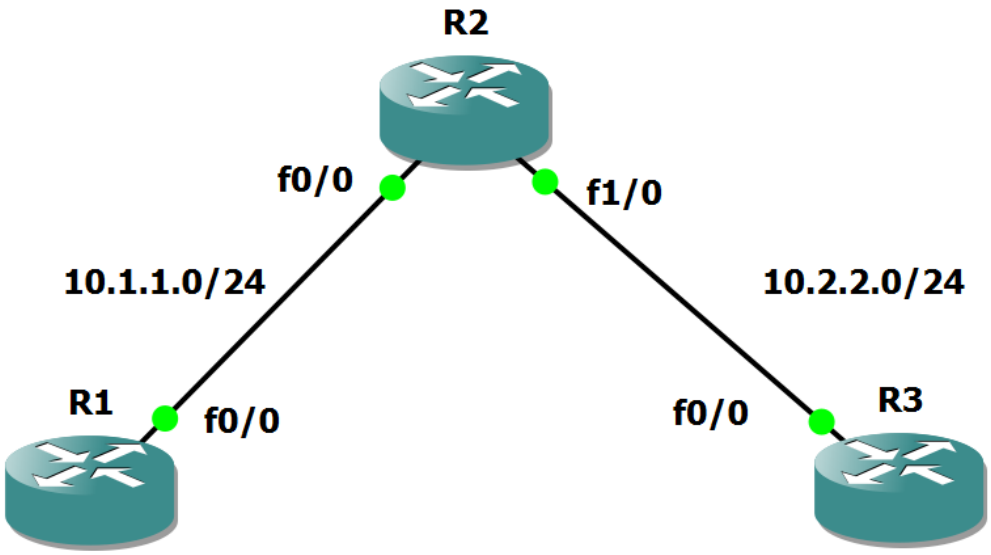
do ping 192.168.3.3

do ping 192.168.2.2

```
R1(config-router)#
R1(config-router)#do ping 192.168.3.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/24/32 ms
R1(config-router)#do ping 192.168.2.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/24 ms
R1(config-router)#
```

Practical No: 4

Secure the management plane



On Router R1 Console:

R1#conf t

R1(config)#int f0/0

R1(config-if)#ip add 10.1.1.1 255.255.255.0

R1(config-if)#no sh

R1(config-if)#int lo0

R1(config-if)#ip add 192.168.1.1 255.255.255.0

R1(config-if)#no sh

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int f0/0
R1(config-if)#ip add 10.1.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

```
R1(config-if)#int lo0
R1(config-if)#ip add 192.168.1.1 255.255.255.0
R1(config-if)#no sh
R1(config-if)#
```

On Router R2 Console :

R2 # conf t

R2(config) # int f0/0

R2(config-if) # ip add 10.1.1.2 255.255.255.0

R2(config-if) # no sh

R2(config-if) # int f1/0

R2(config-if) # ip add 10.2.2.2 255.255.255.0

R2(config-if) # no sh

```
R2(config)#int f0/0
R2(config-if)#ip add 10.1.1.2 255.255.255.0
R2(config-if)#no sh
```

```
R2(config-if)#
R2(config-if)#ip add 10.2.2.2 255.255.255.0
R2(config-if)#no sh
```

On Router R3 Console

R3 # conf t

R3(config) # int f0/0

R3(config-if) # ip add 10.2.2.3 255.255.255.0

R3(config-if) # no sh

R3(config-if) #

R3(config-if) # int lo0

R3(config-if) # ip add 192.168.3.3 255.255.255.0

```
R3(config)#int f0/0
R3(config-if)#ip add 10.2.2.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

```
R3(config-if)#int lo0
R3(config-if)#ip add 192.168.3.3 255.255.255.0
R3(config-if)#no sh
R3(config-if)#
```

Part 2 : Routing

R1 Console :

R1(config-if) # exit

R1(config) #

R1(config) # ip route 0.0.0.0 0.0.0.0 10.1.1.2

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#ip route 0.0.0.0 0.0.0.0 10.1.1.2
R1(config)#
```

R2 Console :

R2(config-if) # exit

R2(config) # ip route 192.168.1.0 255.255.255.0 10.1.1.1

R2(config) # ip route 192.168.3.0 255.255.255.0 10.2.2.3

```
R2(config-if)#exit
R2(config)#ip route 192.168.1.0 255.255.255.0 10.1.1.1
R2(config)#ip route 192.168.3.0 255.255.255.0 10.2.2.3
```

R3 Console :

R3(config-if) # exit

R3(config) # ip route 0.0.0.0 0.0.0.0 10.2.2.2

```
R3(config-if)#exit
R3(config)#ip route 0.0.0.0 0.0.0.0 10.2.2.2
R3(config)#
```

Ping

R1 Console :

R1(config) # do ping 192.168.3.3

```
R1(config)#do ping 192.168.3.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/48/76 ms
R1(config)#
```

R3 Console :

R3(config) # do ping 192.168.1.1

```
R3(config)#do ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/45/60 ms
R3(config)#
```

Part 3: Security Management Access

R1 Console

r1(config) # hostname r1

r1(config) # security password min-length 10

r1(config) # enable secret class12345

r1(config) #

r1(config) # line console 0

r1(config-line) # password ciscoconpass

r1(config-line) # exec-timeout 5 0

r1(config-line) # login

r1(config-line) # logging synchronous

r1(config-line) # exit

r1(config) #

r1(config) # line vty 0 4

r1(config-line) # password ciscovtypass

r1(config-line) # exec-timeout 5 0

r1(config-line) # login

r1(config-line) # exit

r1(config) #

r1(config) # line aux 0

r1(config-line) # no exec

r1(config-line) # end

r1(config) # service password-encryption

r1(config) # banner motd $Unauthorized access not allowed$

r1(config) # exit

```
R1(config)#
R1(config)#hostname r1
r1(config)#security password min-length 10
r1(config)#enable secret class12345
r1(config)#
r1(config)#
r1(config)#line console 0
r1(config-line)#password ciscoconpass
r1(config-line)#exec-timeout 5 0
r1(config-line)#login
r1(config-line)#logging synchronous
r1(config-line)#exit
r1(config)#line vty 0 4
r1(config-line)#password ciscovtypass
r1(config-line)#
r1(config-line)#exec-timeout 5 0
r1(config-line)#
r1(config-line)#login
r1(config-line)#exit
r1(config)#
r1(config)#
r1(config)#line aux 0
r1(config-line)#
r1(config-line)#no exec
r1(config-line)#end
r1#
```

```
r1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
r1(config)#service password-encryption
r1(config)#banner motd $Unauthorized access not allowed$
r1(config)#exit
r1#
```

R3 Console (Same as R1)

R3(config) # hostname r3

r3(config) # security password min-length 10

r3(config) # enable secret class12345

r3(config) # line console 0

```
r3(config-line) # password ciscoconpass
r3(config-line) # exec-timeout 5 0
r3(config-line) # login
r3(config-line) # logging synchronous
r3(config-line) # exit
r3(config) # line vty 0 4
r3(config-line) # password ciscovtypass
r3(config-line) #
r3(config-line) #
r3(config-line) #
r3(config-line) # exec-timeout 5 0
r3(config-line) # login
r3(config-line) # exit
r3(config) #
r3(config) # line aux 0
r3(config-line) # no exec
r3(config-line) # end
r3 #
r3 # conf t
r3(config) # service password-encryption
r3(config) # banner motd $Unauthorized access not allowed$
r3(config) # exit
```

```
R3(config)#hostname r3
r3(config)#security password min-length 10
r3(config)#enable secret class12345
r3(config)#line console 0
r3(config-line)#password ciscoconpass
r3(config-line)#exec-timeout 5 0
r3(config-line)#login
r3(config-line)#
r3(config-line)#logging synchronous
r3(config-line)#exit
r3(config)#
r3(config)#line vty 0 4
r3(config-line)#password ciscovtypass
r3(config-line)#exec-timeout 5 0
r3(config-line)#login
r3(config-line)#exit
r3(config)#line aux 0
r3(config-line)#no exec
r3(config-line)#
r3(config-line)#end
r3#
```

```
r3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
r3(config)#
r3(config)#
r3(config)#service password-encryption
r3(config)#banner motd $Unauthorized access not allowed$
r3(config)#exit
r3#
```

R3 Console :

r3 # telnet 10.1.1.1

(password-> ciscovtypass)

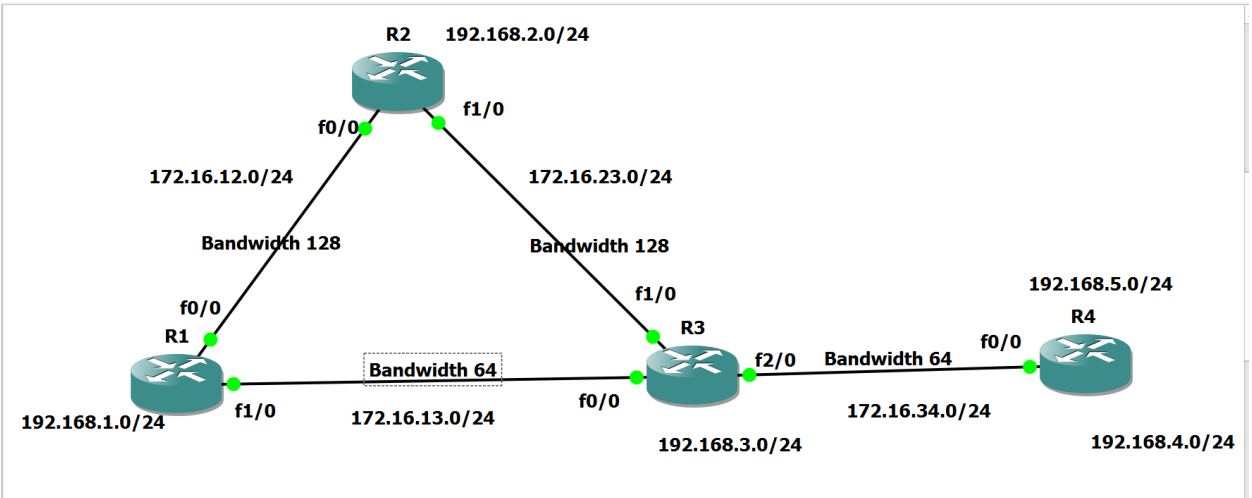
```
r3#telnet 10.1.1.1
Trying 10.1.1.1 ... Open
Unauthorized access not allowed

User Access Verification

Password:
Password:
r1>
```

Practical No: 5

Configure and verify path control using PBR (Policy Based Routing)



STEP 1: Perform IP configuration

On router 1 console :

R1 # conf t

R1(config) # hostname r1

r1(config) # int f0/0

r1(config-if) # ip add 172.16.12.1 255.255.255.0

r1(config-if) # bandwidth 128

r1(config-if) # no sh

```
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#hostname r1
r1(config)#int f0/0
r1(config-if)#ip add 172.16.12.1 255.255.255.0
r1(config-if)#bandwidth 128
r1(config-if)#no sh
r1(config-if)#
```

r1(config-if) # int f1/0

r1(config-if) # ip add 172.16.13.1 255.255.255.0

r1(config-if) # bandwidth 64

r1(config-if) # no sh

```
r1(config-if)#int f1/0
r1(config-if)#ip add 172.16.13.1 255.255.255.0
r1(config-if)#bandwidth 64
r1(config-if)#no sh
```

r1(config-if) # int lo0

r1(config-if) # ip add 192.168.1.1 255.255.255.0

r1(config-if) # do sh ip int br | include up

```
r1(config-if)#int lo0
r1(config-if)#ip add 192.168.1.1 255.255.255.0
r1(config-if)#
r1(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.12.1     YES manual up                    up
FastEthernet1/0        172.16.13.1     YES manual up                    up
Loopback0              192.168.1.1     YES manual up                    up
r1(config-if)#
```

On router 2 console

R2 # conf t

R2(config) # hostname r2

r2(config) #

```
R2#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#hostname r2
```

r2(config) # int f0/0

r2(config-if) # ip add 172.16.12.2 255.255.255.0

r2(config-if) # bandwidth 128

r2(config-if) # no sh

```
r2(config-if)#int f0/0
r2(config-if)# ip add 172.16.12.2 255.255.255.0
r2(config-if)#bandwidth 128
r2(config-if)#no sh
r2(config-if)#
```

r2(config-if) # int f1/0

r2(config-if) # ip add 172.16.23.2 255.255.255.0

r2(config-if) # bandwidth 128

r2(config-if) # no sh

```
r2(config-if)#int f1/0
r2(config-if)#ip add 172.16.23.2 255.255.255.0
r2(config-if)#bandwidth 128
r2(config-if)#no sh
r2(config-if)#
```

r2(config-if) # int lo0

r2(config-if) # ip add 192.168.2.2 255.255.255.0

r2(config-if) #

r2(config-if) # do sh ip int br | include up

```
r2(config-if)# int lo0
r2(config-if)#ip add 192.168.2.2 255.255.255.0
r2(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.12.2     YES manual up                    up
FastEthernet1/0        172.16.23.2     YES manual up                    up
Loopback0              192.168.2.2     YES manual up                    up
r2(config-if)#
```

On router 3 console

R3 # conf t

R3(config) # hostname r3

```
R3#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#hostname r3
```

r3(config) # int f0/0

r3(config-if) # ip add 172.16.13.3 255.255.255.0

r3(config-if) # bandwidth 64

r3(config-if) # no sh

r3(config-if) #

```
r3(config-if)#int f0/0
r3(config-if)#ip add 172.16.13.3 255.255.255.0
r3(config-if)#bandwidth 64
r3(config-if)#no sh
r3(config-if)#
```

r3(config-if) # int f1/0

r3(config-if) # ip add 172.16.23.3 255.255.255.0

r3(config-if) # bandwidth 128

r3(config-if) # no sh

r3(config-if) #

```
r3(config-if)#int f1/0
r3(config-if)#ip add 172.16.23.3 255.255.255.0
r3(config-if)#bandwidth 128
r3(config-if)#no sh
r3(config-if)#
```

r3(config-if) # int f2/0

r3(config-if) # ip add 172.16.34.3 255.255.255.0

r3(config-if) # bandwidth 64

r3(config-if) # no sh

```
r3(config-if)# int f2/0
r3(config-if)#ip add 172.16.34.3 255.255.255.0
r3(config-if)#bandwidth 64
r3(config-if)#no sh
r3(config-if)#
```

r3(config-if) # int lo0

r3(config-if) # ip add 192.168.3.3 255.255.255.0

r3(config-if) #

r3(config-if) # do sh ip int br | include up

```
r3(config-if)#int lo0
r3(config-if)#ip add 192.168.3.3 255.255.255.0
r3(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.13.3     YES manual up                    up
FastEthernet1/0        172.16.23.3     YES manual up                    up
FastEthernet2/0        172.16.34.3     YES manual up                    up
Loopback0              192.168.3.3     YES manual up                    up
r3(config-if)#
```

On router 4 console

R4 # conf t

R4(config) # hostname r4

r4(config) #

```
R4#
R4#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#hostname r4
r4(config)#
```

r4(config) # int f0/0

r4(config-if) # ip add 172.16.34.4 255.255.255.0

r4(config-if) # bandwidth 64

r4(config-if) # no sh

```
r4(config)#
r4(config)#int f0/0
r4(config-if)#ip add 172.16.34.4 255.255.255.0
r4(config-if)#bandwidth 64
r4(config-if)#no sh
r4(config-if)#
```

r4(config-if) # int lo0

r4(config-if) # ip add 192.168.4.1 255.255.255.0

r4(config-if) #

```
r4(config-if)#int lo0
r4(config-if)#ip add 192.168.4.1 255.255.255.0
r4(config-if)#
```

r4(config-if) # int lo1

r4(config-if) # ip add 192.168.5.1 255.255.255.0

r4(config-if) #

r4(config-if) # do sh ip int br | include up

```
r4(config-if)#int lo1
r4(config-if)#ip add 192.168.4.1 255.255.255.0
% 192.168.4.0 overlaps with Loopback0
r4(config-if)#ip add 192.168.5.1 255.255.255.0
r4(config-if)#do sh ip int br | include up
FastEthernet0/0        172.16.34.4     YES manual up                    up
Loopback0              192.168.4.1     YES manual up                    up
Loopback1              192.168.5.1     YES manual up                    up
r4(config-if)#
```

STEP 2 : Configure eigrp on all routers On router 1 console

On router 1 console

r1(config) # router eigrp 1

r1(config-router) # network 172.16.12.0 0.0.0.255

r1(config-router) # network 172.16.13.0 0.0.0.255

r1(config-router) # network 192.168.1.0

r1(config-router) # no auto-summary

```
r1(config-if)#
r1(config-if)#router eigrp 1
r1(config-router)#network 172.16.12.0 0.0.0.255
r1(config-router)#network 172.16.13.0 0.0.0.255
r1(config-router)#network 192.168.1.0
r1(config-router)#no auto-summary
r1(config-router)#
```

On router 2 console

r2(config) # router eigrp 1

r2(config-router) # network 172.16.12.0 0.0.0.255

r2(config-router) #

r2(config-router) # network 172.16.23.0 0.0.0.255

r2(config-router) # network 192.168.2.0

r2(config-router) # no auto-summary

```
r2(config-router)#router eigrp 1
r2(config-router)#network 172.16.12.0 0.0.0.255
r2(config-router)#network 172.16.23.0 0.0.0.255
r2(config-router)#network 192.168.2.0
r2(config-router)#no auto-summary
r2(config-router)#
```

On router 3 console

r3(config-if) # router eigrp 1

r3(config-router) # network 172.16.13.0 0.0.0.255

r3(config-router) # network 172.16.13.0 0.0.0.255

r3(config-router) # network 172.16.23.0 0.0.0.255

r3(config-router) # network 172.16.34.0 0.0.0.255

r3(config-router) # network 192.168.3.0

r3(config-router) # no auto-summary

```
r3(config-router)#router eigrp 1
r3(config-router)#network 172.16.13.0 0.0.0.255
r3(config-router)#network 172.16.13.0 0.0.0.255
r3(config-router)#network 172.16.23.0 0.0.0.255
```

```
r3(config-router)#network 172.16.34.0 0.0.0.255
r3(config-router)#network 192.168.3.0
r3(config-router)#no auto-summary
r3(config-router)#
```

On router 4 console

r4(config) # router eigrp 1

r4(config-router) # network 172.16.34.0 0.0.0.255

r4(config-router) #

r4(config-router) # network 192.168.4.0

r4(config-router) # network 192.168.5.0

r4(config-router) # no auto-summary

```
r4(config-router)#
r4(config-router)#router eigrp 1
r4(config-router)#network 172.16.34.0 0.0.0.255
```

```
r4(config-router)#network 192.168.4.0
r4(config-router)#network 192.168.5.0
r4(config-router)#network 192.168.5.0
r4(config-router)#
```

STEP 3: Command on all routers

do sh ip route

r4(config) # do ping 192.168.1.1

```
r4(config-router)#do ping 192.168.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 568/800/992 ms
r4(config-router)#
```

r1(config) # do ping 192.168.4.1

```
r1(config-router)#do ping 192.168.4.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.4.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 392/684/820 ms
r1(config-router)#
```

On Router R4

r4(config) # do traceroute 192.168.1.1 source 192.168.4.1

r4(config) #

r4(config) # do traceroute 192.168.1.1 source 192.168.5.1

```
r4(config-router)#
r4(config-router)#do traceroute 192.168.1.1 source 192.168.4.1
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.34.3 400 msec 560 msec 12 msec
  2 172.16.23.2 776 msec 748 msec 1024 msec
  3 172.16.12.1 592 msec 624 msec 1204 msec
r4(config-router)#do traceroute 192.168.1.1 source 192.168.5.1
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.34.3 408 msec 392 msec 540 msec
  2 172.16.23.2 596 msec 936 msec 964 msec
  3 172.16.12.1 976 msec 1160 msec 1140 msec
r4(config-router)#
```

Configure PBR to provide path control

- All traffic from source 192.168.5.1 should take route R4 -> R3 -> R1

- All traffic from source 192.168.4.1 should take route R4 -> R3 -> R2 -> R1

On router 3 console :

r3(config) # ip access-list standard pbr-acl

r3(config-std-nacl) # permit 192.168.5.0 0.0.0.255

r3(config-std-nacl) # exit

r3(config) #

r3(config) #

r3(config) # route-map r3-to-r1 permit

r3(config-route-map)#match ip address pbr-acl

r3(config-route-map)#set ip next-hop 172.16.13.1

r3(config-route-map)## exit

r3(config-route-map)#

r3(config-route-map)#

r3(config-route-map)#int f2/0

r3(config-if)# ip policy route-map r3-to-r1

r3(config-if)#end

```
r3(config-router)#ip access-list standard pbr-acl
r3(config-std-nacl)#permit 192.168.5.0 0.0.0.255
r3(config-std-nacl)#exit
r3(config)#route-map r3-to-r1 permit
r3(config-route-map)#match ip address pbr-acl
r3(config-route-map)#set ip next-hop 172.16.13.1
r3(config-route-map)## exit
r3(config-route-map)#
r3(config-route-map)#
r3(config-route-map)#int f2/0
r3(config-if)# ip policy route-map r3-to-r1
r3(config-if)#end
```

On router 4 console

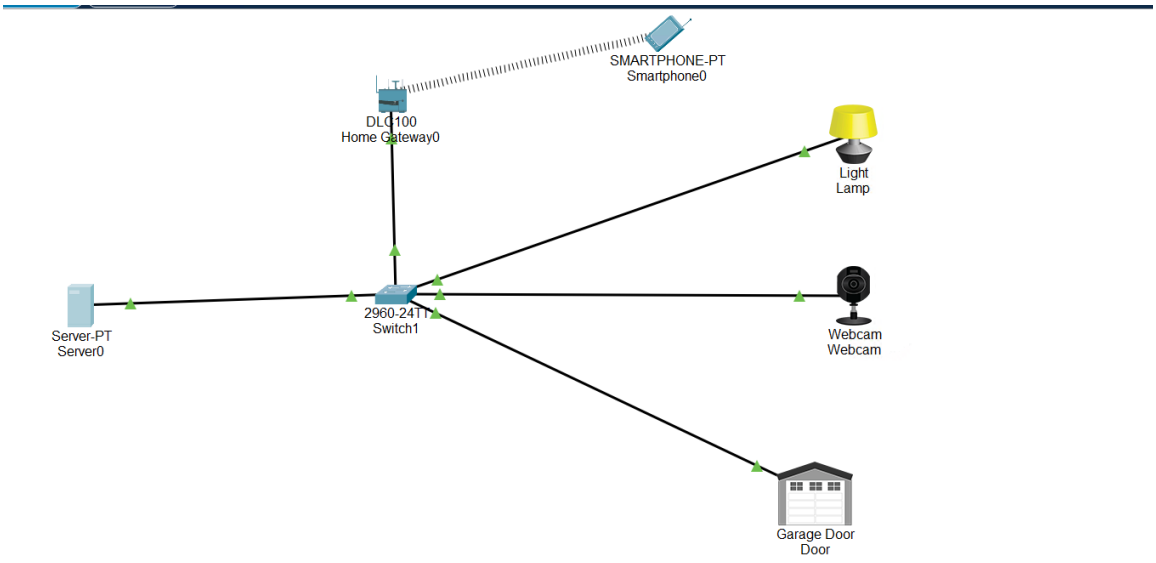
r4(config) # do traceroute 192.168.1.1 source 192.168.4.1

r4(config) # do traceroute 192.168.1.1 source 192.168.5.1

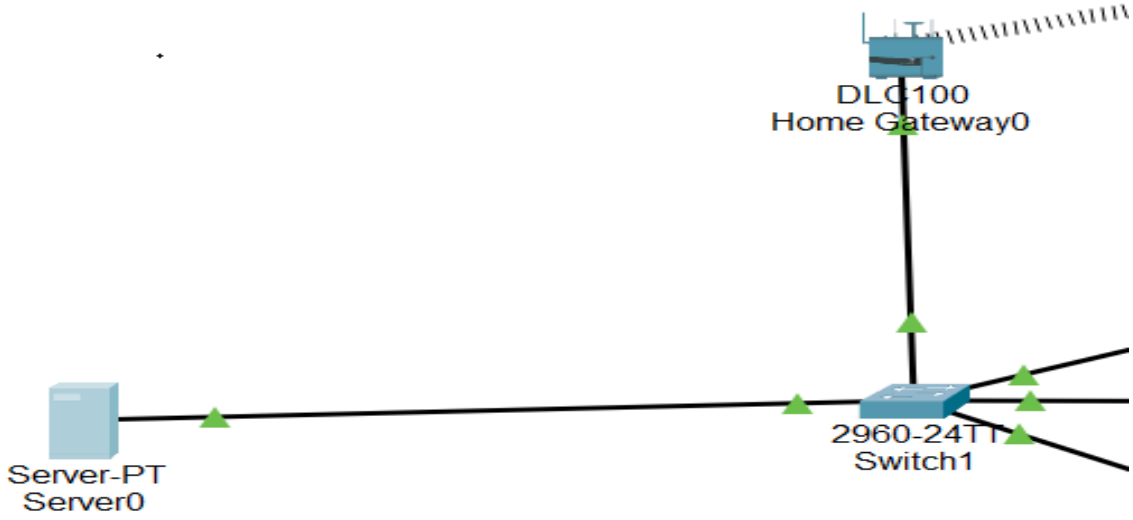
```
r4(config-router)#do traceroute 192.168.1.1 source 192.168.4.1
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.34.3 584 msec 384 msec 388 msec
  2 172.16.23.2 784 msec 752 msec 920 msec
  3 172.16.12.1 592 msec 1044 msec 1048 msec
r4(config-router)#do traceroute 192.168.1.1 source 192.168.5.1
Type escape sequence to abort.
Tracing the route to 192.168.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 172.16.34.3 396 msec 400 msec 568 msec
  2 172.16.13.1 972 msec 944 msec 936 msec
r4(config-router)#
```

Practical No: 6

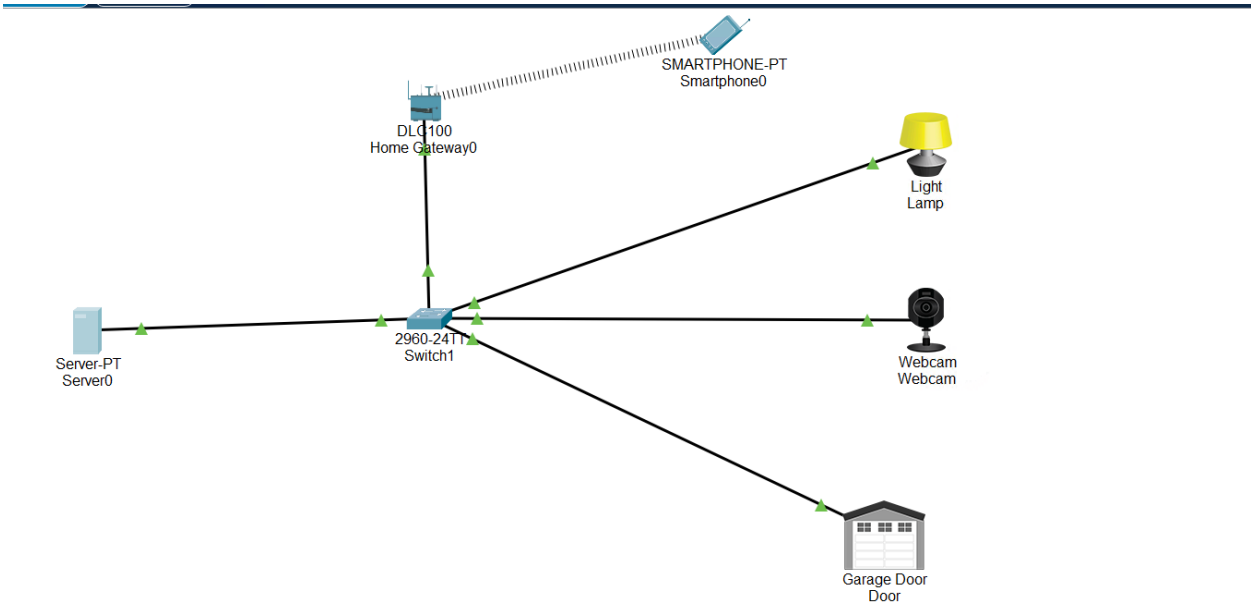
IP Service Level agreements and Remote SPAN in Campus Environment



Step 1: Take Server, Switch, Home Gateway and connect them with the network using FastEthernet



Step 2: Take Devices(Lamp, Smart Phone, Camera and Door) connect them with the network using FastEthernet and Wireless



Step 3: Assign static IP address to All the devices

Server:192.168.1.1

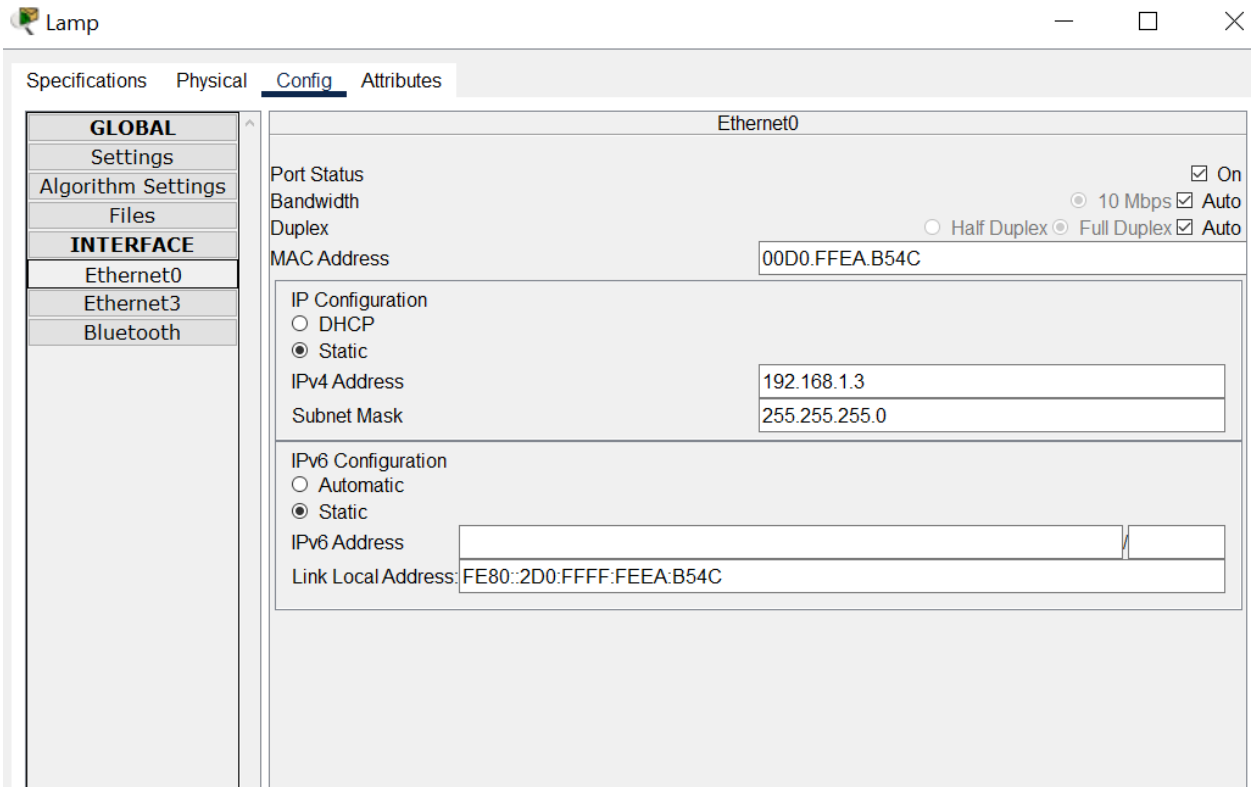
Smartphone: 192.168.1.2

Lamp: 192.168.1.3

Camera: 192.168.1.4

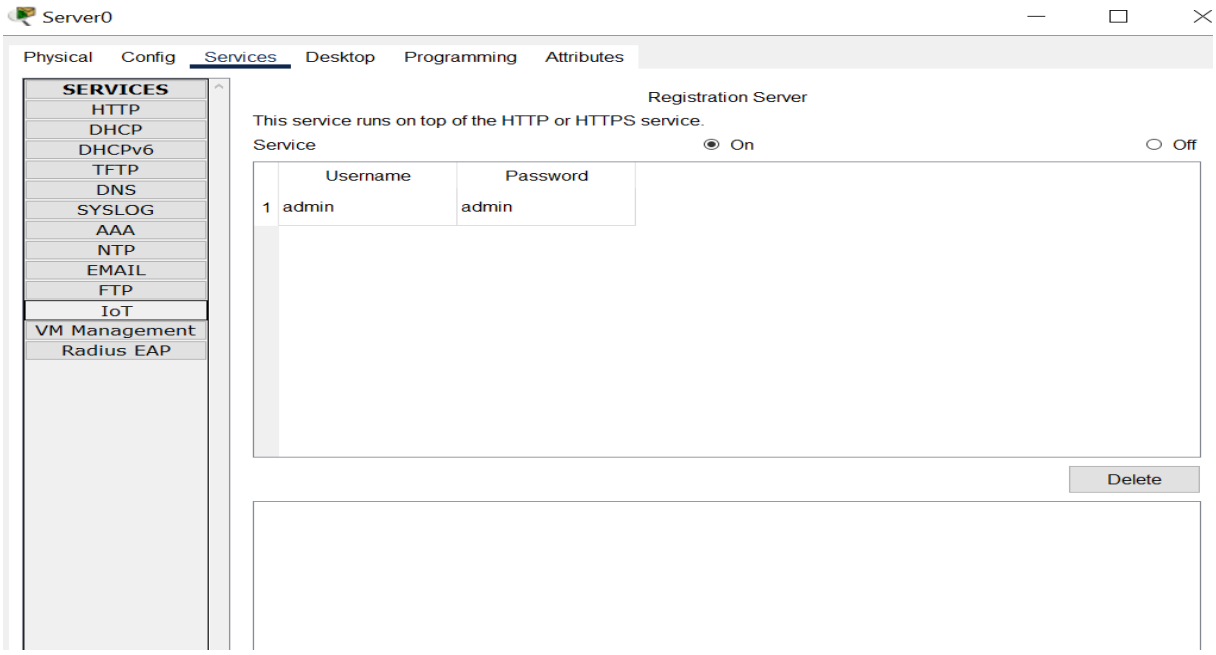
Door: 192.168.1.5

Example:



Step 4: Enable the IoT server from the server devices and create the user

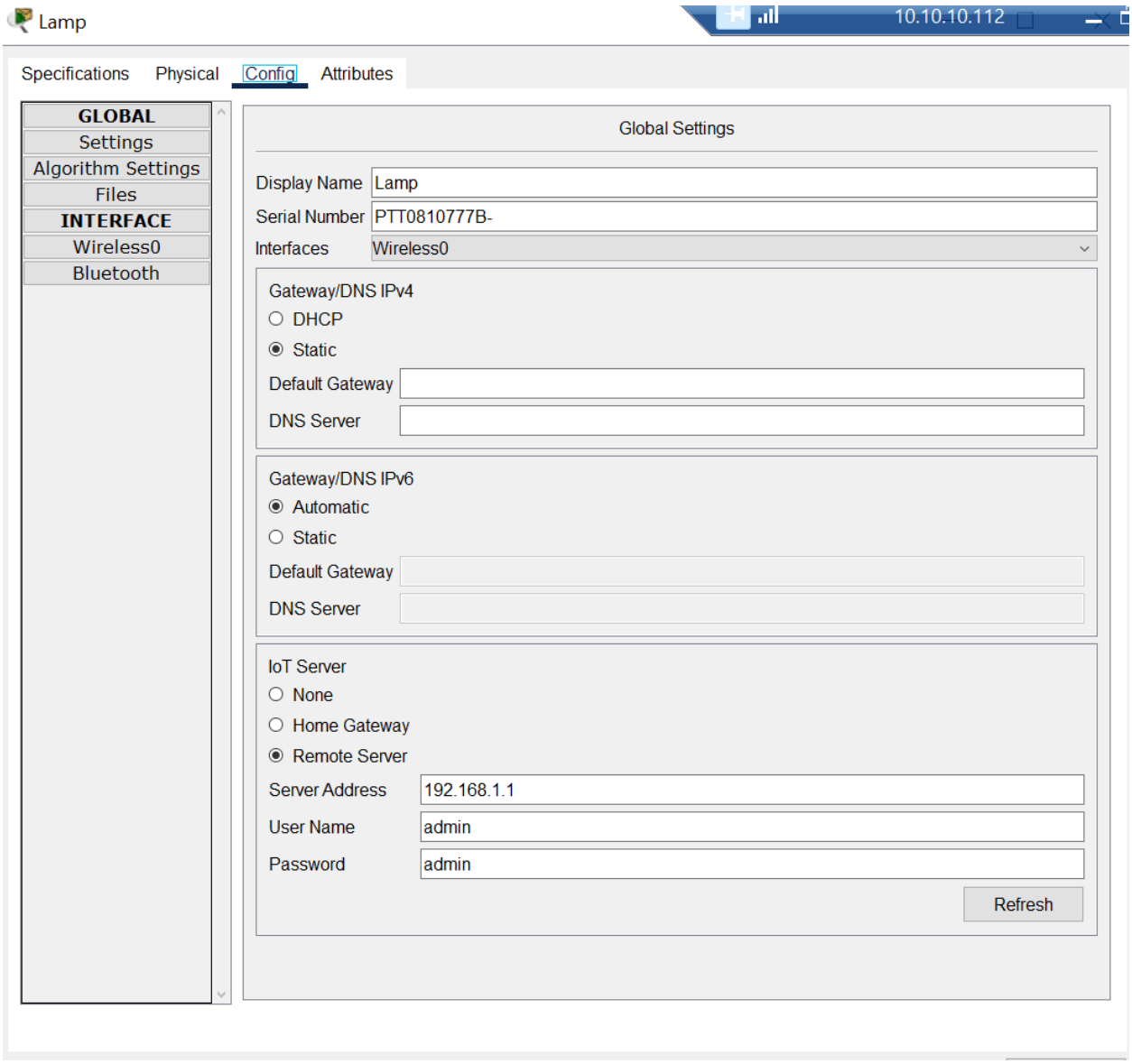
Server—Services—IoT—Turn on



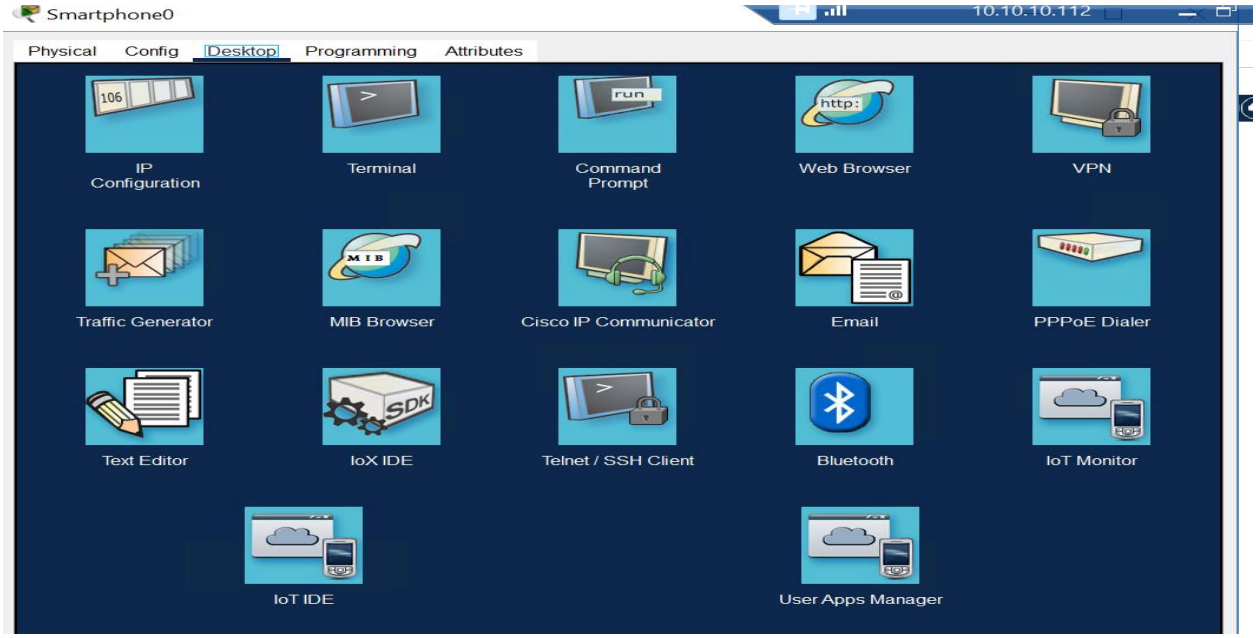
Step 5: Provide IoT server Ip address and credentials in all the devices

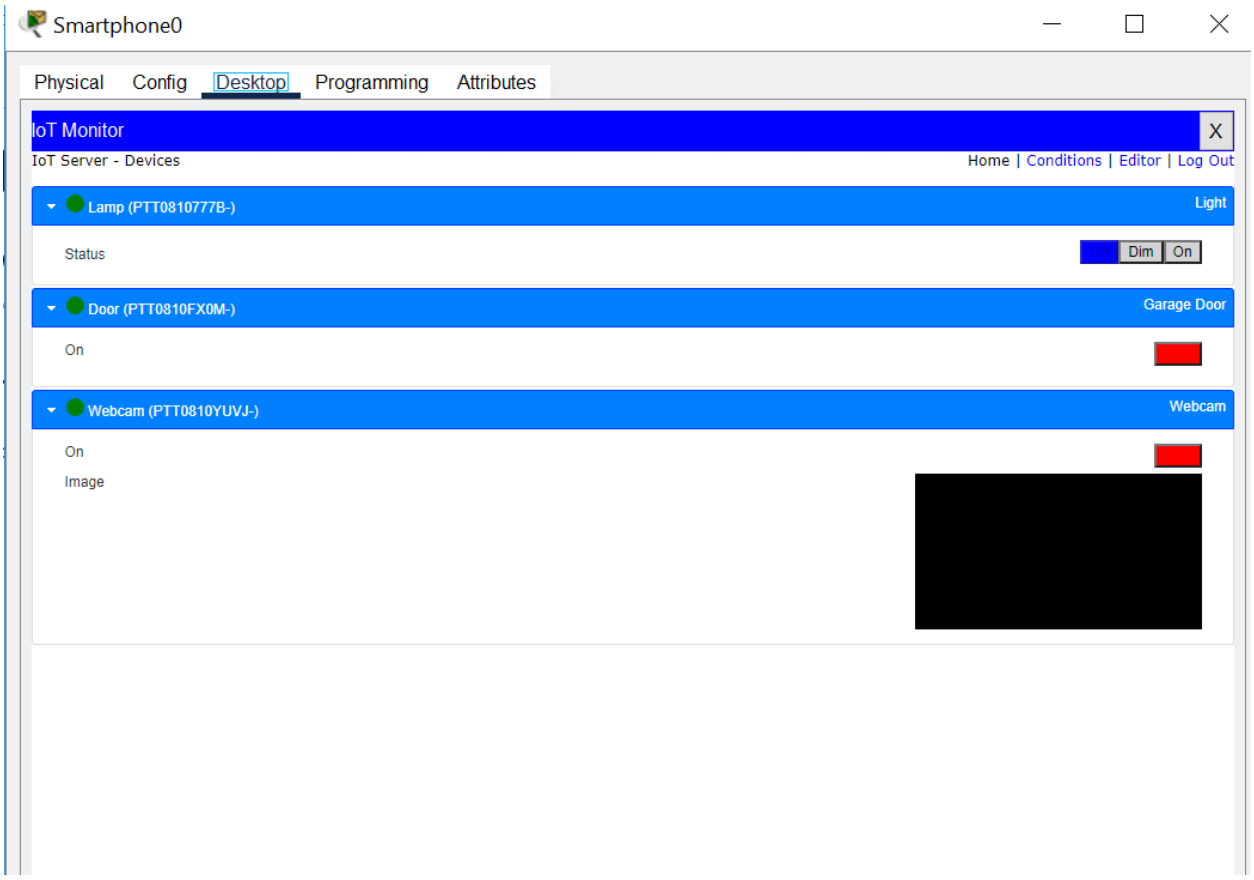
Devices—Config—Iot Server- Remote Server

Provide the Ip address of server and credentials

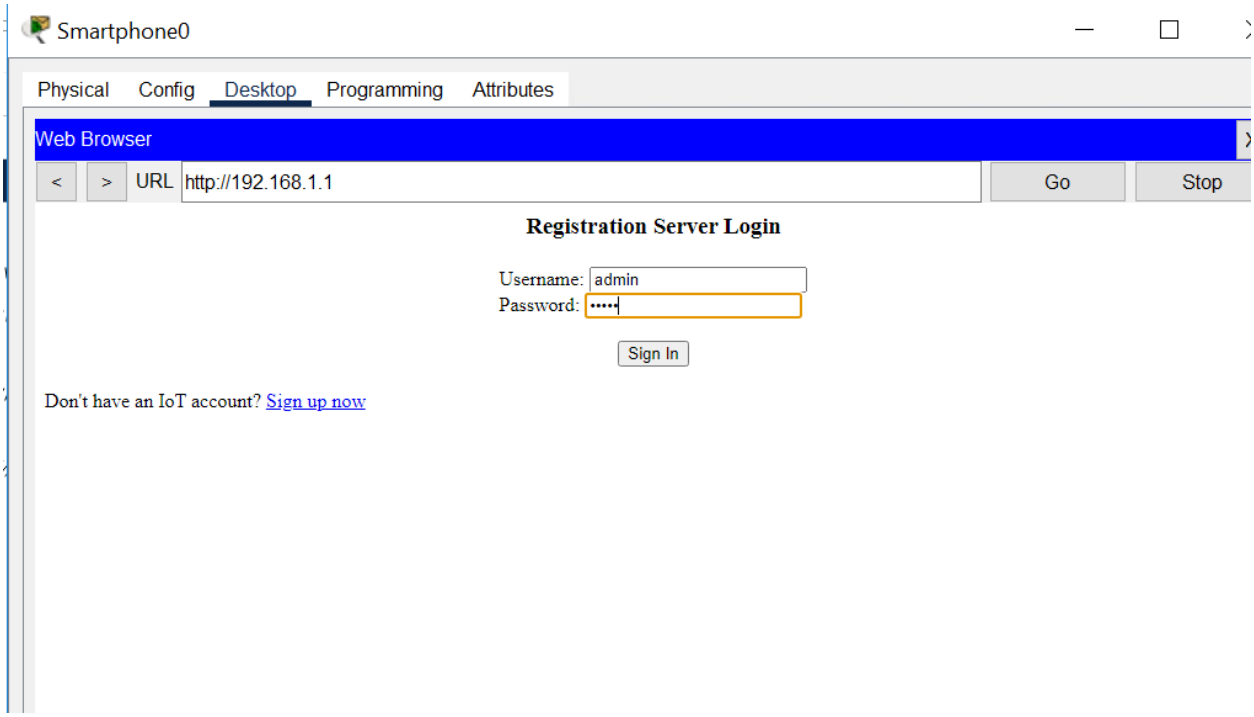


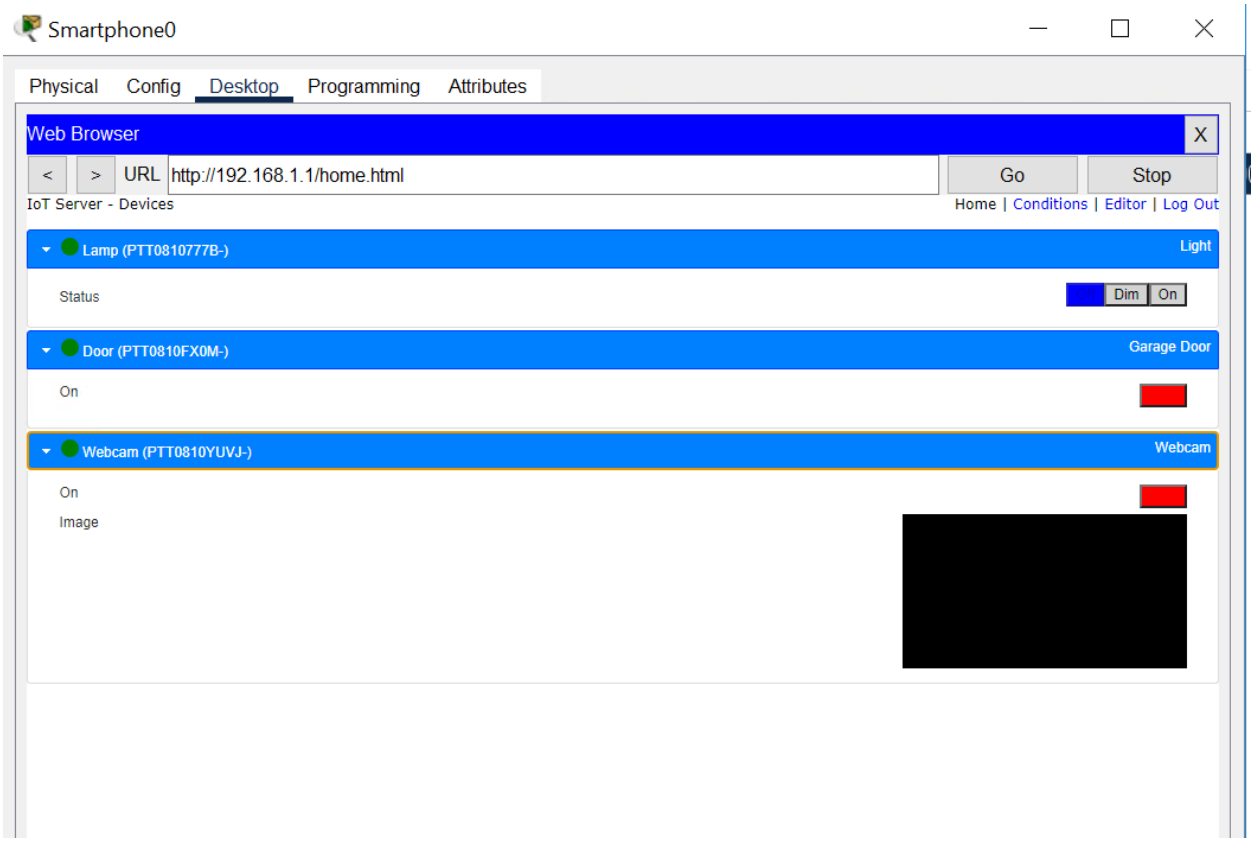
Step 6: In IoT monitoring of Smartphone, we can see all the devices.





Step 7: We can see the connection through web browser





KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

NAAC Accredited Grade B+

(Affiliated to University of Mumbai)

KALAMBOLI, 410 218 MAHARASHTRA

2024-2025

DEPARTMENT OF INFORMATION TECHNOLOGY

PRACTICAL BOOK

ON

COMPUTER VISION

Submitted to,

UNIVERSITY OF MUMBAI

BY

MAHESH TANAJI CHAVAN

Seat No:- 1312671

MASTER OF SCIENCE INFORMATION TECHNOLOGY

PART – I (SEMESTER - II)

(2024-2025)

KLE SOCIETY'S SCIENCE AND COMMERCE COLLEGE

NAAC Accredited Grade B+

(*Affiliated to University of Mumbai*)

KALAMBOLI, 410 218 MAHARASHTRA

CERTIFICATE

This is to certify that

Mr/Ms. _____

of class _____, Semester _____ has successfully completed the practical for the subject,

_____

in M.sc.(Information Technolgy) during the academic year 20 - 20 as per the syllabus prescribed by the University of mumbai.

Prof. In Charge
Date:_____

Head of Deapartment
Date:_____

External Examiner
Date:_____

Principal Sign
Date:_____

College Stamp

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Sr. No	Title	Date	Signature
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PRACTICAL – 1

Aim: Perform Geometric transformation.

Theory:

Geometric Transformations:
Geometric transformation is a fundamental technique used in image processing that involves manipulating the spatial arrangement of pixels in an image. It is used to modify the geometric properties of an image, such as its size, shape, position, and orientation. OpenCV provides two transformation functions, cv2.warpAffine and cv2.warpPerspective, with which you can have all kinds of transformations. cv2.warpAffine takes a 2x3 transformation matrix while cv2.warpPerspective takes a 3x3 transformation matrix as input.

Translation
Translation is the shifting of object's location. If you know the shift in (x,y) direction, let it be (t_x, t_y), you can create the transformation matrix $\mathbf{M}$ as follows:

$$M = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \end{bmatrix}$$

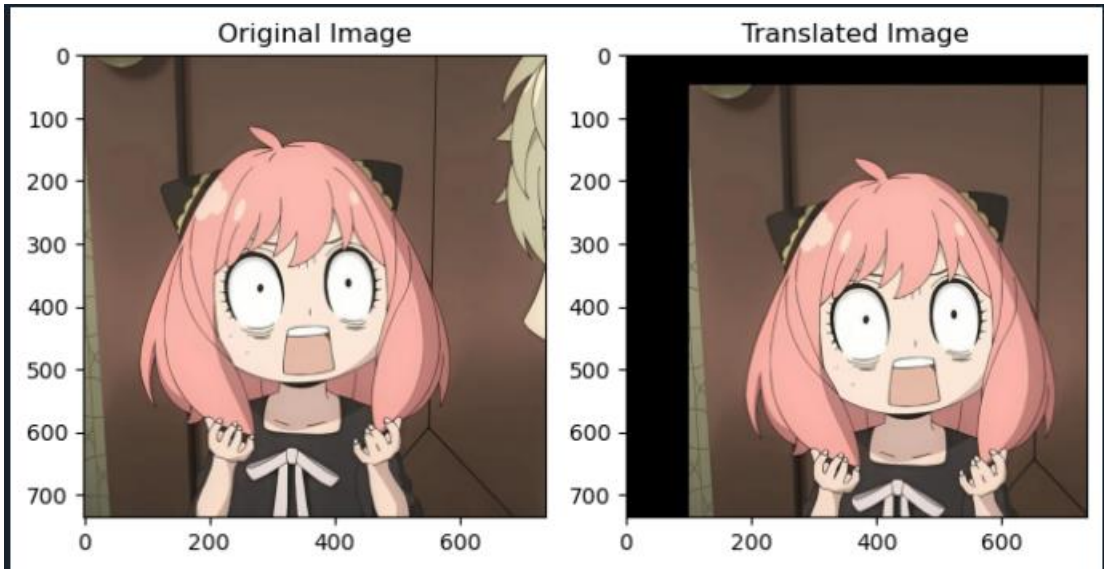
You can take make it into a Numpy array of type np.float32 and pass it into cv2.warpAffine() function. See below example for a shift of (100,50):

Warning:
Third argument of the cv2.warpAffine() function is the size of the output image, which should be in the form of (width, height). Remember width = number of columns, and height = number of rows.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
M = np.float32([[1, 0, 100], [0, 1, 50]])
dst = cv2.warpAffine(img_rgb, M, (cols, rows))
fig, axs = plt.subplots(1, 2, figsize=(7, 4))
axs[0].imshow(img_rgb)
axs[0].set_title('Original Image')
axs[1].imshow(dst)
axs[1].set_title('Translated Image')
plt.tight_layout()
plt.show()
```

Output:


Original Image
Translated Image
0
100
200
300
400
500
600
700
0
200
400
600

PRACTICAL – 1(A)

Aim: Image Scaling

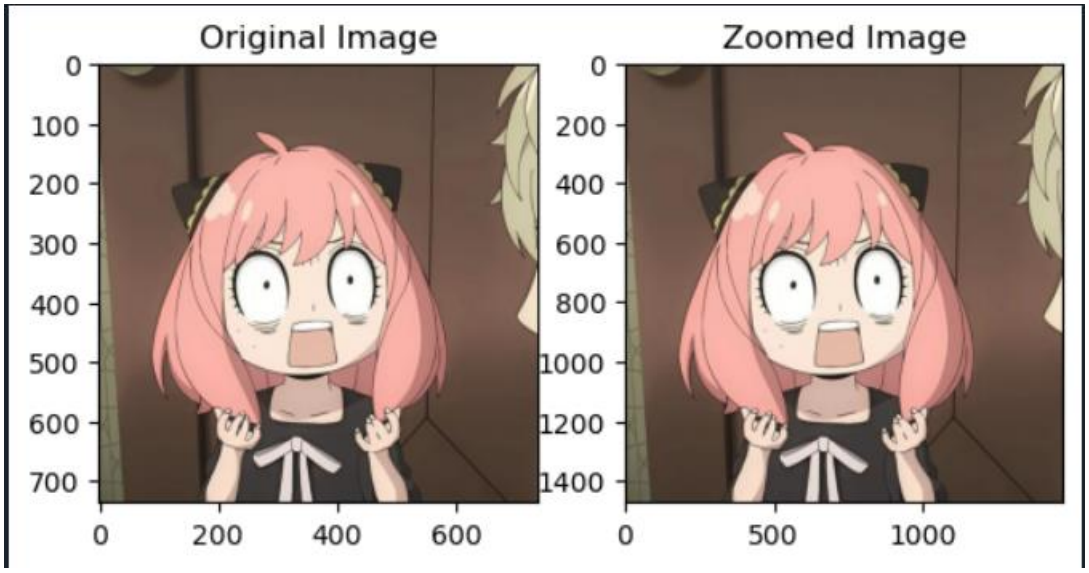
Theory:

Scaling:
Scaling is just resizing of the image. OpenCV comes with a function cv2.resize() for this purpose. The size of the image can be specified manually, or you can specify the scaling factor. Different interpolation methods are used. Preferable interpolation methods are cv2.INTER_AREA for shrinking and cv2.INTER_CUBIC (slow) & cv2.INTER_LINEAR for zooming. By default, interpolation method used is cv2.INTER_LINEAR for all resizing purposes. You can resize an input image either of following methods:

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
resize_img = cv2.resize(img_rgb, (0, 0), fx=2, fy=2, interpolation=cv2.INTER_CUBIC)
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(resize_img), plt.title('Zoomed Image')
plt.show()
```

Output:



PRACTICAL – 1(B)

Aim: Image Shrinking

Theory:

Shrinking

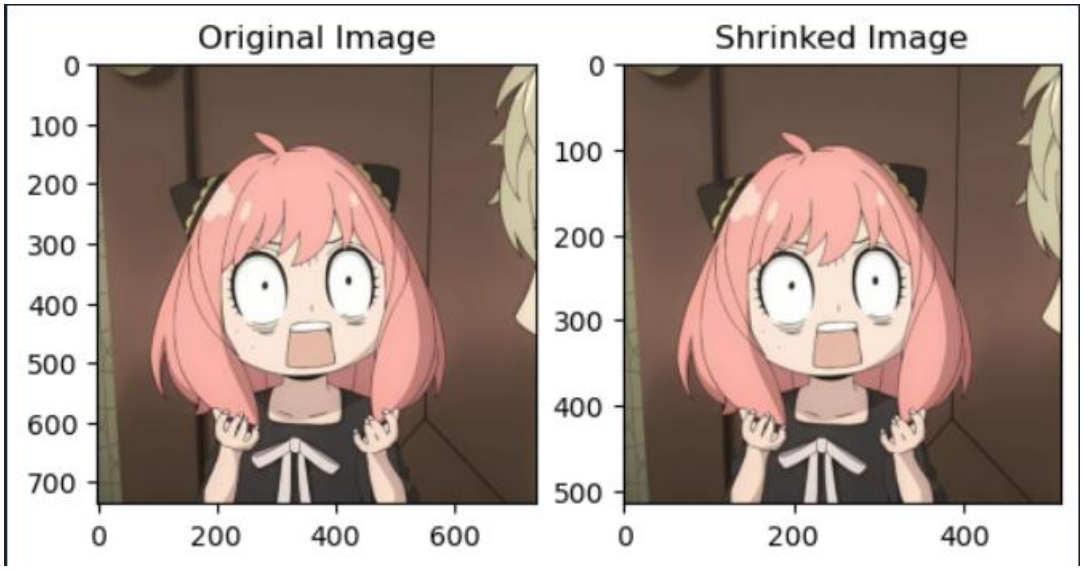
Image shrinking in Python involves reducing the dimensions of an image, effectively making it smaller while maintaining its aspect ratio. This process is commonly done using libraries like PIL (Python Imaging Library) or its fork, Pillow. By resizing the image to smaller dimensions, either by specifying new dimensions or a scaling factor, you can achieve the desired reduction in size.

This is useful for tasks like image compression, thumbnail generation, or preparing images for web display, where smaller file sizes are advantageous. The process typically involves opening the image, calculating the new dimensions, resizing the image accordingly, and then saving the resized image to a new file.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
resize_img = cv2.resize(img_rgb, (0,0), fx=0.7, fy=0.7, interpolation=cv2.INTER_AREA)
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(resize_img), plt.title('Shrinked Image')
plt.show()
```

Output:



PRACTICAL – 1(C)

Aim: Image Rotation

Theory:

Rotation

Rotation of an image for an angle θ is achieved by the transformation matrix of the form

$$M = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix}$$

But OpenCV provides scaled rotation with adjustable center of rotation so that you can rotate at any location you prefer. Modified transformation matrix is given by

$$\begin{bmatrix} \alpha & \beta & (1-\alpha)\cdot center.x - \beta \cdot center.y \\ -\beta & \alpha & \beta \cdot center.x + (1-\alpha)\cdot center.y \end{bmatrix}$$

where:

$$\alpha = scale \cdot \cos\theta,$$
$$\beta = scale \cdot \sin\theta$$

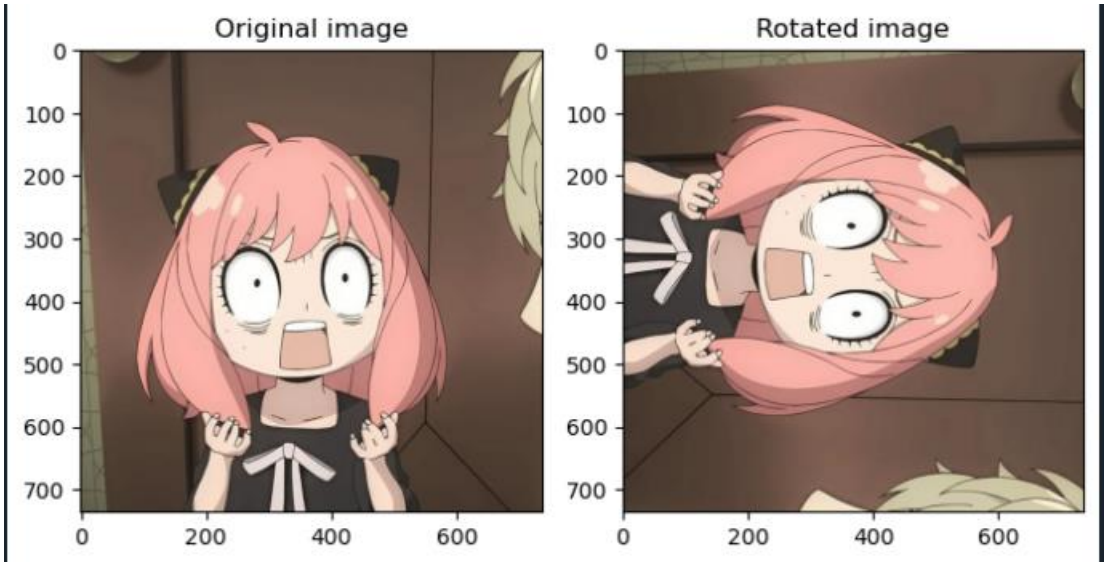
To find this transformation matrix, OpenCV provides a function, **cv2.getRotationMatrix2D**. Check below example which rotates the image by 90 degree with respect to center without any scaling.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
center = (cols // 2, rows // 2)
angle = -90
scale = 1
rotation_matrix = cv2.getRotationMatrix2D(center, angle, scale)
```

```
rotated_image = cv2.warpAffine(img_rgb, rotation_matrix, (cols, rows))
fig, axs = plt.subplots(1, 2, figsize=(7, 4))
axs[0].imshow(img_rgb)
axs[0].set_title("Original image")
axs[1].imshow(rotated_image)
axs[1].set_title("Rotated image")
plt.tight_layout()
plt.show()
```

Output:



PRACTICAL – 1(D)

Aim: Affine Transformation

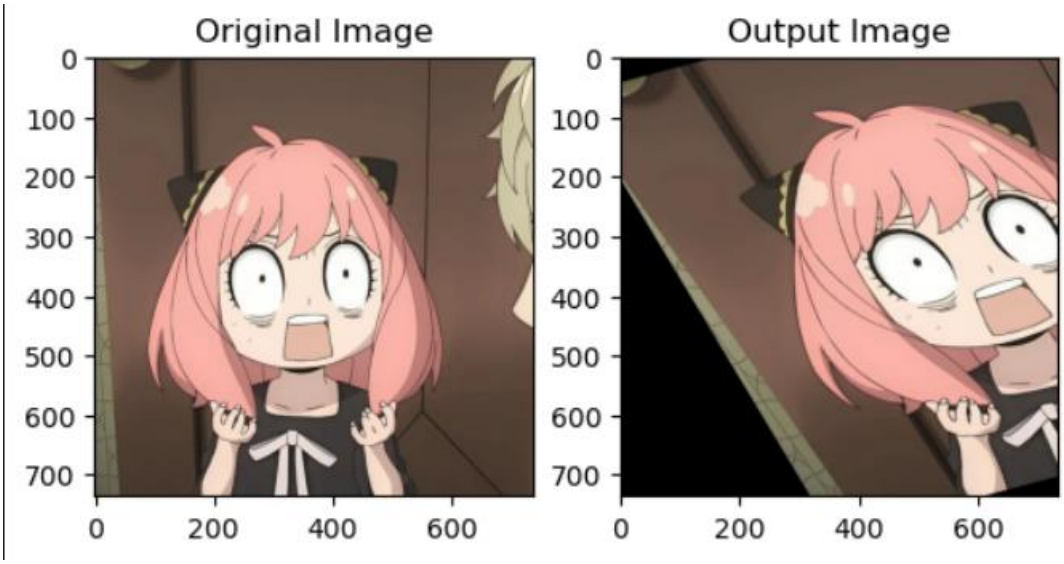
Theory:

In **affine** transformation, all parallel lines in the original image will still be parallel in the output image. To find the transformation matrix, we need three points from input image and their corresponding locations in output image. Then **cv2.getAffineTransform** will create a 2x3 matrix which is to be passed to **cv2.warpAffine**.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
pts1 = np.float32([[50,50],[200,50],[50,200]])
pts2 = np.float32([[10,100],[200,50],[100,250]])
M = cv2.getAffineTransform(pts1,pts2)
dst = cv2.warpAffine(img_rgb, M, (cols, rows))
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 1(E)

Aim: Perspective Transformation.

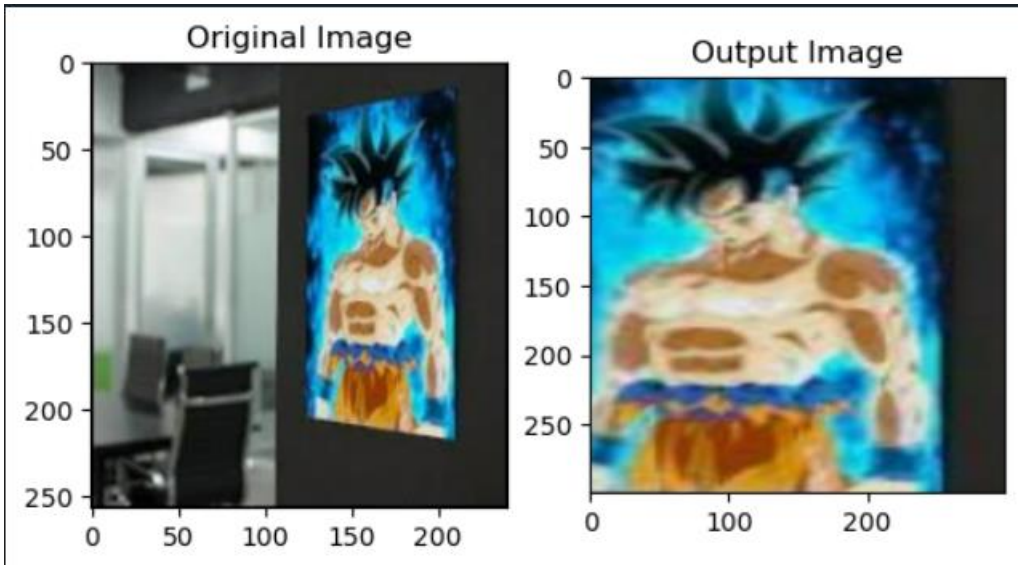
Theory:

For perspective transformation, you need a 3x3 transformation matrix. Straight lines will remain straight even after the transformation. To find this transformation matrix, you need 4 points on the input image and corresponding points on the output image. Among these 4 points, 3 of them should not be collinear. Then transformation matrix can be found by the function **cv2.getPerspectiveTransform**. Then apply **cv2.warpPerspective** with this 3x3 transformation matrix.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/1e.png")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
pts1 = np.float32([[133,34],[226,16],[133,206],[226,219]])
pts2 = np.float32([[0,0],[300,0],[0,300],[300,300]])
M = cv2.getPerspectiveTransform(pts1, pts2)
dst = cv2.warpPerspective(img_rgb, M, (300,300))
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 1(F)

Aim: Shearing X-axis.

Theory:

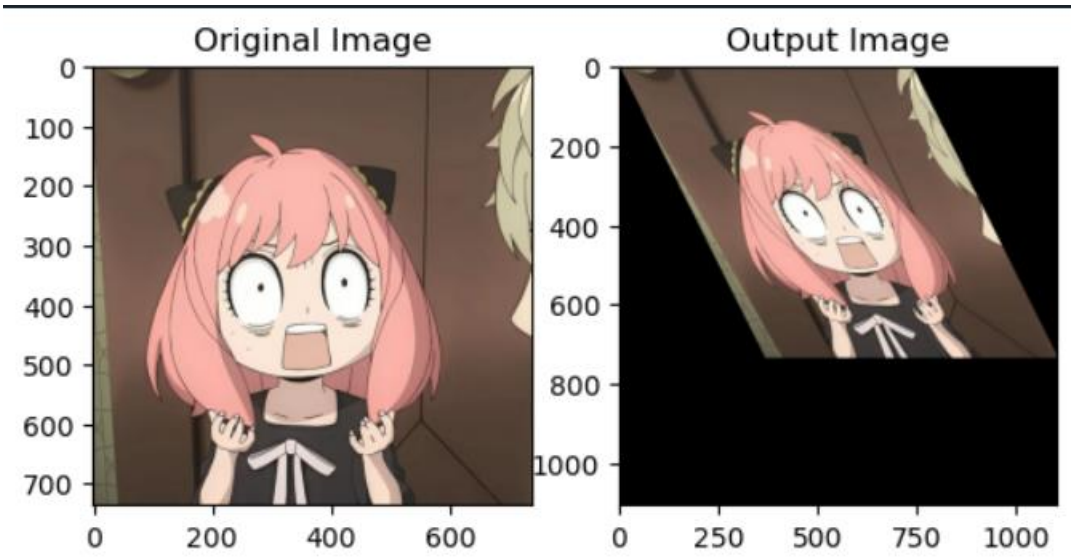
Shearing:
deals with changing the shape and size of the 2D object along x-axis and y- axis. It is similar to sliding the layers in one direction to change the shape of the 2D object.It is an ideal technique to change the shape of an existing object in a two dimensional plane. In a two dimensional plane, the object size can be changed along X direction as well as Y direction.

X-Shear:
In x shear, the y co-ordinates remain the same but the x co-ordinates changes.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread(("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg"))
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
M = np.float32([[1, 0.5, 0], [0, 1, 0], [0, 0, 1]])
dst = cv2.warpPerspective(img_rgb, M, (int(cols * 1.5), int(rows * 1.5)))
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 1(G)

Aim: Shearing Y-axis.

Theory:

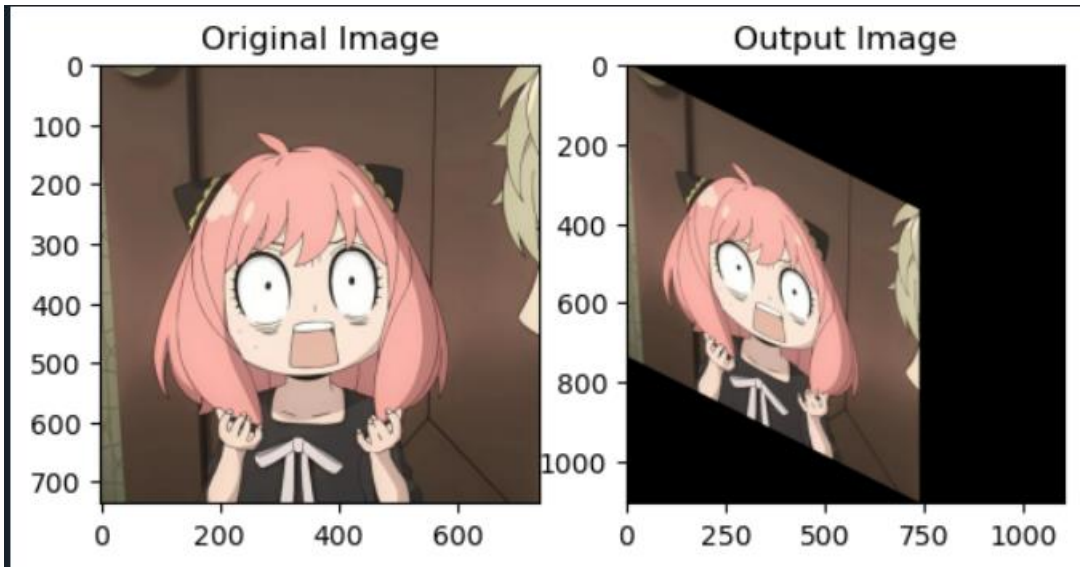
Shearing:
deals with changing the shape and size of the 2D object along x-axis and y- axis. It is similar to sliding the layers in one direction to change the shape of the 2D object.It is an ideal technique to change the shape of an existing object in a two dimensional plane. In a two dimensional plane, the object size can be changed along X direction as well as Y direction.

Y-Shear:
In y shear, the x co-ordinates remain the same but the y co-ordinates changes.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
M = np.float32([[1, 0, 0], [0.5, 1, 0], [0, 0, 1]])
dst = cv2.warpPerspective(img_rgb, M, (int(cols * 1.5), int(rows * 1.5)))
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 1(H)

Aim: Reflected Image.

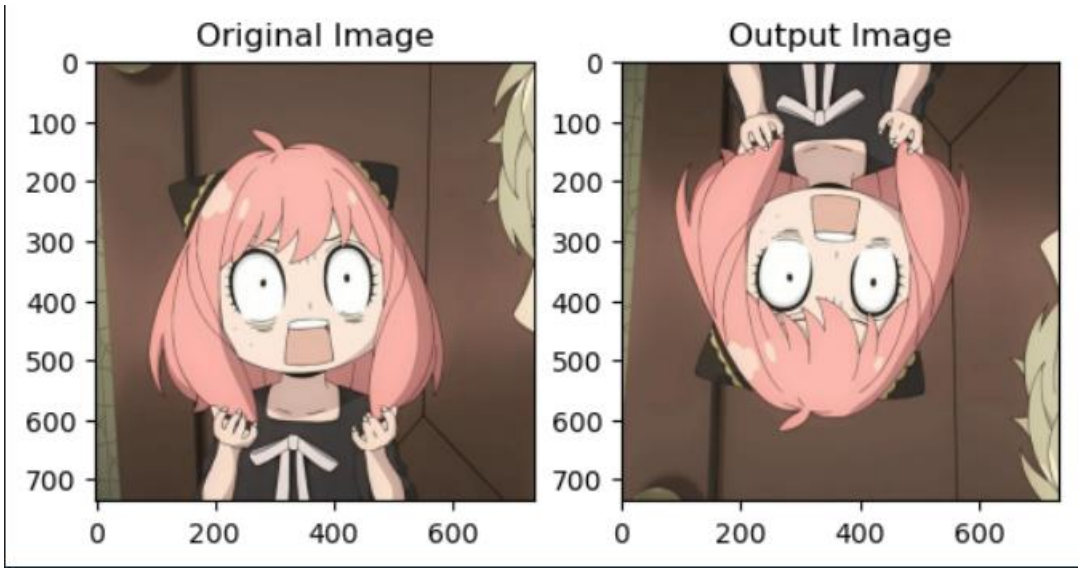
Theory:

Image Reflection:
Image reflection is used to flip the image vertically or horizontally. For reflection along the x-axis, we set the value of Sy to -1, Sx to 1, and vice-versa for the y-axis reflection.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
M = np.float32([[1, 0, 0], [0, -1, rows], [0, 0, 1]])
dst = cv2.warpPerspective(img_rgb, M, (cols, rows))
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 1(I)

Aim: Cropped Image.

Theory:

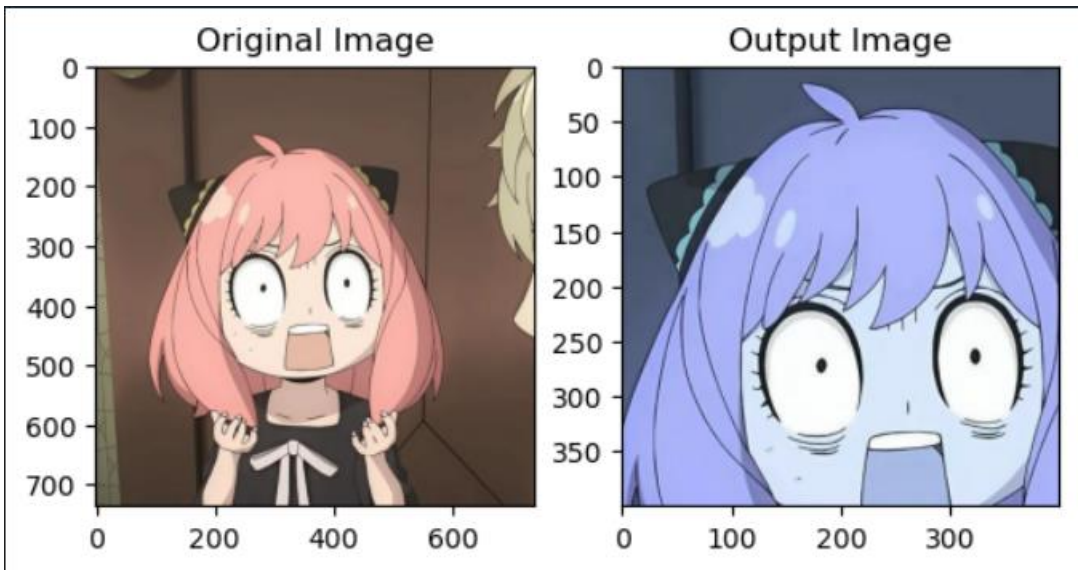
Image Cropping

Cropping is the removal of unwanted outer areas from an image.

Code:

```
import cv2
import matplotlib.pyplot as plt
import numpy as np
img = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical1/anya1.jpg")
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
rows, cols, channels = img_rgb.shape
dst = img[100:500, 100:500]
plt.subplot(121), plt.imshow(img_rgb), plt.title('Original Image')
plt.subplot(122), plt.imshow(dst), plt.title('Output Image')
plt.show()
```

Output:



PRACTICAL – 2

Aim: Perform Image Stitching.

Theory:

Image stitching is the process of combining multiple overlapping images to create a seamless, high-resolution output image. This technique is commonly used to create panoramic images, virtual tours, and even some medical imaging applications.

Image stitching involves several steps:

1. **Feature detection**: Identifying and extracting unique features (e.g., corners, edges) from each input image. Compute the SIFT-key points and descriptors for both the images.
2. **Feature matching**: Finding correspondences between features in the overlapping regions of the input images. Compute distances between every descriptor in one image and every descriptor in the other image. Select the top 'm' matches for each descriptor of an image.
3. **Homography estimation**: Estimating the transformation (e.g., rotation, scaling, translation) that aligns the input images. Run RANSAC to estimate homography
4. **Warping**: Applying the estimated transformation to the input images. Warp to align for stitching
5. **Blending**: Combining the warped images into a single seamless output image. Now stitch them together

Explanation of Code:

Firstly, we have to find out the features matching in both the images. These best matched features act as the basis for stitching. We extract the key points and sift descriptors for both the images as follows:

```
sift = cv2.SIFT_create()
# find the keypoints and descriptors with SIFT
kp1, des1 = sift.detectAndCompute(img1,None)
kp2, des2 = sift.detectAndCompute(img2,None)
```

kp1 and kp2 are keypoints, des1 and des2 are the descriptors of the respective images. Now, the obtained descriptors in one image are to be recognized in the image too. We do that as follows:

```
bf = cv2.BFMatcher()
matches = bf.knnMatch(des1,des2, k=2)
```

The BFMatcher() matches the features which are more similar. When we set parameter k=2, we are asking the knnMatcher to give out 2 best matches for each descriptor.

'**matches'** is a list of list, where each sub-list consists of 'k' objects. Often in images, there are tremendous chances where the features may be existing in many places of the image. This may mislead us to use trivial features for our experiment. So we filter out through all the matches to obtain the best ones. So we apply ratio test using the top 2 matches obtained above. We consider a match if the ratio defined below is predominantly greater than the specified ratio.

```
# Apply ratio test
good = []
for m in matches:
if m[0].distance < 0.5*m[1].distance:
good.append(m)
matches = np.asarray(good)
```

It's time to align the images now. As you know that a homography matrix is needed to perform the transformation, and the homography matrix requires at least 4 matches, we do the following.

```
if len(matches[:,0]) >= 4:
src = np.float32([ kp1[m.queryIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)
dst = np.float32([ kp2[m.trainIdx].pt for m in matches[:,0] ]).reshape(-1,1,2)H,
masked = cv2.findHomography(src, dst, cv2.RANSAC, 5.0)
#print H
else:
raise AssertionError("Can't find enough keypoints.")
```

And finally comes the last part, stitching of the images. Now that we found the homography for transformation, we can now proceed to warp and stitch them together:

```
dst = cv2.warpPerspective(img_,H,(img.shape[1] + img_.shape[1],
img.shape[0]))
plt.subplot(122),plt.imshow(dst),plt.title('Warped Image')
plt.show()
plt.figure()
dst[0:img.shape[0], 0:img.shape[1]] = img
cv2.imwrite('output.jpg',dst)
plt.imshow(dst)
plt.show()
```

We get warped image plotted using matplotlib to well visualize the warping.

Code:

```
import cv2
import numpy as np
import matplotlib.pyplot as plt
# Load images
img1 = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical2/right.jpg")
img2 = cv2.imread("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical2/left.jpg")
# Convert to grayscale
gray1 = cv2.cvtColor(img1, cv2.COLOR_BGR2GRAY)
gray2 = cv2.cvtColor(img2, cv2.COLOR_BGR2GRAY)
# SIFT feature detector
```

```
sift = cv2.SIFT_create()
kp1, des1 = sift.detectAndCompute(gray1, None)
kp2, des2 = sift.detectAndCompute(gray2, None)
# BFMatcher with KNN
bf = cv2.BFMatcher()
matches = bf.knnMatch(des1, des2, k=2)
# Apply Lowe's ratio test
good_matches = []
for m, n in matches:
    if m.distance < 0.5 * n.distance:
        good_matches.append(m)
if len(good_matches) > 4:
    src_pts = np.float32([kp1[m.queryIdx].pt for m in good_matches]).reshape(-1, 1, 2)
    dst_pts = np.float32([kp2[m.trainIdx].pt for m in good_matches]).reshape(-1, 1, 2)
    # Compute homography
    H, mask = cv2.findHomography(src_pts, dst_pts, cv2.RANSAC, 5.0)
    # Get dimensions for output
    height, width, _ = img2.shape
    panorama_width = width + img1.shape[1]
    # Warp first image
    result = cv2.warpPerspective(img1, H, (panorama_width, height))
    result[0:height, 0:width] = img2  # Overlay second image
    # Save and display
    cv2.imwrite("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical2/result.jpg", result)
    plt.imshow(cv2.cvtColor(result, cv2.COLOR_BGR2RGB))
    plt.title("Stitched Panorama")
    plt.axis("off")
    plt.show()
else:
    print("Not enough keypoints found for stitching.")
```

Output:

PRACTICAL – 3

Aim: Perform Camera Calibration.

Theory:

A camera is an integral part of several domains like robotics, space exploration, etc camera is playing a major role. It helps to capture each and every moment and helpful for many analyses. In order to use the camera as a visual sensor, we should know the parameters of the camera. **Camera Calibration** is nothing but estimating the parameters of a camera, parameters about the camera are required to determine an accurate relationship between a 3D point in the real world and its corresponding 2D projection (pixel) in the image captured by that calibrated camera.
We need to consider both internal parameters like focal length, optical center, and radial distortion coefficients of the lens etc., and external parameters like rotation and translation of the camera with respect to some real world coordinate system.

Camera Calibration can be done in a step-by-step approach:

- **Step 1:** First define real world coordinates of 3D points using known size of checkerboard pattern.
- **Step 2:** Different viewpoints of check-board image is captured.

- **Step 3:** findChessboardCorners() is a method in OpenCV and used to find pixel coordinates (u, v) for each 3D point in different images
- **Step 4:** Then calibrateCamera() method is used to find camera parameters.

It will take our calculated (threedpoints, twodpoints, grayColor.shape[::-1], None, None) as parameters and returns list having elements as Camera matrix, Distortion coefficient, Rotation Vectors, and Translation Vectors.
Camera Matrix helps to transform 3D objects points to 2D image points and the Distortion Coefficient returns the position of the camera in the world, with the values of Rotation and Translation vectors

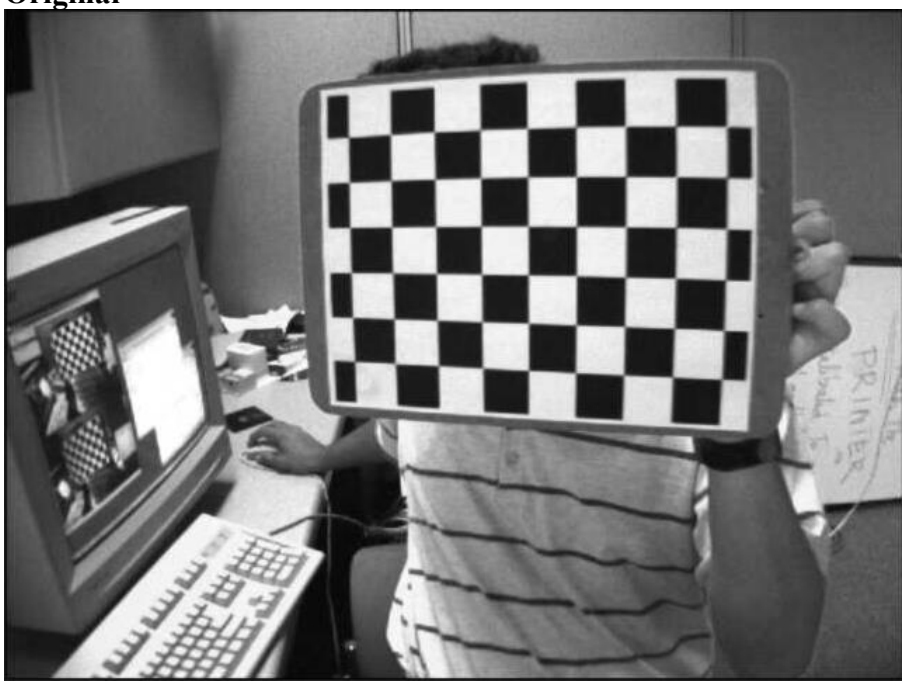
Code:

```
import numpy as np
import cv2 as cv
# Termination criteria for corner refinement
criteria = (cv.TERM_CRITERIA_EPS + cv.TERM_CRITERIA_MAX_ITER, 30, 0.001)
# Prepare object points (3D points)
objp = np.zeros((6*7, 3), np.float32)
objp[:, :2] = np.mgrid[0:7, 0:6].T.reshape(-1, 2)
# Lists to store object points and image points
objpoints = []
imgpoints = []
# Manually enter image paths
image_paths = [
   "C:/Users/DELL/Desktop/practicals/sem2/CV Practicals/practical3/ChessBoard.jpeg"
   #"C:/Users/ADMIN/Desktop/chess22.jpg"
]  # Add more image paths as needed
```

```
for fname in image_paths:
    img = cv.imread(fname)
    gray = cv.cvtColor(img, cv.COLOR_BGR2GRAY)
    ret, corners = cv.findChessboardCorners(gray, (7,6), None)
    if ret:
        objpoints.append(objp)
        corners2 = cv.cornerSubPix(gray, corners, (11, 11), (-1, -1), criteria)
        imgpoints.append(corners2)
        cv.drawChessboardCorners(img, (7,6), corners, ret)
        cv.imshow('img', img)
        cv.waitKey(500)
cv.destroyAllWindows()
# Camera calibration
ret, mtx, dist, rvecs, tvecs = cv.calibrateCamera(objpoints, imgpoints, gray.shape[::-1], None,
None)
# Print calibration results
print("Camera matrix: ")
print(mtx)
print("Distortion coefficients: ")
print(dist)
print("Rotation Vectors: ")
print(rvecs)
print("Translation Vectors: ")
print(tvecs)
# Read an image for undistortion
undistort_img_path = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical3/ChessBoard.jpeg"
img = cv.imread(undistort_img_path)
h, w = img.shape[:2]
newcameramtx, roi = cv.getOptimalNewCameraMatrix(mtx, dist, (w, h), 1, (w, h))
dst = cv.undistort(img, mtx, dist, None, newcameramtx)
x, y, w, h = roi
dst = dst[y:y+h, x:x+w]
# Save the undistorted image
cv.imwrite('C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical3/calibresult.png', dst)
print("Undistorted image saved as calibresult.png")
```

Output:

Original



Result

PRACTICAL – 4(A)

Aim: Perform the following Face detection.

Theory:

Face detection involves identifying a person's face in an image or video. This is done by analyzing the visual input to determine whether a person's facial features are present. Since human faces are so diverse, face detection models typically need to be trained on large amounts of input data for them to be accurate. The training dataset must contain a sufficient representation of people who come from different backgrounds, genders, and cultures.

These algorithms also need to be fed many training samples comprising different lighting, angles, and orientations to make correct predictions in real-world scenarios. These nuances make face detection a non-trivial, time-consuming task that requires hours of model training and millions of data samples.

The OpenCV package comes with pre-trained models for face detection, which means that we don't have to train an algorithm from scratch. More specifically, the library employs a machine learning approach called Haar cascade to identify objects in visual data.

Face detection approach called Haar Cascade for face detection using OpenCV and Python.

Intro to Haar Cascade Classifiers

This method was first introduced in the paper Rapid Object Detection Using a Boosted Cascade of Simple Features, written by Paul Viola and Michael Jones.

The idea behind this technique involves using a cascade of classifiers to detect different features in an image. These classifiers are then combined into one strong classifier that can accurately distinguish between samples that contain a human face from those that don't.

The Haar Cascade classifier that is built into OpenCV has already been trained on a large dataset of human faces, so no further training is required. We just need to load the classifier from the library and use it to perform face detection on an input image.

Installing OpenCV for Python

To install the OpenCV library, simply open your command prompt or terminal window and run the following command:

pip install opencv-python

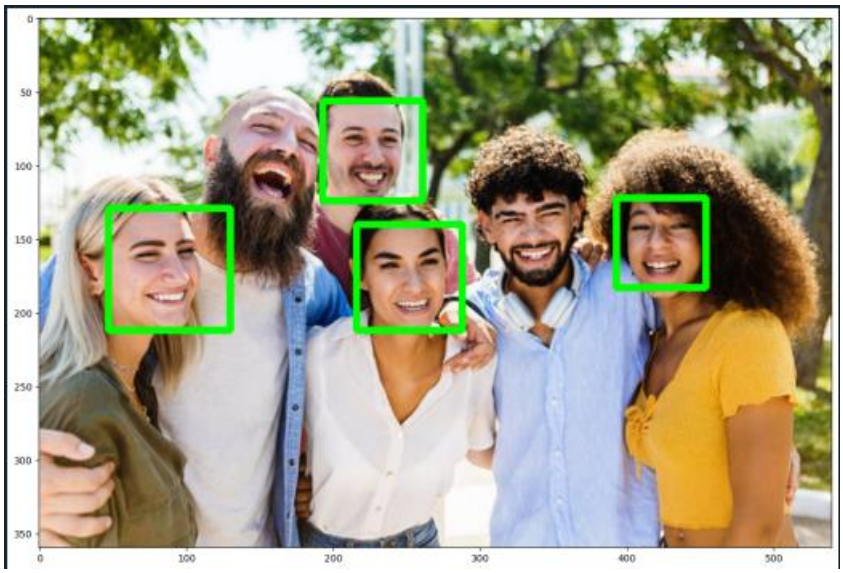
OpenCV for Face Detection in Images We will build a detector to identify the human face in a photo. Make sure to save the picture to your working directory and rename it to input_image before coding along.

Code:

```
import cv2
import matplotlib.pyplot as plt
imagePath = 'C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4a/grpimg.jpg'
img = cv2.imread(imagePath)
print(img.shape)
gray_image = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
face_classifier = cv2.CascadeClassifier(cv2.data.haarcascades +
"haarcascade_frontalface_default.xml")
face = face_classifier.detectMultiScale(gray_image, scaleFactor=1.1, minNeighbors=5,
minSize=(40, 40))
```

```
for (x, y, w, h) in face:
    cv2.rectangle(img, (x, y), (x + w, y + h), (0, 255, 0), 4)
img_rgb = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
plt.figure(figsize=(20,10))
plt.imshow(img_rgb)
plt.show()
```

Output:



PRACTICAL – 4(B)

Aim: Perform the following Object detection.

Theory:

Object Detection

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos.

Haar cascade:

Basically, the Haar cascade technique is an approach based on machine learning where we use a lot of positive and negative images to train the classifier to classify between the images. Haar cascade classifiers are considered as the effective way to do object detection with the OpenCV library.

Positive images: These are the images that contain the objects which we want to be identified from the classifier.

Negative Images: These are the images that do not contain any object that we want to be detected by the classifier, and these can be images of everything else.

Requirements for object detection with Python OpenCV:

1. Install OpenCV-Python Library
2. Install matplotlib library
3. An Image with Stop Sign.
4. An xml file “Stop_data.xml” to detect stop sign board.

Code:

```
import cv2
from matplotlib import pyplot as plt
# Load the image
image_path = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4b/practical4b-i/stop_sign.jpg"
imaging = cv2.imread(image_path)
# Check if image loaded correctly
if imaging is None:
    print("Error: Image not found! Check the file path.")
else:
    # Convert to grayscale
    imaging_gray = cv2.cvtColor(imaging, cv2.COLOR_BGR2GRAY)
    imaging_rgb = cv2.cvtColor(imaging, cv2.COLOR_BGR2RGB)
    # Load the Haar Cascade XML file
    xml_path = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4b/practical4b-i/stop_data.xml"
    xml_data = cv2.CascadeClassifier(xml_path)
    # Check if the XML file loaded properly
    if xml_data.empty():
        print("Error: XML file not found! Check the file path.")
    else:
        # Detect objects
        detecting = xml_data.detectMultiScale(imaging_gray, minSize=(30, 30))
        if len(detecting) > 0:
            for (x, y, w, h) in detecting:
                cv2.rectangle(imaging_rgb, (x, y), (x + w, y + h), (0, 255, 0), 9)
        # Display the image
        plt.imshow(imaging_rgb)
        plt.axis("off")  # Hide axes
        plt.show()
```

Output:

PRACTICAL – 4(C)

Aim: Perform the following Pedestrian detection

Theory:

Pedestrian detection

Pedestrian detection is a very important area of research because it can enhance the functionality of a pedestrian protection system in Self Driving Cars. We can extract features like head, two arms, two legs, etc, from an image of a human body and pass them to train a machine learning model. After training, the model can be used to detect and track humans in images and video streams. However, OpenCV has a built-in method to detect pedestrians. It has a pre-trained HOG(Histogram of Oriented Gradients) + Linear SVM model to detect pedestrians in images and video streams.

Histogram of Oriented Gradients

This algorithm checks directly surrounding pixels of every single pixel. The goal is to check how darker is the current pixel compared to the surrounding pixels. The algorithm draws and arrows showing the direction of the image getting darker. It repeats the process for each and every pixel in the image. At last, every pixel would be replaced by an arrow, these arrows are called Gradients. These gradients show the flow of light from light to dark. By using these gradients algorithms perform further analysis.

Requirements

1. opencv-python
2. imutils

Code:

```
import cv2
import imutils
# Initialize HOG descriptor and set the default people detector
hog = cv2.HOGDescriptor()
hog.setSVMDetector(cv2.HOGDescriptor_getDefaultPeopleDetector())
# Load the image
image_path = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4c/Pedestrian_image.jpg"
image = cv2.imread(image_path)
if image is None:
    print("Error: Image not found! Check the file path.")
    exit()
# Resize the image for better processing
image = imutils.resize(image, width=min(400, image.shape[1]))
# Detect people in the image
(regions, _) = hog.detectMultiScale(image, winStride=(4, 4), padding=(4, 4), scale=1.05)
# Draw rectangles around detected people
for (x, y, w, h) in regions:
    cv2.rectangle(image, (x, y), (x + w, y + h), (0, 0, 255), 2)
# Display the output image
cv2.imshow("Detected Pedestrians", image)
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Output:

PRACTICAL – 4(D)

Aim: Perform the following Face Recognition.

Theory:

Face recognition is different from face detection. In face detection, we had only detected the location of human faces, and we recognized the identity of faces in the face recognition task. In this article, we are going to build a face recognition system using python with the help of face recognition library.

There are many algorithms available in the market for face recognition. This broad computer vision challenge is detecting faces from videos and pictures. Many applications can be built on top of recognition systems. Many big companies are adopting recognition systems for their security and authentication purposes.

Use Cases of Recognition Systems

Face recognition systems are widely used in the modern era, and many new innovative systems are built on top of recognition systems.

There are a few used cases :

- Finding Missing Person
- Identifying accounts on social media
- Recognizing Drivers in Cars
- School Attendance System

Several methods and algorithms implement facial recognition systems depending on the performance and accuracy.

Traditional Face Recognition Algorithm

Traditional face recognition algorithms don't meet modern-day's facial recognition standards. They were designed to recognize faces using old conventional algorithms.

OpenCV provides some traditional facial Recognition Algorithms.

- **Eigenfaces**
- **Scale Invariant Feature Transform (SIFT)**
- **Fisher faces**
- **Local Binary Patterns Histograms (LBPH)**

These methods differ in the way they extract image information and match input and output images.

LBPH algorithm is a simple yet very efficient method still in use but it's slow compared to modern days algorithms.

Deep Learning For Face Recognition

There are various deep learning-based facial recognition algorithms available.

- DeepFace
- DeepID series of systems,
- FaceNet
- VGGFace

Generally, face recognizers that are based on landmarks take face images and try to find essential feature points such as eyebrows, corners of the mouth, eyes, nose, lips, etc. There are more than 60 points.

Steps Involved in Face Recognition

1. **Face Detection**: Locate the face, note the coordinates of each face located and draw a bounding box around every faces.

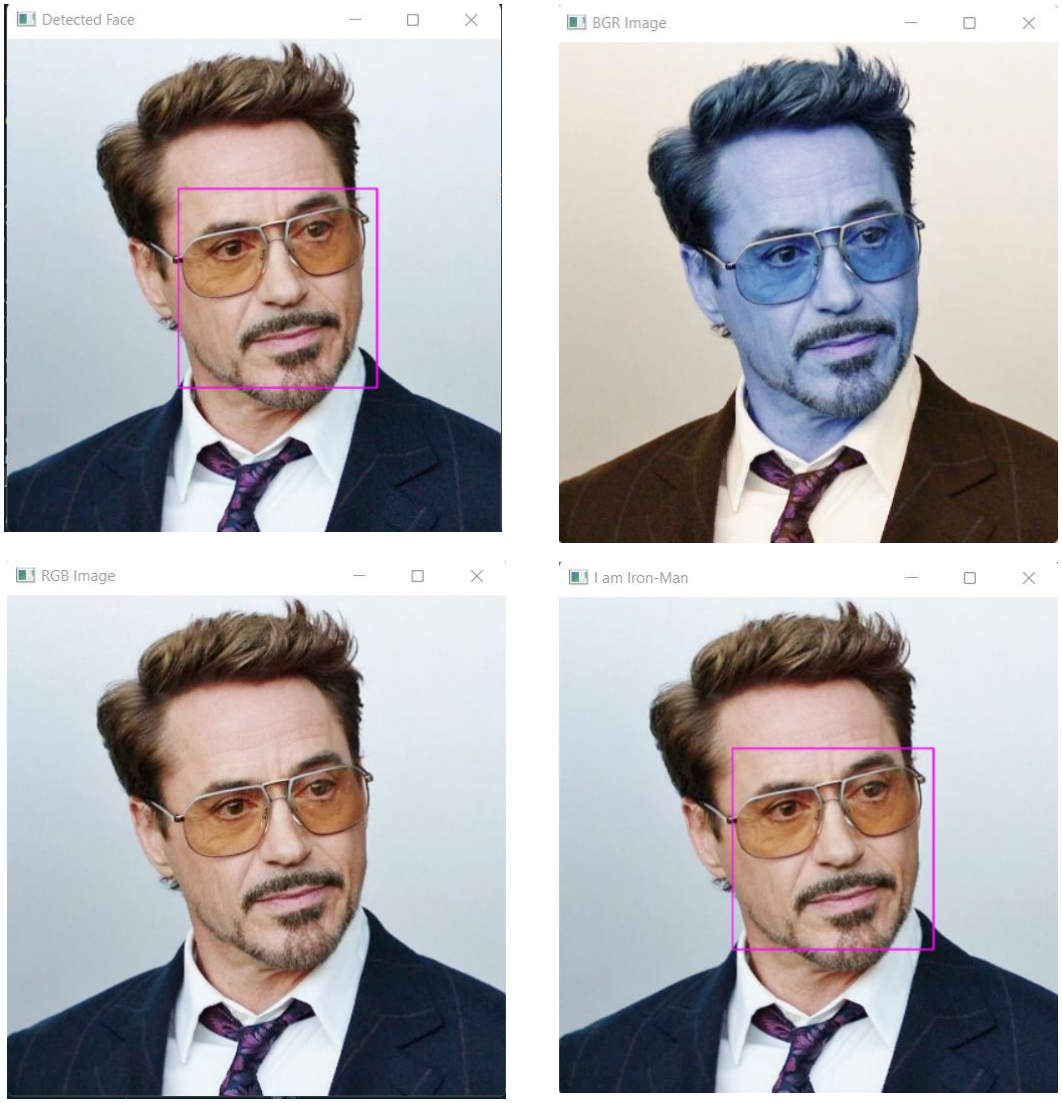
2. **Face Alignments**. Normalize the faces in order to attain fast training.
3. **Feature Extraction**. Local feature extraction from facial pictures for training, this step is performed differently by different algorithms.
4. **Face Recognition**. Match the input face with one or more known faces in our dataset.

Code:

```
import numpy as np
import face_recognition
import os
# Resize helper function
def resize_image(image, scale=0.5):
    width = int(image.shape[1] * scale)
    height = int(image.shape[0] * scale)
    return cv2.resize(image, (width, height))
# Load and check if image exists
image_path_1 = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4d/tonystark.jpg"
image_path_2 = "C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical4/practical4d/rdj_image.jpg"
if not os.path.exists(image_path_1) or not os.path.exists(image_path_2):
    print("Error: One or both image files not found! Check the file paths.")
    exit()
# Load images and convert color
img_bgr = face_recognition.load_image_file(image_path_1)
img_rgb = cv2.cvtColor(img_bgr, cv2.COLOR_BGR2RGB)
# Show BGR and RGB images (resized)
cv2.imshow('BGR Image', resize_image(img_bgr))
cv2.imshow('RGB Image', resize_image(img_rgb))
cv2.waitKey(0)
# Detect faces in the first image
img_modi = face_recognition.load_image_file(image_path_1)
img_modi_rgb = cv2.cvtColor(img_modi, cv2.COLOR_BGR2RGB)
faces = face_recognition.face_locations(img_modi_rgb)
if len(faces) == 0:
    print("No face detected in the first image!")
    exit()
face = faces[0]
copy = img_modi_rgb.copy()
cv2.rectangle(copy, (face[3], face[0]), (face[1], face[2]), (255, 0, 255), 2)
# Show detected face (resized)
cv2.imshow('Detected Face', resize_image(copy))
cv2.waitKey(0)
# Face recognition and comparison
train_encode = face_recognition.face_encodings(img_modi_rgb)[0]
test = face_recognition.load_image_file(image_path_2)
test_rgb = cv2.cvtColor(test, cv2.COLOR_BGR2RGB)
faces_test = face_recognition.face_locations(test_rgb)
```

```
if len(faces_test) == 0:
    print("No face detected in the second image!")
    exit()
test_encode = face_recognition.face_encodings(test_rgb)[0]
# Compare faces
match_result = face_recognition.compare_faces([train_encode], test_encode)
print("Do the faces match?", match_result[0])
# Draw rectangle on detected face and show (resized)
cv2.rectangle(img_modi_rgb, (face[3], face[0]), (face[1], face[2]), (255, 0, 255), 2)
cv2.imshow('I am Iron-Man', resize_image(img_modi_rgb))
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Output:




```
In [1]: runfile('C:/Users/DELL/Desktop/practicals/sem2/CV Practicals/practical4/practical4d/practical
4d.py', wdir='C:/Users/DELL/Desktop/practicals/sem2/CV Practicals/practical4/practical4d')
Do the faces match? True
```

PRACTICAL – 5

Aim: Implement object detection and tracking from video.

Theory:
Object detection is the detection on every single frame and frame after frame.
Object tracking does frame-by-frame tracking but keeps the history of where the object is at a time after time

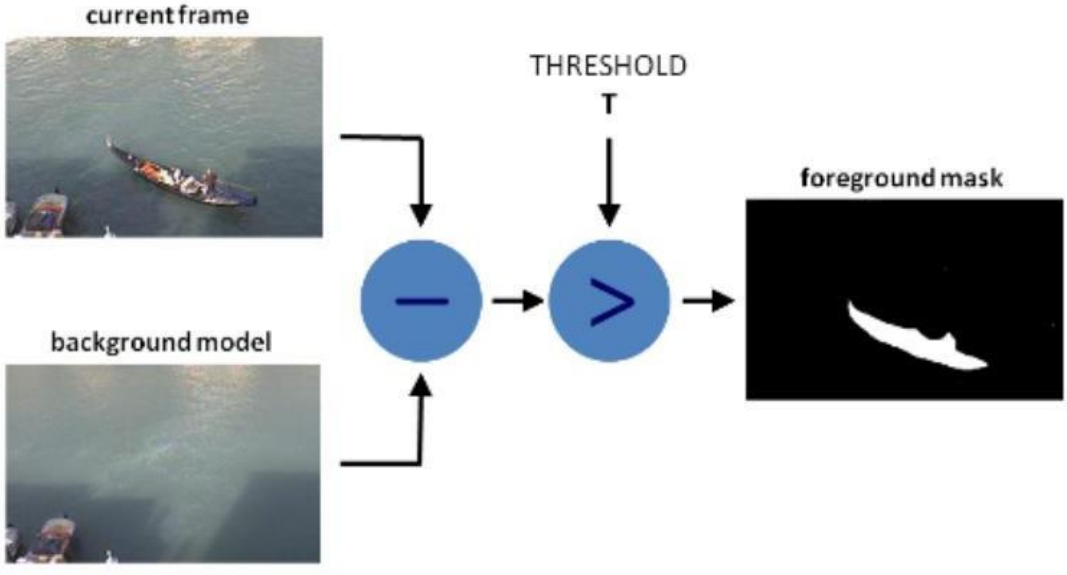
1. **Importing Libraries and Modules:**
   import cv2:
   Imports the OpenCV library used for computer vision tasks. from

   tracker import *:

   Imports all functions and classes from a tracker module, which likely contains the implementation of the EuclideanDistTracker.
2. **Creating Objects and Initializing Video Capture:**
   tracker = EuclideanDistTracker():
   Instantiates the Euclidean Distance Tracker. cap =

   cv2.VideoCapture("highway.mp4"):

   Initializes video capture with the video file "highway.mp4".
3. **Object Detection Initialization:**
   object_detector = cv2.createBackgroundSubtractorMOG2(history=100, varThreshold=40):
   Initializes a background subtractor with MOG2 method to differentiate between foreground (moving objects) and the background.
   Background subtraction (BS) is a common and widely used technique for generating a foreground mask (namely, a binary image containing the pixels belonging to moving objects in the scene) by using static cameras.
   As the name suggests, BS calculates the foreground mask performing a subtraction between the current frame and a background model, containing the static part of the scene or, more in general, everything that can be considered as background given the characteristics of the observed scene.



4. **Processing Video Frames**: The while True loop starts an infinite loop to process video frames until manually stopped.

ret, frame = cap.read(): Reads the next frame from the video.
height, width, _ = frame.shape: Retrieves the dimensions of the frame.

5. **Defining Region of Interest (ROI):**
   roi = frame[340: 720,500: 800]: Defines a specific area in the video frame to focus the object detection on. This reduces computation and ignores irrelevant areas.
6. **Object Detection:**
   mask = object_detector.apply(roi): Applies the background subtractor to the ROI to get the foreground mask.
   _, mask = cv2.threshold(mask, 254, 255, cv2.THRESH_BINARY): Applies a threshold to the mask to make it binary, which helps in identifying distinct objects.contours, _ = cv2.findContours(mask, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE):
   Finds the contours of the detected objects in the binary mask.
7. **Filtering and Storing Detections:**
   It iterates through each contour, calculates its area, and if the area is larger than a threshold (100), it calculates a bounding box for the object.These bounding boxes ([x, y, w, h]) are added to the detections list representing detected objects.
8. Object Tracking:boxes_ids = tracker.update(detections): The tracker updates with the current frame's detections and returns the tracked objects with their IDs.The loop then iterates through these tracked objects, drawing their ID and bounding box on the ROI.
9. **Displaying Results:cv2.imshow():**
   Displays the ROI, the original frame, and the binary mask in separate windows.key = cv2.waitKey(30): Waits for a key press for 30 ms and breaks the loop if the 'Esc' key is pressed.
10. **Cleanup:cap.release() and cv2.destroyAllWindows():**
    Releases the video capture and closes all OpenCV windows.

In summary, this script is a complete system for object detection and tracking in a video. It uses MOG2 for background subtraction to detect moving objects and tracks them using a Euclidean Distance Tracker. It processes and visualizes the results in real-time until the user exits by pressing the 'Esc' key.

Code:

```
import cv2
import numpy as np
from object_detection import ObjectDetection
import math
# Initialize Object Detection
od = ObjectDetection()
cap = cv2.VideoCapture("C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical5/practical5a/los_angeles.mp4")
# Initialize count
count = 0
center_points_prev_frame = []
tracking_objects = {}
track_id = 0
while True:
    ret, frame = cap.read()
```

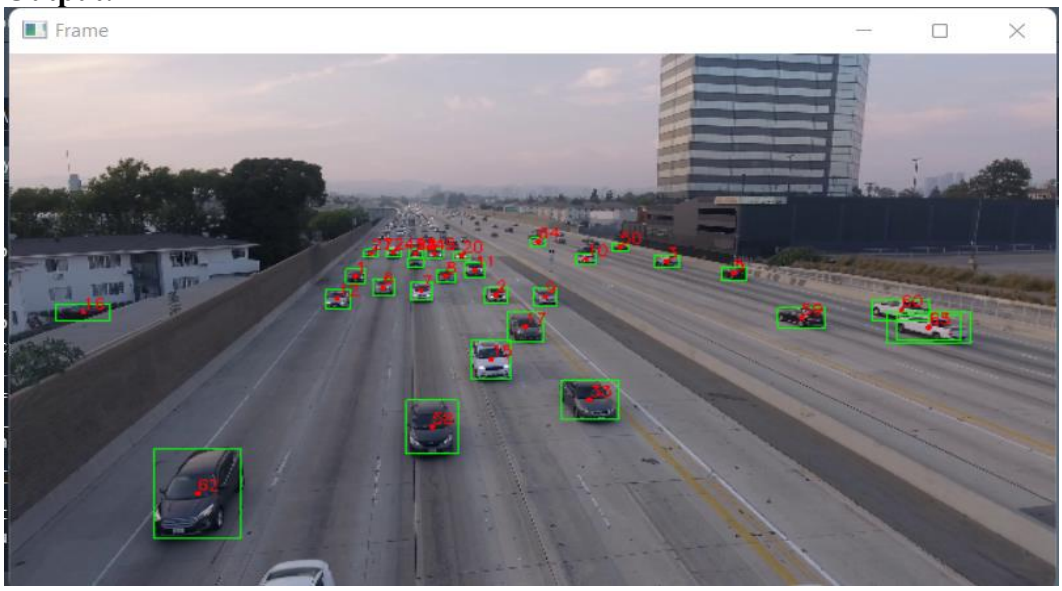
```
count += 1
if not ret:
    break
# Convert frame to grayscale
gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
# Apply thresholding to create a binary mask
_, mask = cv2.threshold(gray, 50, 255, cv2.THRESH_BINARY)
# Point current frame
center_points_cur_frame = []
# Detect objects on frame
(class_ids, scores, boxes) = od.detect(frame)
for box in boxes:
    (x, y, w, h) = box
    cx = int((x + x + w) / 2)
    cy = int((y + y + h) / 2)
    center_points_cur_frame.append((cx, cy))
    # Draw bounding boxes
    cv2.rectangle(frame, (x, y), (x + w, y + h), (0, 255, 0), 2)
# Only at the beginning we compare previous and current frame
if count <= 2:
    for pt in center_points_cur_frame:
        for pt2 in center_points_prev_frame:
            distance = math.hypot(pt2[0] - pt[0], pt2[1] - pt[1])
            if distance < 20:
                tracking_objects[track_id] = pt
                track_id += 1
else:
    tracking_objects_copy = tracking_objects.copy()
    center_points_cur_frame_copy = center_points_cur_frame.copy()
    for object_id, pt2 in tracking_objects_copy.items():
        object_exists = False
        for pt in center_points_cur_frame_copy:
            distance = math.hypot(pt2[0] - pt[0], pt2[1] - pt[1])
            # Update IDs position
            if distance < 20:
                tracking_objects[object_id] = pt
                object_exists = True
                if pt in center_points_cur_frame:
                    center_points_cur_frame.remove(pt)
                continue
        # Remove IDs lost
        if not object_exists:
            tracking_objects.pop(object_id)
    # Add new IDs found
    for pt in center_points_cur_frame:
        tracking_objects[track_id] = pt
        track_id += 1
for object_id, pt in tracking_objects.items():
    cv2.circle(frame, pt, 5, (0, 0, 255), -1)
    cv2.putText(frame, str(object_id), (pt[0], pt[1] - 7), 0, 1, (0, 0, 255), 2)
print("Tracking objects")
print(tracking_objects)
```

```
    print("CUR FRAME LEFT PTS")
    print(center_points_cur_frame)
    # Resize frames before displaying
    frame_resized = cv2.resize(frame, (640, 360))  # Adjust the resolution as needed
    mask_resized = cv2.resize(mask, (300, 200))  # Adjust the resolution as needed
    cv2.imshow("Frame", frame_resized)
    cv2.imshow("Mask", mask_resized)
    # Make a copy of the points
    center_points_prev_frame = center_points_cur_frame.copy()
    key = cv2.waitKey(1)
    if key == 27:
        break
cap.release()
cv2.destroyAllWindows()
```

object_detection.py

```
import cv2
import numpy as np
class ObjectDetection:
    def __init__(self, weights_path="C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical5/practical5a/yolov3.weights",
cfg_path="C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical5/practical5a/yolov3.cfg"):
        print("Loading Object Detection")
        print("Running opencv dnn with YOLOv3")
        self.nmsThreshold = 0.4
        self.confThreshold = 0.5
        self.image_size = 608
        # Load Network
        net = cv2.dnn.readNet(weights_path, cfg_path)
        # Enable GPU CUDA
        net.setPreferableBackend(cv2.dnn.DNN_BACKEND_CUDA)
        net.setPreferableTarget(cv2.dnn.DNN_TARGET_CUDA)
        self.model = cv2.dnn_DetectionModel(net)
        self.classes = []
        self.load_class_names()
        self.colors = np.random.uniform(0, 255, size=(80, 3))
        self.model.setInputParams(size=(self.image_size, self.image_size), scale=1/255)
    def load_class_names(self, classes_path="C:/Users/DELL/Desktop/practicals/sem2/CV
Practicals/practical5/practical5a/classes.txt"):
        with open(classes_path, "r") as file_object:
            for class_name in file_object.readlines():
                class_name = class_name.strip()
                self.classes.append(class_name)
        self.colors = np.random.uniform(0, 255, size=(80, 3))
        return self.classes
    def detect(self, frame):
        return self.model.detect(frame, nmsThreshold=self.nmsThreshold,
confThreshold=self.confThreshold)
```

Output:




```
In [1]: runfile('C:/Users/DELL/Desktop/practicals/sem2/CV Practicals/practical5/practical5a/practical
5a new.py', wdir='C:/Users/DELL/Desktop/practicals/sem2/CV Practicals/practical5/practical5a')
Loading Object Detection
Running opencv dnn with YOLOv3
Tracking objects
{}
CUR FRAME LEFT PTS
[(440, 742), (881, 474), (643, 434), (943, 459), (1116, 438), (1268, 435), (794, 436), (613, 473),
(687, 449), (754, 461), (1878, 590), (1426, 466), (766, 649), (843, 423), (744, 415), (135, 520),
(930, 532), (1000, 393), (859, 570), (1754, 636), (669, 392), (704, 394), (741, 405), (822, 400),
(1100, 389), (568, 890), (1157, 398), (1347, 978), (776, 394)]
Tracking objects
{0: (434, 746), 1: (642, 435), 2: (882, 475), 3: (1265, 434), 4: (764, 655), 5: (1421, 464), 6: (687,
450), 7: (754, 462), 8: (794, 436), 9: (943, 460), 10: (1114, 435), 11: (843, 423), 12: (612, 473),
13: (744, 415), 14: (744, 415), 15: (860, 566), 16: (135, 520), 17: (930, 533), 18: (998, 392), 19:
(1864, 587), 20: (822, 400), 21: (669, 391), 22: (741, 404), 23: (741, 404), 24: (704, 394), 25:
(1153, 396), 26: (1350, 982), 27: (665, 399), 28: (776, 394), 29: (1100, 390)}
CUR FRAME LEFT PTS
```

PRACTICAL – 6

Aim: Perform Colorization.

Theory:
We'll create a program to convert a black & white image i.e grayscale image to a colour image. We're going to use the **Caffe colourization model** for this program. And you should be familiar with basic OpenCV functions and uses like reading an image or how to load a pre-trained model using dnn module etc.
The procedure that we'll follow to implement the program:

Steps:

1. Load the model and the **convolution/kernel points**
2. Read and preprocess the image
3. Generate model predictions using the **L channel** from our input image
4. Use the output -> **ab channel** to create a resulting image

What is the L channel and ab channel? Basically like **RGB** colour space, there is something similar, known as **Lab colour space**. And this is the basis on which our program is based. Let's discuss what it is briefly:

What is Lab Colour Space?
Like RGB, lab colour has 3 channels L, a, and b. But here instead of pixel values, these have different significances i.e :

- **L-channel:** light intensity
- **a channel:** green-red encoding
- **b channel:** blue-red encoding

And In our program, we'll use the L channel of our image as input to our model to predict ab channel values and then rejoin it with the L channel to generate our final image.

Automatic colorization of photos using deep neural networks is a technology that can add color to black and white photos without the need for manual coloring. This technology uses deep neural networks that have been trained on large datasets of color images to learn the relationship between luminance and color, which can then be used to predict the color channels of grayscale images. This technique has many applications, including restoring old photos and enhancing the visual appeal of images.

Background

Before the advent of computer technology, adding color to a black-and-white photograph was a manual and time-consuming process that required skilled artists. With the introduction of automated colorization methods, the process became quicker but often inaccurate and still required manual intervention. Deep neural networks are a type of machine learning algorithm inspired by the human brain, and they have made it possible to automatically colorize black-and-white photographs with high accuracy and speed. These networks are trained on large datasets of color images and use what they learned to generate plausible colorizations for grayscale images. Using deep neural networks for automatic colorization has many practical applications, such as restoring old photographs, enhancing medical images, and creating realistic 3D models from 2D images.

Code:

```
import numpy as np
import cv2
from cv2 import dnn

proto_file = 'C:/Users/DELL/Downloads/colorization_deploy_v2.prototxt'
model_file = 'C:/Users/DELL/Downloads/colorization_release_v2.caffemodel'
hull_pts = 'C:/Users/DELL/Downloads/pts_in_hull.npy'
img_path = 'C:/Users/DELL/Downloads/goku_pika.webp'

net = dnn.readNetFromCaffe(proto_file, model_file)
kernel = np.load(hull_pts)
img = cv2.imread(img_path)
scaled = img.astype("float32") / 255.0
lab_img = cv2.cvtColor(scaled, cv2.COLOR_BGR2LAB)
class8 = net.getLayerId("class8_ab")
conv8 = net.getLayerId("conv8_313_rh")
pts = kernel.transpose().reshape(2, 313, 1, 1)
net.getLayer(class8).blobs = [pts.astype("float32")]
net.getLayer(conv8).blobs = [np.full((1, 313), 2.606, dtype="float32")]
resized = cv2.resize(lab_img, (224, 224))
L = cv2.split(resized)[0]
L -= 50
net.setInput(cv2.dnn.blobFromImage(L))
ab_channel = net.forward()[0, :, :, :].transpose((1, 2, 0))
ab_channel = cv2.resize(ab_channel, (img.shape[1], img.shape[0]))
L = cv2.split(lab_img)[0]
colorized = np.concatenate((L[:, :, np.newaxis], ab_channel), axis=2)
colorized = cv2.cvtColor(colorized, cv2.COLOR_LAB2BGR)
colorized = np.clip(colorized, 0, 1)
colorized = (255 * colorized).astype("uint8")
img = cv2.resize(img, (250, 500))
colorized = cv2.resize(colorized, (250, 500))
result = cv2.hconcat([img, colorized])

cv2.imshow("Grayscale -> Colour", result)
cv2.waitKey(0)


# Use following link to download proto_file, model_file, hull_pts files
"https://storage.openvinotoolkit.org/repositories/datumaro/models/colorization/"
# Another link "https://github.com/abhilipsaJena/image_colorization-OpenCV/tree/main"
```

Output:

PRACTICAL – 7

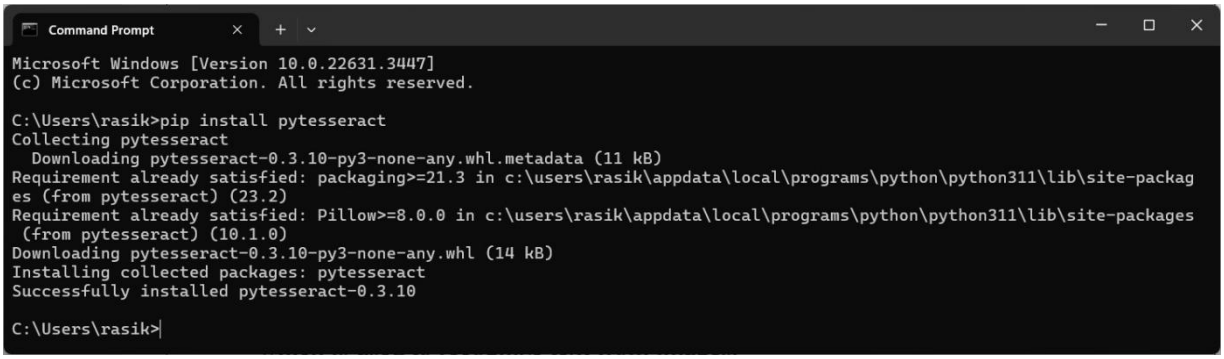
Aim: Perform Text Detection and Recognition.

Theory:

Required Installations:

pip install opencv-python

pip install pytesseract



Follow the instructions given in below Link:

https://builtin.com/articles/python-tesseract

OpenCV package is used to read an image and perform certain image processing techniques. Python-tesseract is a wrapper for Google's Tesseract-OCR Engine which is used to recognize text from images.
Python-tesseract is an optical character recognition (OCR) tool for python. That is, it will recognize and "read" the text embedded in images.
Python-tesseract is a wrapper for Google's Tesseract-OCR Engine. It is also useful as a stand-alone invocation script to tesseract, as it can read all image types supported by the Pillow and Leptonica imaging libraries, including jpeg, png, gif, bmp, tiff, and others. Additionally, if used as a script, Python-tesseract will print the recognized text instead of writing it to a file.

Approach:

After the necessary imports, a sample image is read using the imread function of opencv.

Applying image processing for the image:

The colorspace of the image is first changed and stored in a variable. For color conversion we use the function cv2.cvtColor(input_image, flag). The second parameter flag determines the type of conversion. We can chose among cv2.COLOR_BGR2GRAY and cv2.COLOR_BGR2HSV. cv2.COLOR_BGR2GRAY helps us to convert an RGB image to gray scale image and cv2.COLOR_BGR2HSV is used to convert an RGB image to HSV (Hue, Saturation, Value) color-space image. Here, we use cv2.COLOR_BGR2GRAY. A threshold is applied to the converted image using cv2.threshold function.

There are 3 types of thresholding:

1. Simple Thresholding
2. Adaptive Thresholding
3. Otsu's Binarization

For more information on thresholding, refer Thresholding techniques using OpenCV. cv2.threshold() has 4 parameters, first parameter being the color-space changed image,

followed by the minimum threshold value, the maximum threshold value and the type of thresholding that needs to be applied.

To get a rectangular structure:

cv2.getStructuringElement() is used to define a structural element like elliptical, circular, rectangular etc. Here, we use the rectangular structural element (cv2.MORPH_RECT). cv2.getStructuringElement takes an extra size of the kernel parameter. A bigger kernel would make group larger blocks of texts together. After choosing the correct kernel, dilation is applied to the image with cv2.dilate function. Dilation makes the groups of text to be detected more accurately since it dilates (expands) a text block.

Finding Contours:

cv2.findContours() is used to find contours in the dilated image. There are three arguments in cv.findContours(): the source image, the contour retrieval mode and the contour approximation method.

This function returns contours and hierarchy. Contours is a python list of all the contours in the image. Each contour is a Numpy array of (x, y) coordinates of boundary points in the object. Contours are typically used to find a white object from a black background. All the above image processing techniques are applied so that the Contours can detect the boundary edges of the blocks of text of the image. A text file is opened in write mode and flushed. This text file is opened to save the text from the output of the OCR.

Applying OCR:

Loop through each contour and take the x and y coordinates and the width and height using the function cv2.boundingRect(). Then draw a rectangle in the image using the function cv2.rectangle() with the help of obtained x and y coordinates and the width and height. There are 5 parameters in the cv2.rectangle(), the first parameter specifies the input image, followed by the x and y coordinates (starting coordinates of the rectangle), the ending coordinates of the rectangle which is (x+w, y+h), the boundary color for the rectangle in RGB value and the size of the boundary. Now crop the rectangular region and then pass it to the tesseract to extract the text from the image. Then we open the created text file in append mode to append the obtained text and close the file.

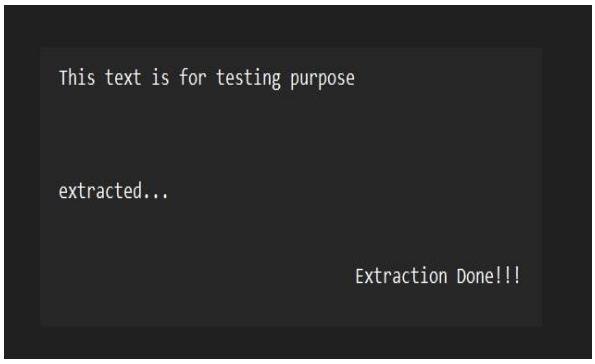
Code:

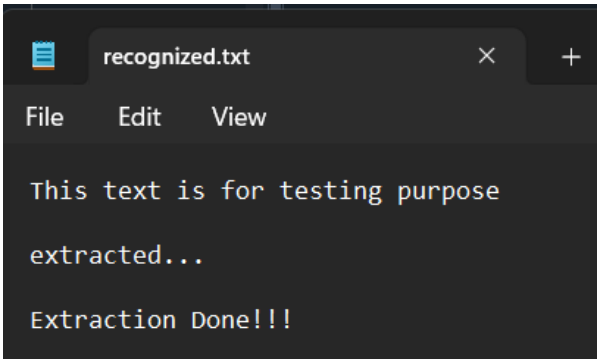
```
import cv2
import pytesseract

pytesseract.pytesseract.tesseract_cmd = 'C:/Program Files/Tesseract-OCR/tesseract.exe'
img = cv2.imread("C:/Users/DELL/Downloads/textforextract.jpg")
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
ret, thresh1 = cv2.threshold(gray, 0, 255, cv2.THRESH_OTSU |
cv2.THRESH_BINARY_INV)
rect_kernel = cv2.getStructuringElement(cv2.MORPH_RECT, (18, 18))
dilation = cv2.dilate(thresh1, rect_kernel, iterations=1)
contours, hierarchy = cv2.findContours(dilation, cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_NONE)
im2 = img.copy()
file = open('C:/Users/DELL/Downloads/recognized.txt', 'w+') #output file location
file.write("")
file.close()
for cnt in contours:
    x, y, w, h = cv2.boundingRect(cnt)
    rect = cv2.rectangle(im2, (x, y), (x + w, y + h), (0, 255, 0), 2)
    cropped = im2[y:y + h, x:x + w]
    file = open('C:/Users/DELL/Downloads/recognized.txt', 'a')  #output file location
    text = pytesseract.image_to_string(cropped)
    file.write(text)
    file.write("\n")
    file.close()

# To download tesseract.exe use following link "https://github.com/UB-
Mannheim/tesseract/wiki"
```

Output:





PRACTICAL – 8

Aim: Construct 3D model from Images.

Theory:
Transforming a 2D image into a 3D environment requires depth estimation, which can be a difficult operation depending on the amount of precision and information required. OpenCV supports a variety of depth estimation approaches, including stereo vision and depth from focus/defocus.

In this practical we'll see a basic technique utilizing stereovision:

Transform a 2D image into a 3D space using OpenCV:

Transforming a 2D image into a 3D space using OpenCV refers to the process of converting a two-dimensional image into a three-dimensional spatial representation using the Open Source Computer Vision Library (OpenCV). This transformation involves inferring the depth information from the 2D image, typically through techniques such as stereo vision, depth estimation, or other computer vision algorithms, to create a 3D model with depth perception. This process enables various applications such as 3D reconstruction, depth sensing, and augmented reality.

Importance of transformations of a 2D image into a 3D space
Transforming 2D images into 3D space becomes crucial in various fields due to its numerous applications and benefits:
Depth Perception: We are able to detect depth by transforming 2D pictures into 3D space. This makes it possible to use augmented reality, object recognition, and scene understanding.
3D Reconstruction: Converting 2D photos into 3D space makes it easier to recreate 3D scenes, which is crucial in industries like robotics, computer vision, and the preservation of cultural assets.
Stereo Vision: Stereo vision depends on converting 2D images into 3D space. It entails taking pictures from various angles and calculating depth from the difference between matching spots. It is employed in 3D modeling, autonomous navigation, and depth sensing, among other applications.
Medical Imaging: Improved visualization, diagnosis, and treatment planning are possible in medical imaging when 2D medical scans—such as CT or MRI scans—are converted into 3D space.
Virtual Reality and Simulation: In virtual reality, simulation, and gaming, realistic 3D worlds must be constructed from 2D photos or video. This requires translating 2D visuals into 3D space.

How you get a 3D image from a 2D?
In conventional photography, you can either utilize a mirror and attach a camera to it to create an immediate 3D effect, or you can take a shot, step to your right (or left), and then shoot another, ensuring that all components from the first photo are present in the second.
However, if you just move a 2D picture left by 10 pixels, nothing changes. This is because you are shifting the entire environment, and no 3D information is saved. Instead, there must be a bigger shift distance between the foreground and backdrop. In other words, the farthest point distant from the lens remains motionless while the nearest

point moves.
How is this related to using a 2D image to create a 3D image?
We need a method to move the pixels since an picture becomes three-dimensional when the foreground moves more than the background.
Fortunately, a technique known as depth detection exists that generates what is known as a depth map.
Now remember that this is only an estimate. Furthermore, it won't reach every nook and corner. All that depth detection does is use cues like shadows, haze, and depth of focus to determine if an object is in the forefront or background.

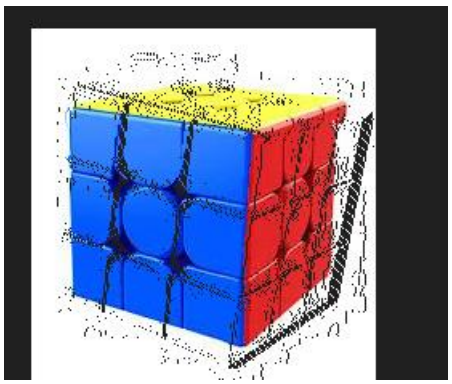
Code:

```
from PIL import Image
import numpy as np
import os

def shift_image(img, depth_img, shift_amount=10):
    img = img.convert("RGBA")
    data = np.array(img)
    depth_img = depth_img.convert("L")
    depth_data = np.array(depth_img)
    deltas = ((depth_data / 255.0) * float(shift_amount)).astype(int)
    shifted_data = np.zeros_like(data)
    height, width, _ = data.shape
    for y, row in enumerate(deltas):
        for x, dx in enumerate(row):
            if x + dx < width and x + dx >= 0:
                shifted_data[y, x + dx] = data[y, x]
    shifted_image = Image.fromarray(shifted_data.astype(np.uint8))
    return shifted_image

img = Image.open("C:/Users/DELL/Downloads/cube1.jpeg")
depth_img = Image.open("C:/Users/DELL/Downloads/cube2.jpeg")
shifted_img = shift_image(img, depth_img, shift_amount=10)
shifted_img.show()
```

Output:



PRACTICAL – 9

Aim: Perform Feature extraction using RANSAC.

Theory:

Image registration is a digital image processing technique that helps us align different images of the same scene. For instance, one may click the picture of a book from various angles. Below are a few instances that show the diversity of camera angles. Now, we may want to "align" a particular image to the same angle as a reference image. In the images above, one may consider the first image to be an "ideal" cover photo, while the second and third images do not serve well for book cover photo purposes. The image registration algorithm helps us align the second and third pictures to the same plane as the first one.

How does image registration work?

Alignment can be looked at as a simple coordinate transform. The algorithm works as follows:

- Convert both images to grayscale.
- Match features from the image to be aligned, to the reference image and store the coordinates of the corresponding key points. Keypoints are simply the selected few points that are used to compute the transform (generally points that stand out), and descriptors are histograms of the image gradients to characterize the appearance of a keypoint. In this post, we use ORB (Oriented FAST and Rotated BRIEF) implementation in the OpenCV library, which provides us with both key points as well as their associated descriptors.
- Match the key points between the two images. In this post, we use BFMatcher, which is a brute force matcher. BFMatcher.match() retrieves the best match, while BFMatcher.knnMatch() retrieves top K matches, where K is specified by the user.
- Pick the top matches, and remove the noisy matches.
- Find the homomorphy transform.
- Apply this transform to the original unaligned image to get the output image.

Applications of Image Registration –

Some of the useful applications of image registration include:

- Stitching various scenes (which may or may not have the same camera alignment) together to form a continuous panoramic shot.
- Aligning camera images of documents to a standard alignment to create realistic scanned documents.
- Aligning medical images for better observation and analysis.

Code:

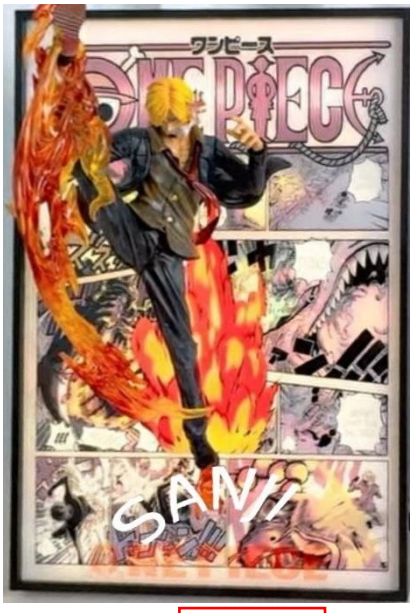
```
import cv2
import numpy as np

img1_color = cv2.imread("C:/Users/DELL/Downloads/wii1.jpeg")
img2_color = cv2.imread("C:/Users/DELL/Downloads/wii2.jpeg")
img1 = cv2.cvtColor(img1_color, cv2.COLOR_BGR2GRAY)
img2 = cv2.cvtColor(img2_color, cv2.COLOR_BGR2GRAY)
height, width = img2.shape
orb_detector = cv2.ORB_create(5000)
kp1, d1 = orb_detector.detectAndCompute(img1, None)
kp2, d2 = orb_detector.detectAndCompute(img2, None)
matcher = cv2.BFMatcher(cv2.NORM_HAMMING, crossCheck=True)
matches = matcher.match(d1, d2)
matches = sorted(matches, key=lambda x: x.distance)
matches = matches[:int(len(matches) * 0.9)]
no_of_matches = len(matches)
p1 = np.zeros((no_of_matches, 2))
p2 = np.zeros((no_of_matches, 2))
for i in range(len(matches)):
    p1[i, :] = kp1[matches[i].queryIdx].pt
    p2[i, :] = kp2[matches[i].trainIdx].pt
homography, mask = cv2.findHomography(p1, p2, cv2.RANSAC)
transformed_img = cv2.warpPerspective(img1_color, homography, (width, height))
cv2.imwrite('C:/Users/DELL/Downloads/output.jpg', transformed_img)
```

Output:

Input

Reference



Output

PRACTICAL – 10

Aim: Perform Image matting and composition.

Theory:
Image matting and composition are two interconnected image processing techniques. Image matting focuses on separating a foreground object from its background, often by estimating the opacity (alpha value) of each pixel. This results in an alpha matte, which is used in the subsequent image composition step. Image composition then combines this extracted foreground with a different background, effectively blending them together.

Image Matting:

- **Goal:**

To accurately separate a foreground object from its background.

- **Method:**

Involves estimating the alpha value for each pixel, representing the degree to which it belongs to the foreground.

- **Output:**

An alpha matte, which is a grayscale image where pixel values indicate the foreground's opacity.

- **Key considerations:**

Handling fine details (hair, fur, transparent objects) and similar foreground/background colors are challenges in image matting.
Image Composition:

- **Goal:**

To combine a foreground element with a new background.

- **Method:**

Uses the alpha matte generated during image matting to blend the foreground and background pixels.

- **Process:**

The alpha values determine how much of the foreground and background colors contribute to the final composite image.

- **Example:**

Replacing a background in a photo or creating visual effects in movies often involves image matting and composition.

In essence, image matting provides the necessary information (the alpha matte) to perform image composition, allowing for seamless integration of different image elements.

Code:

```
import cv2
import numpy as np

image_path = "C:/Users/Admin/Downloads/girl.jpg"
background_path = "C:/Users/Admin/Downloads/home.jpeg"
output_path = "C:/Users/Admin/Downloads/result.jpeg"
def grabcut_matting(image_path, background_path, output_path):
    # Load the input image and background
    img = cv2.imread(image_path)
    bg = cv2.imread(background_path)
    # Check if images are loaded successfully
    if img is None:
        print(f"Error loading image: {image_path}")
        return
    if bg is None:
        print(f"Error loading background: {background_path}")
        return
    # Resize background to match the input image size
    bg = cv2.resize(bg, (img.shape[1], img.shape[0]))
    # Create initial mask
    mask = np.zeros(img.shape[:2], np.uint8)
    # Define a rectangle containing the foreground object (manually adjustable)
    rect = (50, 50, img.shape[1] - 100, img.shape[0] - 100)
    # Allocate memory for models (needed by GrabCut)
    bgdModel = np.zeros((1, 65), np.float64)
    fgdModel = np.zeros((1, 65), np.float64)
    # Apply GrabCut
    cv2.grabCut(img, mask, rect, bgdModel, fgdModel, 5, cv2.GC_INIT_WITH_RECT)
    # Prepare the mask for compositing
    mask2 = np.where((mask == 2) | (mask == 0), 0, 1).astype('uint8')
    mask3 = cv2.merge([mask2, mask2, mask2])
    # Extract the foreground
    foreground = img * mask3
    cv2.imshow('Foreground', foreground)
    # Extract the background where the mask is 0
    background = bg * (1 - mask3)
    # Combine foreground and new background
    result = cv2.add(foreground, background)
    # Save the result to output path
    cv2.imwrite(output_path, result)
    cv2.imshow('Composited Image', result)
    cv2.waitKey(0)
    cv2.destroyAllWindows()
# Call the function with paths
grabcut_matting(image_path, background_path, output_path)
```

Output: