CP5261 DATA ANALYTICS LABORATORY LTPC0042

OBJECTIVES:

- To implement Map Reduce programs for processing big data
- To realize storage of big data using H base, Mongo DB
- To analyze big data using linear models
- To analyze big data using machine learning techniques such as SVM / Decision tree classification and clustering

LIST OF EXPERIMENTS

Hadoop

1. Install, configure and run Hadoop and HDFS
2. Implement word count / frequency programs using MapReduce
3. Implement an MR program that processes a weather dataset

R

4. Implement Linear and logistic Regression
5. Implement SVM / Decision tree classification techniques
6. Implement clustering techniques
7. Visualize data using any plotting framework
8. Implement an application that stores big data in Hbase / MongoDB / Pig using Hadoop / R.

TOTAL: 60 PERIODS

OUTCOMES:

Upon Completion of this course, the students will be able to:

- Process big data using Hadoop framework
- Build and apply linear and logistic regression models
- Perform data analysis with machine learning methods
- Perform graphical data analysis

EX. NO: 1	Install, configure and run Hadoop and HDFS

Step by step Hadoop 2.8.0 installation on Windows 10 Prepare:

These software's should be prepared to install Hadoop 2.8.0 on window 10 64 bits.

1) Download Hadoop 2.8.0
   (Link: http://wwweu.apache.org/dist/hadoop/common/hadoop-2.8.0/hadoop-2.8.0.tar.gz OR http://archive.apache.org/dist/hadoop/core//hadoop-2.8.0/hadoop-2.8.0.tar.gz)
2) Java JDK 1.8.0.zip
   (Link: http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html)

Set up:

1) Check either Java 1.8.0 is already installed on your system or not, use "Javac -version" to check Java version

2) If Java is not installed on your system then first install java under "C:\JAVA" Java setup

3) Extract files Hadoop 2.8.0.tar.gz or Hadoop-2.8.0.zip and place under "C:\Hadoop-2.8.0" hadoop

4) Set the path HADOOP_HOME Environment variable on windows 10(see Step 1, 2, 3 and 4 below) hadoop

5) Set the path JAVA_HOME Environment variable on windows 10(see Step 1, 2, 3 and 4 below) java

6) Next we set the Hadoop bin directory path and JAVA bin directory path

Configuration

a) File C:/Hadoop-2.8.0/etc/hadoop/core-site.xml, paste below xml paragraph and save this file.

```
<configuration>
   <property>
       <name>fs.defaultFS</name>
       <value>hdfs://localhost:9000</value>
   </property>
</configuration>
```

b)Rename "mapred-site.xml.template" to "mapred-site.xml" and edit this file C:/Hadoop-2.8.0/etc/hadoop/mapred-site.xml, paste below xml paragraph and save this file.

```
<configuration>
   <property>
       <name>mapreduce.framework.name</name>
       <value>yarn</value>
   </property>
</configuration>
```

c) Create folder "data" under "C:\Hadoop-2.8.0"

1) Create folder "datanode" under "C:\Hadoop-2.8.0\data"
2) Create folder "namenode" under "C:\Hadoop-2.8.0\data" data

d) Edit file C:\Hadoop-2.8.0/etc/hadoop/hdfs-site.xml, paste below xml paragraph and save this file.

```
<configuration>
   <property>
```

```
      <name>dfs.replication</name>
      <value>1</value>
   </property>
   <property>
      <name>dfs.namenode.name.dir</name>
      <value>C:\hadoop-2.8.0\data\namenode</value>
   </property>
   <property>
      <name>dfs.datanode.data.dir</name>
      <value>C:\hadoop-2.8.0\data\datanode</value>
   </property>
</configuration>
```

e) Edit file C:/Hadoop-2.8.0/etc/hadoop/yarn-site.xml, paste below xml paragraph and save this file.

```
<configuration>
   <property>
         <name>yarn.nodemanager.aux-services</name>
         <value>mapreduce_shuffle</value>
   </property>
   <property>
         <name>yarn.nodemanager.auxservices.mapreduce.shuffle.class</name>
         <value>org.apache.hadoop.mapred.ShuffleHandler</value>
   </property>
</configuration>
```

f) Edit file C:/Hadoop-2.8.0/etc/hadoop/hadoop-env.cmd by closing the command line "JAVA_HOME=%JAVA_HOME%" instead of set "JAVA_HOME=C:\Java" (On C:\java this is path to file jdk.18.0)

Hadoop Configuration

7) Download file Hadoop Configuration.zip (Link: https://github.com/MuhammadBilalYar/HADOOP-INSTALLATION-ON-WINDOW-10/blob/master/Hadoop%20Configuration.zip)

8) Delete file bin on C:\Hadoop-2.8.0\bin, replaced by file bin on file just download (from Hadoop Configuration.zip).

9) Open cmd and typing command "hdfs namenode –format" .You will see hdfs namenode –format

Testing

10) Open cmd and change directory to "C:\Hadoop-2.8.0\sbin" and type "start-all.cmd" to start apache.

11) Make sure these apps are running.

a) Name node

b)Hadoop data node

c) YARN Resource Manager

d)YARN Node Manager hadoop nodes

12) Open: http://localhost:8088

13) Open: http://localhost:50070

Ex. No: 2 Date:	Implementation of word count programs using MapReduce

Procedure:

Prepare:

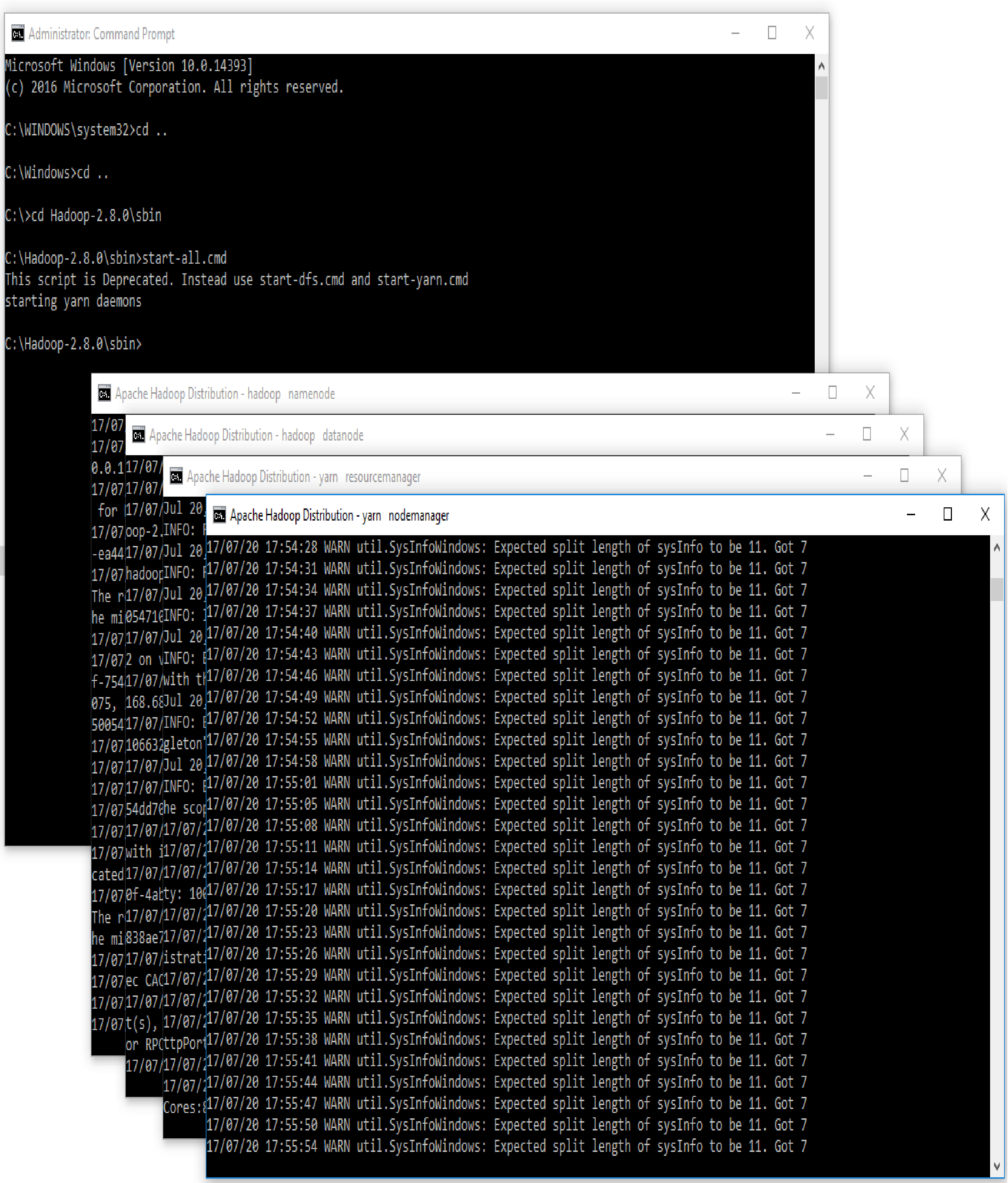
1. Download MapReduceClient.jar
   (Link: https://github.com/MuhammadBilalYar/HADOOP-INSTALLATION-ON-WINDOW-10/blob/master/MapReduceClient.jar)
2. Download Input_file.txt
   (Link: https://github.com/MuhammadBilalYar/HADOOP-INSTALLATION-ON-WINDOW-10/blob/master/input_file.txt)

Place both files in "C:/"

Hadoop Operation:

1. Open cmd in Administrative mode and move to "C:/Hadoop-2.8.0/sbin" and start cluster


```
Start-all.cmd
```


Administrator: Command Prompt
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.
C:\WINDOWS\system32>cd ..
C:\Windows>cd ..
C:\>cd Hadoop-2.8.0\sbin
C:\Hadoop-2.8.0\sbin>start-all.cmd
This script is Deprecated. Instead use start-dfs.cmd and start-yarn.cmd
starting yarn daemons
C:\Hadoop-2.8.0\sbin>
Apache Hadoop Distribution - hadoop namenode
Apache Hadoop Distribution - hadoop datanode
Apache Hadoop Distribution - yarn resourcemanager
Apache Hadoop Distribution - yarn nodemanager
17/07/20 17:54:28 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:31 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:34 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:37 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:40 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:43 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:46 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:49 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:52 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:55 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:54:58 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:01 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:05 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:08 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:11 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:14 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:17 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:20 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:23 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:26 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:29 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:32 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:35 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:38 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:41 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:44 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:47 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:50 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7
17/07/20 17:55:54 WARN util.SysInfoWindows: Expected split length of sysInfo to be 11. Got 7

2. Create an input directory in HDFS.

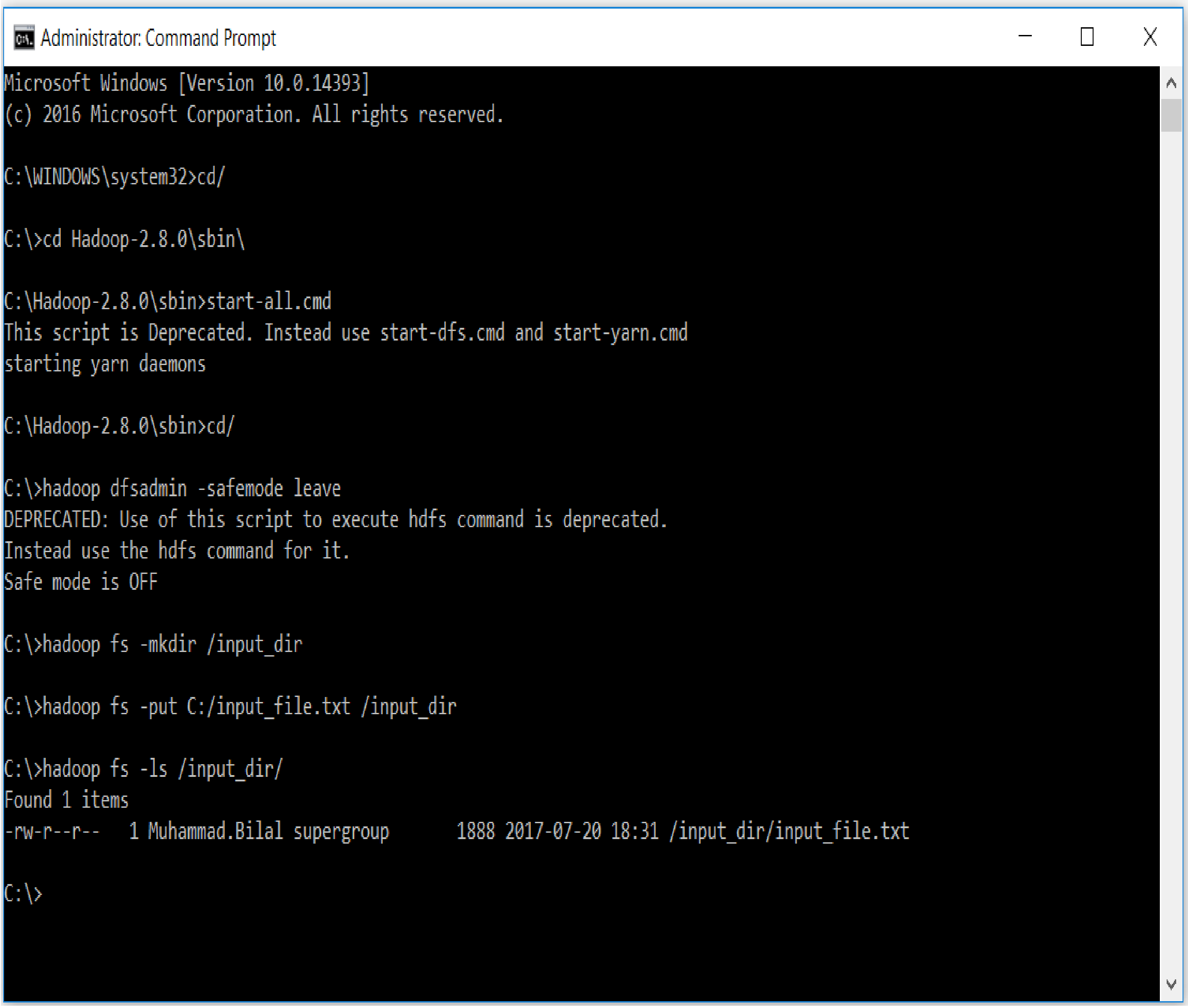
hadoop fs -mkdir /input_dir

3. Copy the input text file named input_file.txt in the input directory (input_dir) of HDFS.

hadoop fs -put C:/input_file.txt /input_dir

4. Verify input_file.txt available in HDFS input directory (input_dir).

hadoop fs -ls /input_dir/



```
Administrator: Command Prompt
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>cd/

C:\>cd Hadoop-2.8.0\sbin\

C:\Hadoop-2.8.0\sbin>start-all.cmd
This script is Deprecated. Instead use start-dfs.cmd and start-yarn.cmd
starting yarn daemons

C:\Hadoop-2.8.0\sbin>cd/

C:\>hadoop dfsadmin -safemode leave
DEPRECATED: Use of this script to execute hdfs command is deprecated.
Instead use the hdfs command for it.
Safe mode is OFF

C:\>hadoop fs -mkdir /input_dir

C:\>hadoop fs -put C:/input_file.txt /input_dir

C:\>hadoop fs -ls /input_dir/
Found 1 items
-rw-r--r--   1 Muhammad.Bilal supergroup       1888 2017-07-20 18:31 /input_dir/input_file.txt

C:\>
```

5. Verify content of the copied file.

hadoop dfs -cat /input_dir/input_file.txt

```
C:\>hadoop fs -ls /input_dir/
Found 1 items
-rw-r--r--   1 Muhammad.Bilal supergroup       1888 2017-07-20 18:31 /input_dir/input_file.txt

C:\>hadoop dfs -cat /input_dir/input_file.txt
DEPRECATED: Use of this script to execute hdfs command is deprecated.
Instead use the hdfs command for it.
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
23   23   27  43   24   25   26   26   26   26   25   26  25
26   27   28  28   28   30   31   31   31   30   30   30  29
31   32   32  32   33   34   35   36   36   34   34   34  34
39   38   39  39   39   41   42   43   40   39   38   38  40
38   39   39  39   39   41   41   41   28   40   39   39  45
```

6. Run MapReduceClient.jar and also provide input and out directories.

hadoop jar C:/MapReduceClient.jar wordcount /input_dir /output_dir

Administrator: Command Prompt

```
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=1999
                HDFS: Number of bytes written=120
                HDFS: Number of read operations=6
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=2
        Job Counters
                Launched map tasks=1
                Launched reduce tasks=1
                Data-local map tasks=1
                Total time spent by all maps in occupied slots (ms)=2180
                Total time spent by all reduces in occupied slots (ms)=2442
                Total time spent by all map tasks (ms)=2180
                Total time spent by all reduce tasks (ms)=2442
                Total vcore-milliseconds taken by all map tasks=2180
                Total vcore-milliseconds taken by all reduce tasks=2442
                Total megabyte-milliseconds taken by all map tasks=2232320
                Total megabyte-milliseconds taken by all reduce tasks=2500608
        Map-Reduce Framework
                Map input records=30
                Map output records=390
                Map output bytes=2730
                Map output materialized bytes=195
                Input split bytes=111
                Combine input records=390
                Combine output records=21
                Reduce input groups=21
                Reduce shuffle bytes=195
                Reduce input records=21
                Reduce output records=21
                Spilled Records=42
                Shuffled Maps =1
                Failed Shuffles=0
                Merged Map outputs=1
                GC time elapsed (ms)=70
                CPU time spent (ms)=764
                Physical memory (bytes) snapshot=471478272
                Virtual memory (bytes) snapshot=619429888
                Total committed heap usage (bytes)=353894400
        Shuffle Errors
                BAD_ID=0
                CONNECTION=0
                IO_ERROR=0
                WRONG_LENGTH=0
                WRONG_MAP=0
                WRONG_REDUCE=0
        File Input Format Counters
                Bytes Read=1888
        File Output Format Counters
                Bytes Written=120

C:\>
```

7. Verify content for generated output file.

hadoop dfs -cat /output_dir/*

```
C:\>hadoop dfs -cat /output_dir/*
DEPRECATED: Use of this script to execute hdfs command is deprecated.
Instead use the hdfs command for it.
23      12
24      6
25      18
26      36
27      12
28      24
29      6
30      24
31      24
32      18
33      6
34      30
35      6
36      12
38      24
39      66
40      18
41      24
42      6
43      12
45      6

C:\>
```

Some Other useful commands

8) To leave Safe mode

hadoop dfsadmin –safemode leave

9) To delete file from HDFS directory

hadoop fs -rm -r /iutput_dir/input_file.txt

10) To delete directory from HDFS directory

hadoop fs -rm -r /iutput_dir

```
C:\>hadoop dfsadmin -safemode leave
DEPRECATED: Use of this script to execute hdfs command is deprecated.
Instead use the hdfs command for it.
Safe mode is OFF

C:\>hadoop fs -rm -r /input_dir/input_file.txt
Deleted /input_dir/input_file.txt



C:\>hadoop fs -rm -r /input_dir
Deleted /input_dir

C:\>
```

Ex. No: 3 Date:	Implementation of an MR program that processes a weather dataset

Aim:

Program

AverageMapper.java

```
import org.apache.hadoop.io.*;
import org.apache.hadoop.mapreduce.*;
import java.io.IOException;

public class AverageMapper extends Mapper <LongWritable, Text, Text, IntWritable>
{

public static final int MISSING = 9999;

public void map(LongWritable key, Text value, Context context) throws
IOException,  InterruptedException
	{
		String line = value.toString();
		String year = line.substring(15,19);
		int temperature;
		if (line.charAt(87)=='+')
			temperature = Integer.parseInt(line.substring(88, 92));
		else
			temperature = Integer.parseInt(line.substring(87, 92));

		String quality = line.substring(92, 93);
		if(temperature != MISSING && quality.matches("[01459]"))
		context.write(new Text(year),new IntWritable(temperature));
	}
```

```
}
```

AverageReducer.java

```
import org.apache.hadoop.mapreduce.*;
import java.io.IOException;

public class AverageReducer extends Reducer <Text, IntWritable,Text, IntWritable >
 {
public void reduce(Text key,  Iterable<IntWritable> values, Context context) throws IOException,
InterruptedException
	{
	int max_temp = 0;
	int count = 0;
	for (IntWritable value : values)
		{
			max_temp += value.get();
			count+=1;
		}
	context.write(key, new IntWritable(max_temp/count));
	}				}
```

AverageDriver.java

```
import org.apache.hadoop.io.*;
import org.apache.hadoop.fs.*;
import org.apache.hadoop.mapreduce.*;
import org.apache.hadoop.mapreduce.lib.input.FileInputFormat;
import org.apache.hadoop.mapreduce.lib.output.FileOutputFormat;

public class AverageDriver
{
```

```
    public static void main (String[] args) throws Exception
    {
        if (args.length != 2)
        {
            System.err.println("Please Enter the input and output parameters");
            System.exit(-1);
        }

        Job job = new Job();
        job.setJarByClass(AverageDriver.class);
        job.setJobName("Max temperature");

        FileInputFormat.addInputPath(job,new Path(args[0]));
        FileOutputFormat.setOutputPath(job,new Path (args[1]));

        job.setMapperClass(AverageMapper.class);
        job.setReducerClass(AverageReducer.class);

        job.setOutputKeyClass(Text.class);
        job.setOutputValueClass(IntWritable.class);

        System.exit(job.waitForCompletion(true)?0:1);
    }
}
```

EX. NO: 4.A	R – PROGRAMMING INTRODUCTION AND BASICS

R – PROGRAMMING INTRODUCTION AND BASICS

- What is R?
- R Data Types & Operator
- R Matrix Tutorial: Create, Print, Add Column, Slice
- What is Factor in R? Categorical & Continuous
- R Data Frames: Create, Append, Select, Subset
- Lists in R: Create, Select [Example]
- If, Else, Elif Statement in R
- For Loop Syntax and Examples
- While Loop In R With Example
- Apply(), Sapply(), Tapply() in R With Examples
- Import Data into R: Read Csv, Excel, SPSS, STATA, SAS Files
- R Exporting Data to Csv, Excel, STATA, SAS and Text File
- R Select(), Filter(), Arrange():

WHAT IS R?

R is a programming language developed by Ross Ihaka and Robert Gentleman in 1993. R possesses an extensive catalog of statistical and graphical methods. It includes machine learning algorithm, linear regression, time series, statistical inference to name a few. Most of the R libraries are written in R, but for heavy computational task, C, C++ and Fortran codes are preferred. R is not only entrusted by academic, but many large companies also use R programming language, including Uber, Google, Airbnb, Facebook and so on.

Data analysis with R is done in a series of steps; programming, transforming, discovering, modeling and communicate the results

- Program: R is a clear and accessible programming tool
- Transform: R is made up of a collection of libraries designed specifically for data science

- Discover: Investigate the data, refine your hypothesis and analyze them
- Model: R provides a wide array of tools to capture the right model for your data
- Communicate: Integrate codes, graphs, and outputs to a report with R Markdown or build
- Shiny apps to share with the world

What is R used for?

- Statistical inference
- Data analysis
- Machine learning algorithm

R DATA TYPES & OPERATOR

Basic data types

- R works with numerous data types, including
- Scalars
- Vectors (numerical, character, logical)
- Matrices
- Data frames
- Lists

Basics types

- 4.5 is a decimal value called numerics.
- 4 is a natural value called integers. Integers are also numerics.
- TRUE or FALSE is a Boolean value called logical.
- The value inside " " or ' ' are text (string). They are called characters.
- We can check the type of a variable with the class function

Data Types	R Code	Output
# Numeric	x <- 28 class(x)	## [1] "numeric"
# String	y <- "R is Fantastic" class(y)	## [1] "character"
# Boolean	z <- TRUE class(z)	## [1] "logical"

Variables

Variables store values and are an important component in programming, especially for a data scientist. A variable can store a number, an object, a statistical result, vector, dataset, a model prediction basically anything R outputs. We can use that variable later simply by calling the name of the variable. To declare a variable, we need to assign a variable name. The name should not have space. We can use _ to connect to words. To add a value to the variable, use <- or =.

SYNTAX:

SYNTAX	RCODE	OUTPUT

# First way to declare a variable: use the `<-` 	
name_of_variable <- value
# Second way to declare a variable: use the `=` 	
name_of_variable = value
	# Print variable x
	x <- 42
	x
		## [1] 42

	y <- 10 y	## [1] 10
	# We call x and y and apply a subtraction x-y	## [1] 32

Vectors

A vector is a one-dimensional array. We can create a vector with all the basic data type we learnt before. The simplest way to build a vector in R, is to use the c command.

Vectors	Type – Rcode	OUTPUT
# Numerical	vec_num <- c(1, 10, 49) vec_num	## [1] 1 10 49
# Character	vec_chr <- c("a", "b", "c") vec_chr	## [1] "a" "b" "c"
# Boolean	vec_bool <- c(TRUE, FALSE, TRUE) vec_bool	##[1] TRUE FALSE TRUE
# Create the vectors	vect_1 <- c(1, 3, 5) vect_2 <- c(2, 4, 6) # Take the sum of A_vector and B_vector	[1] 3 7 11

	`sum_vect <- vect_1 + vect_2`
	`# Print out total_vector`
	`sum_vect`	

`# Slice the first 5 rows of the vector`	`slice_vector <- c(1,2,3,4,5,6,7,8,9,10)` `slice_vector[1:5]`	`## [1] 1 2 3 4 5`
`# Faster way to create adjacent values`	`c(1:10)`	`## [1] 1 2 3 4 5 6 7 8 9 10`

Operator Description	RCode	OUTPUT

Arithmetic
+ Addition
- Subtraction
* Multiplication
/ Division
^ or ** Exponentiation
	3 + 4
	`4-2`
	`3*5`
	`(5+5)/2`
	`2^5`
		## [1] 7
		## [1] 2
		## [1] 15
		## [1] 5
		## [1] 32

Logical	`logical_vector <- c(1:10)`
	`logical_vector>5`
	`logical_vector[(logical_vector>5)]`
		`## [1]FALSE FALSE FALSE FALSE FALSE TRUE TRUE TRUE TRUE TRUE`
		`## [1] 6 7 8 9 10`

	`# Print 5 and 6`
	`logical_vector <- c(1:10)`
	`logical_vector[(logical_vector>4) & (logical_vector<7)]`
		`## [1] 5 6`

R MATRIX TUTORIAL: CREATE, PRINT, ADD COLUMN, SLICE

What is a Matrix?

A matrix is a 2-dimensional array that has m number of rows and n number of columns. In other words, matrix is a combination of two or more vectors with the same data type. Note: It is possible to create more than two dimensions arrays with R.

SYNTAX: matrix(data, nrow, ncol, byrow = FALSE) Arguments:

- - data: The collection of elements that R will arrange into the rows and columns of the matrix
- - nrow: Number of rows
- - ncol: Number of columns
- - byrow: The rows are filled from the left to the right. We use `byrow = FALSE` (default values), if we want the matrix to be filled by the columns i.e. the values are filled top to bottom.

# Construct a matrix with 5 rows that contain the numbers 1 up to 10 and byrow = TRUE	matrix_a <-matrix(1:10, byrow = TRUE, nrow = 5) matrix_a	> matrix_a [,1] [,2] [1,] 1 2 [2,] 3 4 [3,] 5 6 [4,] 7 8 [5,] 9 10
# Print dimension of the matrix	dim(matrix_a)	## [1] 5 2
# Construct a matrix with 5 rows that contain the numbers 1 up to 10 and byrow = FALSE	matrix_b <-matrix(1:10, byrow = FALSE, nrow = 5) matrix_b	> matrix_b [,1] [,2] [1,] 1 6 [2,] 2 7 [3,] 3 8 [4,] 4 9 [5,] 5 10
	matrix_c <-matrix(1:12, byrow = FALSE, ncol = 3) matrix_c	## [,1] [,2] [,3] ## [1,] 1 5 9 ## [2,] 2 6 10 ## [3,] 3 7 11 ## [4,] 4 8 12

# concatenate c(1:5) to the matrix_a	matrix_a1 <- cbind(matrix_a, c(1:5)) 	
	# Check the dimension
	dim(matrix_a1)
		## [1] 5 3

Slice a Matrix

We can select elements one or many elements from a matrix by using the square brackets [ ]. This is where slicing comes into the picture.

For example:

- matrix_c[1,2] selects the element at the first row and second column.
- matrix_c[1:3,2:3] results in a matrix with the data on the rows 1, 2, 3 and columns 2, 3,

- matrix_c[,1] selects all elements of the first column.
- matrix_c[1,] selects all elements of the first row.

WHAT IS FACTOR IN R? CATEGORICAL & CONTINUOUS

What is Factor in R?

Factors are variables in R which take on a limited number of different values; such variables are often referred to as categorical variables. In a dataset, we can distinguish two types of variables: categorical and continuous. In a categorical variable, the value is limited and usually based on a particular finite group. For example, a categorical variable can be countries, year, gender, occupation. A continuous variable, however, can take any values, from integer to decimal. For example, we can have the revenue, price of a share, etc..

Categorical variables

R stores categorical variables into a factor. Let's check the code below to convert a character variable into a factor variable. Characters are not supported in machine learning algorithm, and the only way is to convert a string to an integer.

SYNTAX:

```
factor(x = character(), levels, labels = levels, ordered = is.ordered(x))
Arguments:
- x: A vector of data. Need to be a string or integer, not decimal.
- Levels: A vector of possible values taken by x. This argument is optional. The default value
 is the unique list of items of the vector x.
- Labels: Add a label to the x data. For example, 1 can take the label `male` while 0, the labe
l `female`.
- ordered: Determine if the levels should be ordered.
```

RCODE:

Create gender vector

gender_vector <- c("Male", "Female", "Female", "Male", "Male")

class(gender_vector)

Convert gender_vector to a factor

factor_gender_vector <-factor(gender_vector)

class(factor_gender_vector)

OUTPUT:

```
## [1] "character"
## [1] "factor"
```

Nominal categorical variable

A categorical variable has several values but the order does not matter. For instance, male or female categorical variable do not have ordering.

RCODE:

```
# Create a color vector

color_vector <- c('blue', 'red', 'green', 'white', 'black', 'yellow')

# Convert the vector to factor

factor_color <- factor(color_vector)

factor_color
```

OUTPUT:

```
## [1] blue red green white black yellow
## Levels: black blue green red white yellow
```

Ordinal categorical variable

Ordinal categorical variables do have a natural ordering. We can specify the order, from the lowest to the highest with order = TRUE and highest to lowest with order = FALSE. We can use summary to count the values for each factor.

RCODE:

```
# Create Ordinal categorical vector
day_vector <- c('evening', 'morning', 'afternoon', 'midday', 'midnight', 'evening')
# Convert `day_vector` to a factor with ordered level
```

```
factor_day <- factor(day_vector, order = TRUE, levels =c('morning', 'midday',
'afternoon', 'evening', 'midnight'))
# Print the new variable
factor_day
```

OUTPUT:

```
## [1] evening morning afternoon midday
midnight evening
## Levels: morning < midday < afternoon < evening < midnight
# Append the line to above code
# Count the number of occurence of each level
summary(factor_day)
## Morning midday afternoon evening midnight
## 1 1 1 2 1
```

Continuous variables

Continuous class variables are the default value in R. They are stored as numeric or integer. We can see it from the dataset below. mtcars is a built-in dataset. It gathers information on different types of car. We can import it by using mtcars and check the class of the variable mpg, mile per gallon. It returns a numeric value, indicating a continuous variable.

RCODE:

```
dataset <- mtcars
class(dataset)
```

OUTPUT:

```
## [1] "numeric"
```

<u>R DATA FRAMES: CREATE, APPEND, SELECT, SUBSET</u>

What is a Data Frame?

A data frame is a list of vectors which are of equal length. A matrix contains only one type of data, while a data frame accepts different data types (numeric, character, factor, etc.).

SYNTAX:

```
data.frame(df, stringsAsFactors = TRUE)
arguments:
-df: It can be a matrix to convert as a data frame or a collection of variables to join
-stringsAsFactors: Convert string to factor by default
```

Create a data frame

RCODE:

```
# Create a, b, c, d variables
a <- c(10,20,30,40)
b <- c('book', 'pen', 'textbook', 'pencil_case')
c <- c(TRUE,FALSE,TRUE,FALSE)
d <- c(2.5, 8, 10, 7)
# Join the variables to create a data frame
df <- data.frame(a,b,c,d)
df
```

OUTPUT:

```
## a b c d
## 1 1 book TRUE 2.5
## 2 2 pen TRUE 8.0
## 3 3 textbook TRUE 10.0
## 4 4 pencil_case FALSE 7.0
```

```
# Name the data frame
names(df) <- c('ID', 'items', 'store', 'price')
df
```

OUTPUT:

```
## ID items store price
## 1 10 book TRUE 2.5
## 2 20 pen FALSE 8.0
## 3 30 textbook TRUE 10.0
## 4 40 pencil_case FALSE 7.0
# Print the structure
str(df)
```

OUTPUT:

```
## 'data.frame': 4 obs. of 4 variables:
## $ ID : num 10 20 30 40
## $ items: Factor w/ 4 levels "book","pen","pencil_case",..: 1 2 4 3
## $ store: logi TRUE FALSE TRUE FALSE
## $ price: num 2.5 8 10 7
```

Slice Data Frame

It is possible to SLICE values of a Data Frame. We select the rows and columns to return into bracket precede by the name of the data frame.

RCODE:

```
## Select Rows 1 to 3 and columns 3 to 4
df[1:3, 3:4]
```

OUTPUT:

```
## store price
## 1 TRUE 2.5
## 2 FALSE 8.0
## 3 TRUE 10.0
```

Append a Column to Data Frame

You can also append a column to a Data Frame. You need to use the symbol $ to append a new Variable.

RCODE:

```
# Create a new vector
quantity <- c(10, 35, 40, 5)
# Add `quantity` to the `df` data frame
df$quantity <- quantity
df
```

OUTPUT:

```
## ID items store price quantity
## 1 10 book TRUE 2.5 10
## 2 20 pen FALSE 8.0 35
## 3 30 textbook TRUE 10.0 40
## 4 40 pencil_case FALSE 7.0 5
```

Note: The number of elements in the vector has to be equal to the no of elements in data frame. Executing the following statement

RCODE:

```
quantity <- c(10, 35, 40)

# Add `quantity` to the `df` data frame

df$quantity <- quantity
```

Select a column of a data frame

Sometimes, we need to store a column of a data frame for future use or perform operation on a column. We can use the $ sign to select the column from a data frame.

RCODE:

```
# Select the column ID
df$ID
```

OUTPUT:

```
## [1] 1 2 3 4
```

Subset a data frame

In the previous section, we selected an entire column without condition. It is possible to subset based on whether or not a certain condition was true.

We use the subset() function.

SYNTAX:

```
subset(x, condition)
arguments:
- x: data frame used to perform the subset
- condition: define the conditional statement
```

We want to return only the items with price above 10, we can do

RCODE:

```
# Select price above 5
subset(df, subset = price > 5)
```

OUTPUT:

```
ID items store price
2 20 pen FALSE 8
3 30 textbook TRUE 10
```

```
4 40 pencil_case FALSE 7
```

LISTS IN R: CREATE, SELECT [EXAMPLE]

What is a List?

A list is a great tool to store many kinds of object in the order expected. We can include matrices, vectors data frames or lists. We can imagine a list as a bag in which we want to put many different items. When we need to use an item, we open the bag and use it. A list is similar; we can store a collection of objects and use them when we need them.

We can use list() function to create a list.

SYNTAX:

```
list(element_1, ...)
arguments:
-element_1: store any type of R object
-...: pass as many objects as specifying. each object needs to be separated by a comma
```

RCODE:

```
# Vector with numeric from 1 up to 5
vect <- 1:5
# A 2x 5 matrix
mat <- matrix(1:9, ncol = 5)
dim(mat)
# select the 10th row of the built-in R data set EuStockMarkets
df <- EuStockMarkets[1:10,]
# Construct list with these vec, mat, and df:
my_list <- list(vect, mat, df)
my_list
```

OUTPUT:

```
## [[1]]
## [1] 1 2 3 4 5

## [[2]]
##      [,1] [,2] [,3] [,4] [,5]
## [1,]    1    3    5    7    9
## [2,]    2    4    6    8    1

## [[3]]
##          DAX    SMI    CAC   FTSE
##  [1,] 1628.75 1678.1 1772.8 2443.6
##  [2,] 1613.63 1688.5 1750.5 2460.2
##  [3,] 1606.51 1678.6 1718.0 2448.2
##  [4,] 1621.04 1684.1 1708.1 2470.4
##  [5,] 1618.16 1686.6 1723.1 2484.7
##  [6,] 1610.61 1671.6 1714.3 2466.8
##  [7,] 1630.75 1682.9 1734.5 2487.9
##  [8,] 1640.17 1703.6 1757.4 2508.4
##  [9,] 1635.47 1697.5 1754.0 2510.5
##  [10,] 1645.89 1716.3 1754.3 2497.4
```

IF, ELSE, ELIF STATEMENT IN R

The if, else, ELIF statement

An if-else statement is a great tool for the developer trying to return an output based on a condition.

SYNTAX:

```
if (condition1) {
expr1
} else it (condition2) {
expr2
} else if (condition3) {
expr3
} else {
expr4
}
```

VAT has different rate according to the product purchased. Imagine we have three different kind of products with different VAT applied:

Categories	Products	VAT
A	Book, magazine, newspaper, etc..	8%
B	Vegetable, meat, beverage, etc..	10%
C	Tee-shirt, jean, pant, etc..	20%

We can write a chain to apply the correct VAT rate to the product a customer bought.

RCODE:

```
category <- 'A'
price <- 10
if (category =='A'){
cat('A vat rate of 8% is applied.','The total price is',price *1.08)
} else if (category =='B'){
cat('A vat rate of 10% is applied.','The total price is',price *1.10)
} else {
cat('A vat rate of 20% is applied.','The total price is',price *1.20)
}
```

OUTPUT:

A vat rate of 8% is applied. The total price is 10.8

<u>FOR LOOP SYNTAX AND EXAMPLES</u>

```
# Create fruit vector
fruit <- c('Apple', 'Orange', 'Passion fruit', 'Banana')
# Create the for statement
for ( i in fruit){
print(i)
}
```

OUTPUT:

```
## [1] "Apple"
## [1] "Orange"
## [1] "Passion fruit"
## [1] "Banana"
```

For Loop over a matrix

A matrix has 2-dimension, rows and columns. To iterate over a matrix, we have to define two for loop, namely one for the rows and another for the column.

SYNTAX:

```
# Create a matrix
mat <- matrix(data = seq(10, 20, by=1), nrow = 6, ncol =2)
# Create the loop with r and c to iterate over the matrix
```

```
for (r in 1:nrow(mat))
for (c in 1:ncol(mat))
print(paste("Row", r, "and column",c, "have values of", mat[r,c]))
```

OUTPUT:

```
## [1] "Row 1 and column 1 have values of 10"
## [1] "Row 1 and column 2 have values of 16"
## [1] "Row 2 and column 1 have values of 11"
## [1] "Row 2 and column 2 have values of 17"
## [1] "Row 3 and column 1 have values of 12"
## [1] "Row 3 and column 2 have values of 18"
## [1] "Row 4 and column 1 have values of 13"
## [1] "Row 4 and column 2 have values of 19"
## [1] "Row 5 and column 1 have values of 14"
## [1] "Row 5 and column 2 have values of 20"
## [1] "Row 6 and column 1 have values of 15"
## [1] "Row 6 and column 2 have values of 10"
```

WHILE LOOP IN R WITH EXAMPLE

A loop is a statement that keeps running until a condition is satisfied. The syntax for a while loop is the following:

```
while (condition) {
    Exp
}
```

SYNTAX:

```
#Create a variable with value 1
begin <- 1
#Create the loop
while (begin <= 10){
#See which we are
cat('This is loop number',begin)
#add 1 to the variable begin after each loop
begin <- begin+1
print(begin)
}
```

OUTPUT:

```
## This is loop number 1[1] 2
## This is loop number 2[1] 3
```

```
## This is loop number 3[1] 4
## This is loop number 4[1] 5
## This is loop number 5[1] 6
## This is loop number 6[1] 7
## This is loop number 7[1] 8
## This is loop number 8[1] 9
## This is loop number 9[1] 10
## This is loop number 10[1] 11
```

APPLY(), SAPPLY(), TAPPLY() IN R WITH EXAMPLES

apply() function

We use apply() over a matrice. This function takes 5 arguments:

SYNTAX:

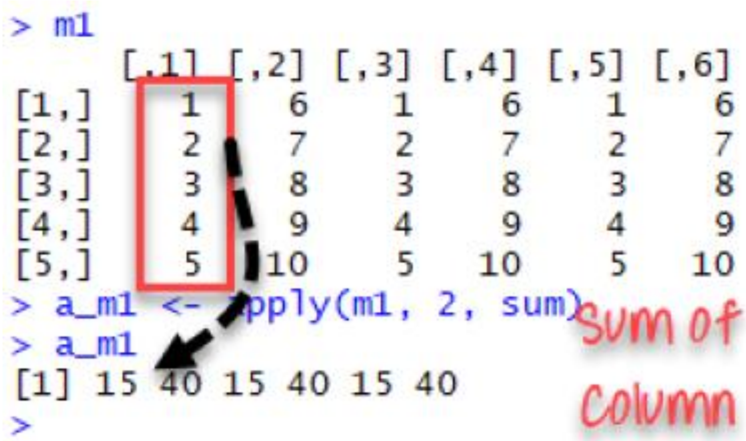
```
apply(X, MARGIN, FUN)
Here:
-x: an array or matrix
-MARGIN:  take a value or range between 1 and 2 to define where to apply the function:
-MARGIN=1`: the manipulation is performed on rows
-MARGIN=2`: the manipulation is performed on columns
-MARGIN=c(1,2)` the manipulation is performed on rows and columns
-FUN: tells which function to apply. Built functions like mean, median, sum, min, max and even
 user-defined functions can be applied>
```

The simplest example is to sum a matrices over all the columns. The code apply(m1, 2, sum) will apply the sum function to the matrix 5x6 and return the sum of each column accessible in the dataset.

RCODE:

```
m1 <- matrix(C<-(1:10),nrow=5, ncol=6)
m1
a_m1 <- apply(m1, 2, sum)
a_m1
```

OUTPUT:



lapply() function

SYNTAX:

```
lapply(X, FUN)
Arguments:
-X: A vector or an object
-FUN: Function applied to each element of x
```

l in lapply() stands for list. The difference between lapply() and apply() lies between the output return. The output of lapply() is a list. lapply() can be used for other objects like data frames and lists. lapply() function does not need MARGIN.

A very easy example can be to change the string value of a matrix to lower case with to lower function. We construct a matrix with the name of the famous movies. The name is in upper case format.

RCODE:

```
movies <- c("SPYDERMAN","BATMAN","VERTIGO","CHINATOWN")
movies_lower <-lapply(movies, tolower)
str(movies_lower)
```

We can use unlist() to convert the list into a vector.

```
movies_lower <-unlist(lapply(movies,tolower))
str(movies_lower)
```


OUTPUT:

```
## List of 4
## $:chr"spyderman"
```

```
## $:chr"batman"
## $:chr"vertigo"
## $:chr"chinatown"

## chr [1:4] "spyderman" "batman" "vertigo" "chinatown"
```

sapply() function

SYNTAX:

sapply() function does the same jobs as lapply() function but returns a vector.

```
sapply(X, FUN)
Arguments:
-X: A vector or an object
-FUN: Function applied to each element of x
```

We can measure the minimum speed and stopping distances of cars from the cars dataset.

RCODE:

```
dt <- cars
lmn_cars <- lapply(dt, min)
smn_cars <- sapply(dt, min)
lmn_cars
smn_cars
lmxcars <- lapply(dt, max)
smxcars <- sapply(dt, max)
lmxcars
smxcars
```

We can use a user built-in function into lapply() or sapply(). We create a function named avg to compute the average of the minimum and maximum of the vector.

```
avg <- function(x) {
( min(x) + max(x) ) / 2}
fcars <- sapply(dt, avg)
fcars
```

OUTPUT:

```
## $speed
## [1] 4
## $dist
## [1] 2
## speed dist
## 4 2
```

```
## $speed
## [1] 25
## $dist
## [1] 120
## speed dist
## 25 120
## speed dist
## 14.5 61.0
```

Function	Arguments	Objective	Input	Output
apply	apply(x, MARGIN, FUN)	Apply a function to the rows or columns or both	Data frame or matrix	vector, list, array
lapply	lapply(X, FUN)	Apply a function to all the elements of the input	List, vector or data frame	list
sapply	sappy(X FUN)	Apply a function to all the elements of the input	List, vector or data frame	vector or matrix

Slice vector

We can use lapply() or sapply() interchangeable to slice a data frame. We create a function, below_average(), that takes a vector of numerical values and returns a vector that only contains the values that are strictly above the average. We compare both results with the identical() function.

RCODE:

```
below_ave <- function(x) {
ave <- mean(x)
return(x[x > ave])
}
dt_s<- sapply(dt, below_ave)
```

```
dt_l<- lapply(dt, below_ave)
identical(dt_s, dt_l)
```

OUTPUT:

```
## [1] TRUE
```

IMPORT DATA INTO R: READ CSV, EXCEL, SPSS, STATA, SAS FILES

Library	Objective	Function	Default Arguments
utils	Read CSV file	read.csv()	file, header =,TRUE, sep = ","
readxl	Read EXCEL file	read_excel()	path, range = NULL, col_names = TRUE
haven	Read SAS file	read_sas()	path
haven	Read STATA file	read_stata()	path
haven	Read SPSS fille	read_sav()	path

Read CSV

One of the most widely data store is the .csv (comma-separated values) file formats. R loads an array of libraries during the start-up, including the utils package. This package is convenient to open csv files combined with the reading.csv () function.

SYNTAX:

```
read.csv(file, header = TRUE, sep = ",")
argument:
-file: PATH where the file is stored
-header: confirm if the file has a header or not, by default, the header is set to TRUE
-sep: the symbol used to split the variable. By default, `,`.
```

RCODE:

```
PATH <-
'https://raw.githubusercontent.com/vincentarelbundock/Rdatasets/master/csv/datasets/m
tc
ars.csv'
df <- read.csv(PATH, header = TRUE, sep = ',', stringsAsFactors =FALSE)
length(df)
class(df$X)
```

OUTPUT:

```
## [1] 12
## [1] "factor"
```

Read Excel files

Excel files are very popular among data analysts. Spreadsheets are easy to work with and flexible. R is equipped with a library readxl to import Excel spreadsheet.

SYNTAX:

```
read_excel(PATH, sheet = NULL, range= NULL, col_names = TRUE)
arguments:
-PATH: Path where the excel is located
-sheet: Select the sheet to import. By default, all
-range: Select the range to import. By default, all non-null cells
-col_names: Select the columns to import. By default, all non-null columns
```

RCODE:

```
require(readxl)
library(readxl)
readxl_example()
readxl_example("geometry.xls")
```

We can import the spreadsheets from the readxl library and count the number of columns in the first sheet.

```
# Store the path of `datasets.xlsx`
example <- readxl_example("datasets.xlsx")
# Import the spreadsheet
df <- read_excel(example)
# Count the number of columns
length(df)
```


OUTPUT

```
> readxl_example()
 [1] "clippy.xls"    "clippy.xlsx"   "datasets.xls"   "datasets.xlsx" "deaths.xls"
   "geometry.xls"  "geometry.xlsx"
 [9] "type-me.xls"   "type-me.xlsx"
```

```
> readxl_example("geometry.xls")
[1] "C:/Users/Admin/Anaconda3/R/library/readxl/extdata/geometry.xls"
>
```

```
## [1] 5
```

Read excel_sheets()

The file datasets.xlsx is composed of 4 sheets. We can find out which sheets are available in the workbook by using excel_sheets() function

RCODE:

```
example <- readxl_example("datasets.xlsx")
excel_sheets(example)
```

If a worksheet includes many sheets, it is easy to select a particular sheet by using the sheet arguments. We can specify the name of the sheet or the sheet index. We can verify if both function returns the same output with identical().

```
example <- readxl_example("datasets.xlsx")
quake <- read_excel(example, sheet = "quakes")
quake_1 <-read_excel(example, sheet = 4)
identical(quake, quake_1)
```

OUTPUT:

```
[1] "iris" "mtcars" "chickwts" "quakes"
## [1] TRUE
```

R EXPORTING DATA TO CSV, EXCEL, SAS, STATA, AND TEXT FILE

Export to Hard drive

To begin with, you can save the data directly into the working directory. The following code prints the path of your working directory:

RCODE:

```
directory <-getwd()
directory
```

OUTPUT:

[1] "/Users/15_Export_to_do"

Create data frame

First of all, let's import the mtcars dataset and get the mean of mpg and disp grouped by gear

RCODE:

```
library(dplyr)
```

```
df <-mtcars % > %
select(mpg, disp, gear) % > %
group_by(gear) % > %
summarize(mean_mpg = mean(mpg), mean_disp = mean(disp))
df
```

OUTPUT:

```
## # A tibble: 3 x 3
##      gear mean_mpg mean_disp
##      <dbl>   <dbl>   lt;dbl>
## 1    3 16.10667  326.3000
## 2    4 24.53333  123.0167
## 3    5 21.38000  202.4800
```

The table contains three rows and three columns. You can create a CSV file with the function write.csv().

Export CSV

SYNTAX:

```
write.csv(df, path)
arguments
-df: Dataset to save. Need to be the same name of the data frame in the environment.
-path: A string. Set the destination path. Path + filename + extension i.e. "/Users/USERNAME/Do
wnloads/mydata.csv" or the filename + extension if the folder is the same as the working direct
ory
```

RCODE:

```
write.csv(df, "table_car.csv")
```

Code Explanation

write.csv(df, "table_car.csv"): Create a CSV file in the hard drive:

df: name of the data frame in the environment

"table_car.csv": Name the file table_car and store it as csv

Note: You can use the function write.csv2() to separate the rows with a semicolon.

```
write.csv2(df, "table_car.csv")
```

Note: For pedagogical purpose only, we created a function called open_folder() to open the directory folder for you. You just need to run the code below and see where the csv file is stored. You should see a file names table_car.csv.

```
# Run this code to create the function
```

RCODE:

```
open_folder <-function(dir){
if (.Platform['OS.type'] == "windows"){
shell.exec(dir)
} else {
system(paste(Sys.getenv("R_BROWSER"), dir))
}
}
# Call the function to open the folder
open_folder(directory)
```

Export to Excel file

Export data to Excel is trivial for Windows users and trickier for Mac OS user. Both users will use the library xlsx to create an Excel file. The slight difference comes from the installation of the library. Indeed, the library xlsx uses Java to create the file. Java needs to be installed if not present in your machine.

Windows users

If you are a Windows user, you can install the library directly with conda:

```
conda install -c r r-xlsx
library(xlsx)
write.xlsx(df, "table_car.xlsx")
library(haven)
write_sav(df, "table_car.sav" ## spss file
write_sas(df, "table_car.sas7bdat")
write_dta(df, "table_car.dta") ## STATA File
save(df, file ='table_car.RData')
```

R SELECT(), FILTER(), ARRANGE():

Verb	Objective	Code	Explanation
glimpse	check the structure of a df	glimpse(df)	Identical to str()
select()	Select/exclude the variables	select(df, A, B,C) select(df, A:C) select(df, -C)	Select the variables A, B and C Select all variables from A to C Exclude C
arrange()	Sort the dataset with one or many variables	arrange(A) arrange(desc (A), B)	Descending sort of variable A and ascending sort of B

EX. NO:4.b DATE:	IMPLEMENT LINEAR AND LOGISTIC REGRESSION

AIM:

PROGRAM:

******SIMPLE LINEAR REGRESSION******

```
dataset = read.csv("data-marketing-budget-12mo.csv", header=T,
colClasses = c("numeric", "numeric", "numeric"))
head(dataset,5)
#/////Simple Regression/////
simple.fit = lm(Sales~Spend,data=dataset)
summary(simple.fit)
```

OUTPUT:

```
Call:
lm(formula = Sales ~ Spend, data = dataset)

Residuals:
   Min     1Q Median     3Q    Max
 -3385  -2097    258   1726   3034

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 1383.4714  1255.2404   1.102    0.296
Spend         10.6222     0.1625  65.378 1.71e-14 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2313 on 10 degrees of freedom
Multiple R-squared:  0.9977, Adjusted R-squared:  0.9974
F-statistic:  4274 on 1 and 10 DF,  p-value: 1.707e-14
```

******MULTIPLE LINEAR REGRESSION ******

```
multi.fit = lm(Sales~Spend+Month, data=dataset)
summary(multi.fit)
```

MULTIPLE LINEAR REGRESSION OUTPUT:

```
Call:
lm(formula = Sales ~ Spend + Month, data = dataset)

Residuals:
     Min       1Q   Median       3Q      Max 
-1793.73 -1558.33    -1.73  1374.19  1911.58 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) -567.6098  1041.8836  -0.545  0.59913    
Spend         10.3825     0.1328  78.159 4.65e-14 ***
Month        541.3736   158.1660   3.423  0.00759 ** 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1607 on 9 degrees of freedom
Multiple R-squared:  0.999,	Adjusted R-squared:  0.9988 
F-statistic:  4433 on 2 and 9 DF,  p-value: 3.368e-14
```

******Logistic Regression ******

```
#selects some column from mtcars

input<- mtcars [,c("am","cyl","hp","wt")]

print(head(input))

input<- mtcars [,c("am","cyl","hp","wt")]

am.data =glm(formula = am ~ cyl+hp+wt,data = input,family = binomial)

print(summary(am.data))
```

OUTPUT:


```
> print(head(input))
                  am cyl  hp    wt
Mazda RX4          1   6 110 2.620
Mazda RX4 Wag      1   6 110 2.875
Datsun 710         1   4  93 2.320
Hornet 4 Drive     0   6 110 3.215
Hornet Sportabout  0   8 175 3.440
Valiant            0   6 105 3.460
```

```
Call:
glm(formula = am ~ cyl + hp + wt, family = binomial, data = input)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-2.17272  -0.14907  -0.01464   0.14116   1.27641

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) 19.70288    8.11637   2.428   0.0152 *
cyl          0.48760    1.07162   0.455   0.6491
hp           0.03259    0.01886   1.728   0.0840 .
wt          -9.14947    4.15332  -2.203   0.0276 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 43.2297  on 31  degrees of freedom
Residual deviance:  9.8415  on 28  degrees of freedom
AIC: 17.841

Number of Fisher Scoring iterations: 8
```


RESULT:

EX. NO: 5 DATE:	IMPLEMENT SVM CLASSIFICATION TECHNIQUES

AIM

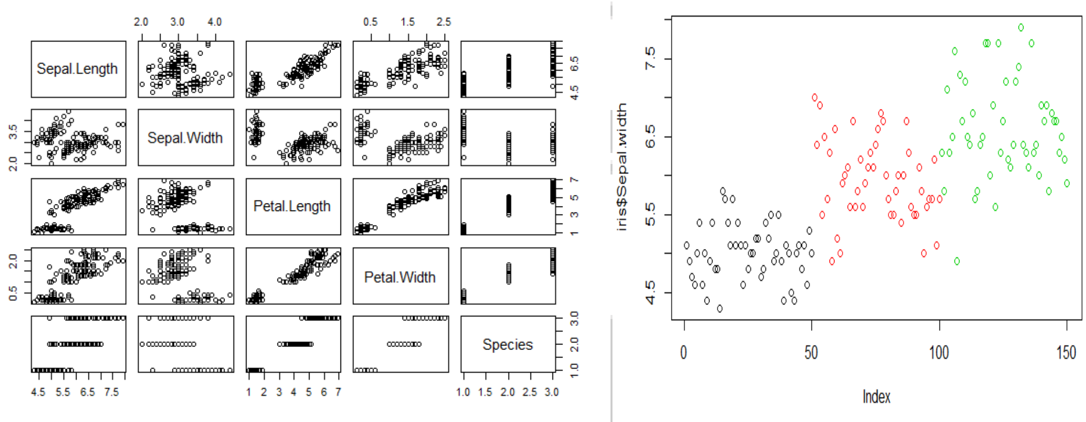
To implement support vector machine (SVM) to find optimum hyper plane (Line in 2D, 3D hyper plane) which maximize the margin between two classes.

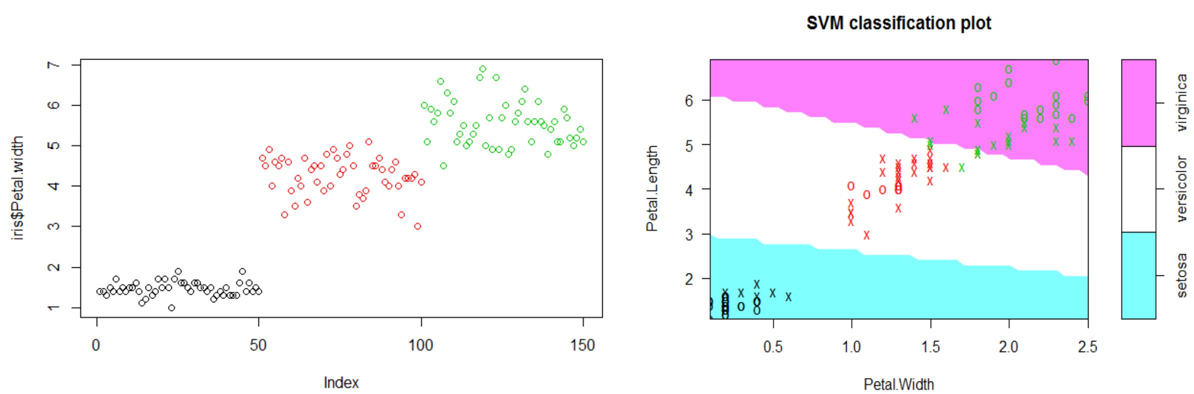
Program

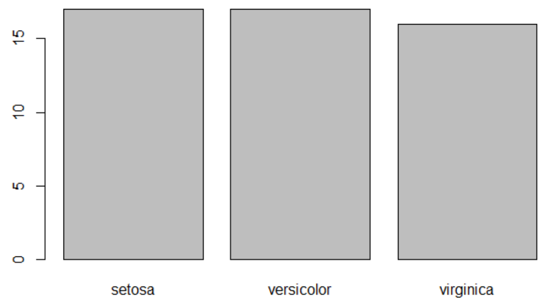
```
library(e1071)

plot(iris)

iris

plot(iris$Sepal.Length, iris$Sepal.width, col=iris$Species)

plot(iris$Petal.Length, iris$Petal.width, col=iris$Species)

s<-sample(150,100)

col<- c("Petal.Length", "Petal.Width", "Species")

iris_train<- iris[s,col]

iris_test<- iris[-s,col]

svmfit<- svm(Species ~., data = iris_train, kernel = "linear", cost = .1, scale = FALSE)

print(svmfit)

plot(svmfit, iris_train[,col])

tuned <- tune(svm, Species~., data = iris_train, kernel = "linear", ranges=
list(cost=c(0.001,0.01,.1,.1,10,100)))

summary(tuned)
```

```
p<-predict(svmfit, iris_test[,col], type="class")

plot(p)

table(p,iris_test[,3] )

mean(p== iris_test[,3])
```

OUTPUT:







RESULT:

EX. NO:6 DATE:	IMPLEMENT DECISION TREE CLASSIFICATION TECHNIQUES

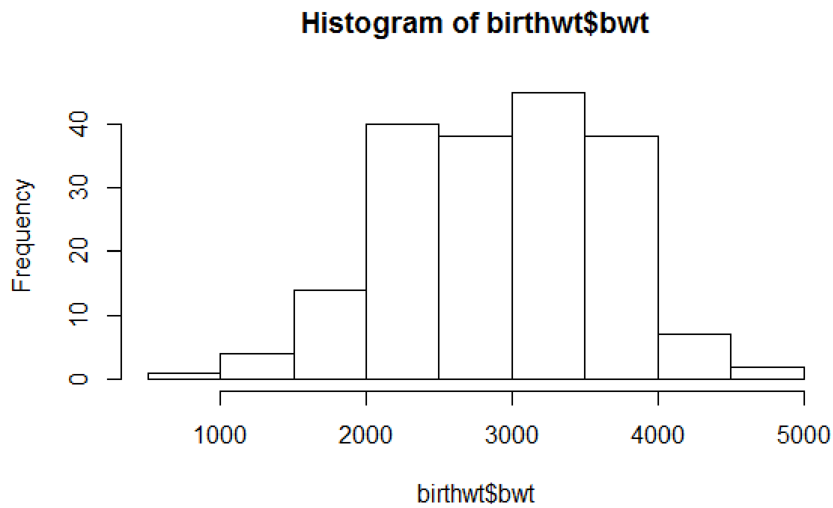
AIM

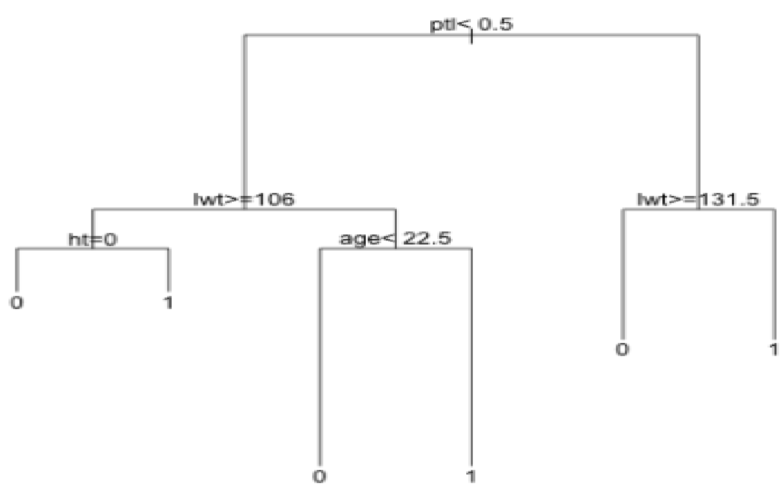
To implement a decision tree used to representing a decision situation in visually and show all those factors within the analysis that are considered relevant to the decision

PROGRAM

```
library(MASS)

library(rpart)

head(birthwt)

hist(birthwt$bwt)

table(birthwt$low)

cols <- c('low', 'race', 'smoke', 'ht', 'ui')

birthwt[cols] <- lapply(birthwt[cols], as.factor)

set.seed(1)

train<- sample(1:nrow(birthwt), 0.75 * nrow(birthwt))

birthwtTree<- rpart(low ~ . - bwt, data = birthwt[train, ], method = 'class')

plot(birthwtTree)

text(birthwtTree, pretty = 0)

summary(birthwtTree)

birthwtPred<- predict(birthwtTree, birthwt[-train, ], type = 'class')

table(birthwtPred, birthwt[-train, ]$low)
```

OUTPUT:





RESULT

EX. NO:7 DATE:	IMPLEMENTATION OF CLUSTERING TECHNIQUES

AIM:

PROGRAM:

library(datasets)

head(iris)

library(ggplot2)

ggplot(iris, aes(Petal.Length, Petal.Width, color = Species)) + geom_point()

set.seed(20)

irisCluster <- kmeans(iris[, 3:4], 3, nstart = 20)

irisCluster

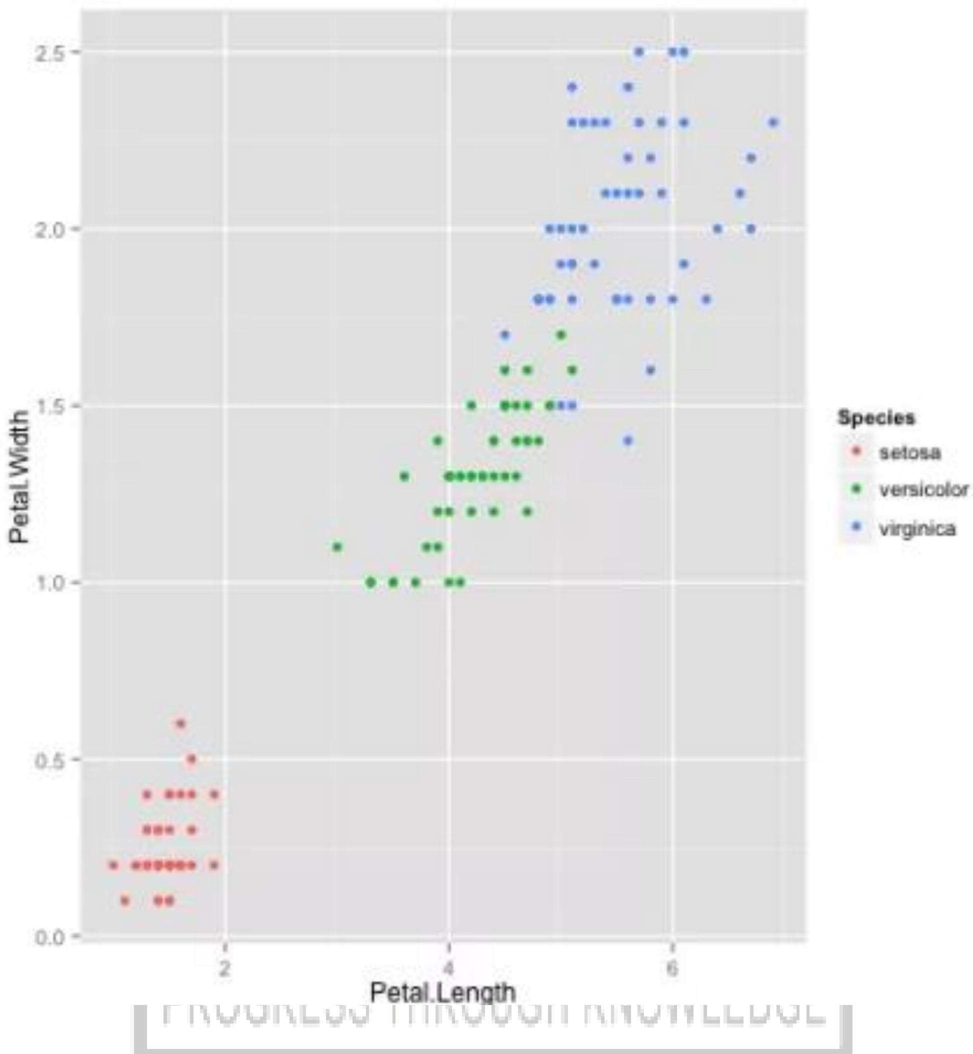
table(irisCluster$cluster, iris$Species)

OUTPUT:

```
head(iris)
  Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1          5.1         3.5          1.4         0.2  setosa
2          4.9         3.0          1.4         0.2  setosa
3          4.7         3.2          1.3         0.2  setosa
4          4.6         3.1          1.5         0.2  setosa
5          5.0         3.6          1.4         0.2  setosa
6          5.4         3.9          1.7         0.4  setosa
```

```
ggplot(iris, aes(Petal.Length, Petal.Width, color =
Species)) + geom_point()
```

Here is the plot:



```
irisCluster
K-means clustering with 3 clusters of sizes 46, 54, 50

Cluster means:
  Petal.Length Petal.Width
1     5.626087    2.047826
2     4.292593    1.359259
3     1.462000    0.246000

Clustering vector:
  [1] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3
 [35] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2
 [69] 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 1 1
[103] 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 2 1 1 2 2 1
1 1 1 1 1 1 1
[137] 1 1 2 1 1 1 1 1 1 1 1 1 1 1

Within cluster sum of squares by cluster:
[1] 15.16348 14.22741  2.02200
 (between_SS / total_SS =  94.3 %)

Available components:

[1] "cluster"      "centers"      "totss"        "withinss"
[5] "tot.withinss" "betweenss"    "size"         "iter"
[9] "ifault"
```

```
table(irisCluster$cluster, iris$Species)
    setosa versicolor virginica
  1      0          2        44
  2      0         48         6
  3     50          0         0
```

RESULT:

EX. NO:8 DATE:	IMPLEMENTATION OF VISUALIZE DATA USING ANY PLOTTING FRAMEWORK

AIM

To implement *Data visualization* is to provide an efficient graphical display for summarizing and reasoning about quantitative information.

1. Histogram

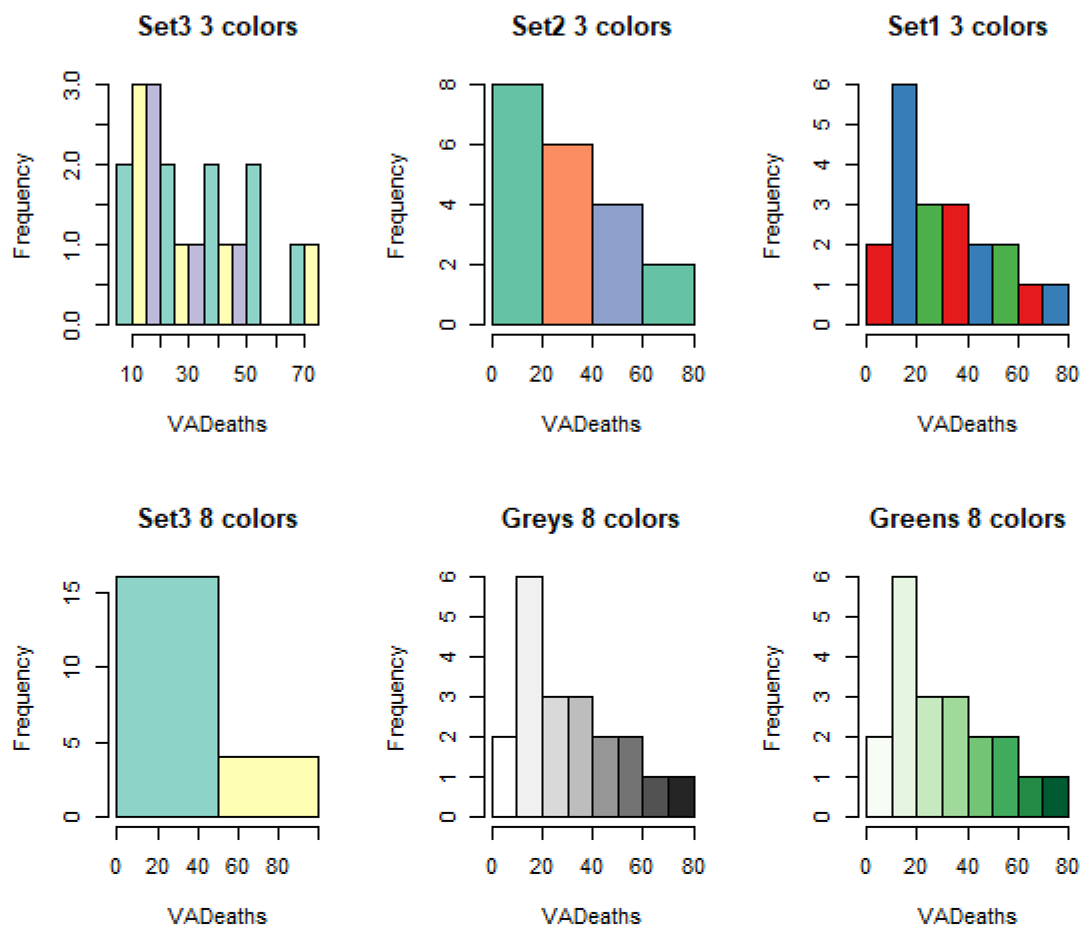
Histogram is basically a plot that breaks the data into bins (or breaks) and shows frequency distribution of these bins. You can change the breaks also and see the effect it has data visualization in terms of understandability.

Note: We have used par(mfrow=c(2,5)) command to fit multiple graphs in same page for sake of clarity(see the code below).

PROGRAM:

```
library(RColorBrewer)

data(VADeaths)
par(mfrow=c(2,3))
hist(VADeaths,breaks=10, col=brewer.pal(3,"Set3"),main="Set3 3 colors")
hist(VADeaths,breaks=3 ,col=brewer.pal(3,"Set2"),main="Set2 3 colors")
hist(VADeaths,breaks=7, col=brewer.pal(3,"Set1"),main="Set1 3 colors")
hist(VADeaths,,breaks= 2, col=brewer.pal(8,"Set3"),main="Set3 8 colors")
hist(VADeaths,col=brewer.pal(8,"Greys"),main="Greys 8 colors")
hist(VADeaths,col=brewer.pal(8,"Greens"),main="Greens 8 colors")
```

OUTPUT:



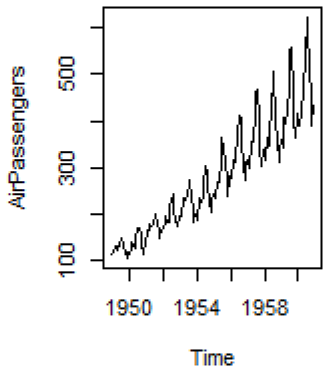
2.1. Line Chart

Below is the line chart showing the increase in air passengers over given time period. Line Charts are commonly preferred when we are to analyses a trend spread over a time period. Furthermore, line plot is also suitable to plots where we need to compare relative changes in quantities across some variable (like time). Below is the code:

PROGRAM:

```
data(AirPassengers)

plot(AirPassengers,type="l") #Simple Line Plot
```

OUTPUT:



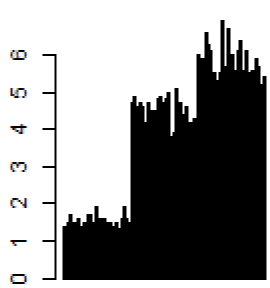
2.2. Bar Chart

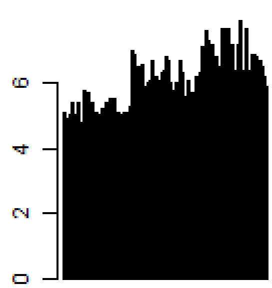
Bar Plots are suitable for showing comparison between cumulative totals across several groups. Stacked Plots are used for bar plots for various categories. Here's the code:

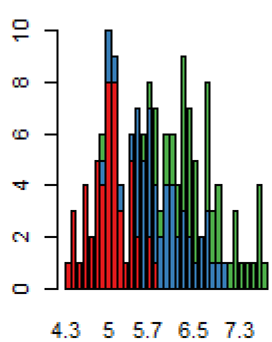
PROGRAM:

```
data("iris")
barplot(iris$Petal.Length) #Creating simple Bar Graph
barplot(iris$Sepal.Length,col = brewer.pal(3,"Set1"))
barplot(table(iris$Species,iris$Sepal.Length),col = brewer.pal(3,"Set1")) #Stacked Plot
```

OUTPUT:







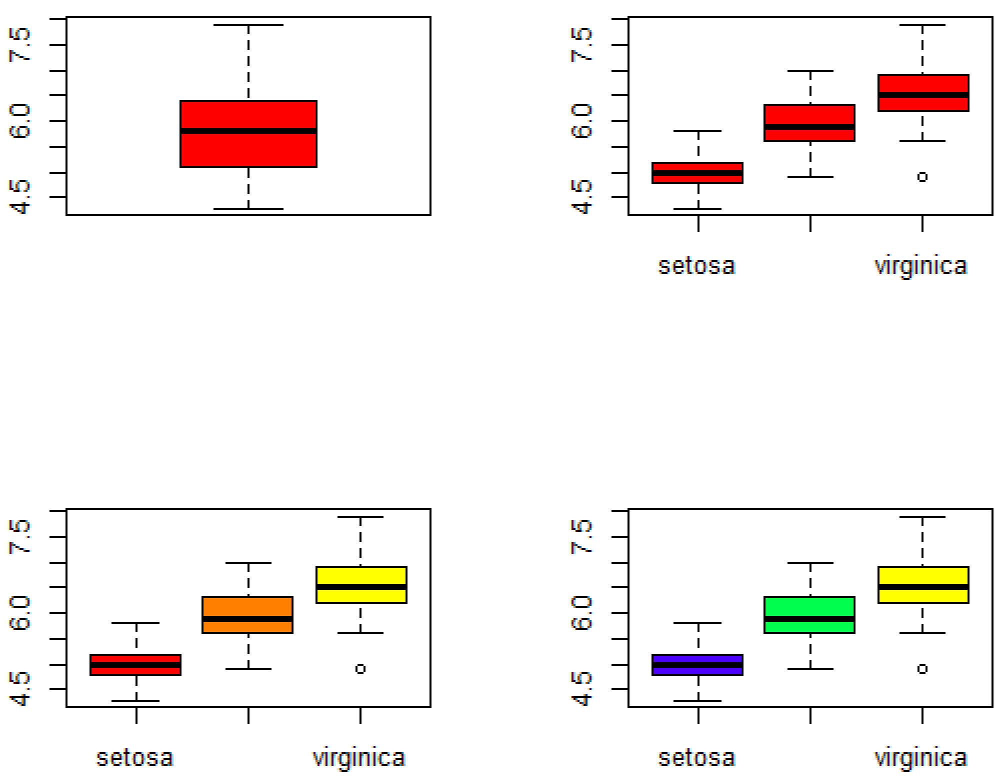
3. Box Plot

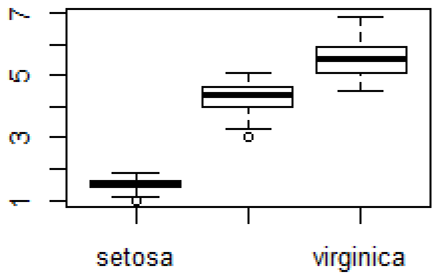
Box Plot shows 5 statistically significant numbers the minimum, the 25th percentile, the median, the 75th percentile and the maximum. It is thus useful for visualizing the spread of the data is and deriving inferences accordingly.

PROGRAM:

```
data(iris)
par(mfrow=c(2,2))
boxplot(iris$Sepal.Length,col="red")
boxplot(iris$Sepal.Length~iris$Species,col="red")
boxplot(iris$Sepal.Length~iris$Species,col=heat.colors(3))
boxplot(iris$Sepal.Length~iris$Species,col=topo.colors(3))
boxplot(iris$Petal.Length~iris$Species) #Creating Box Plot between two variable
```

OUTPUT:





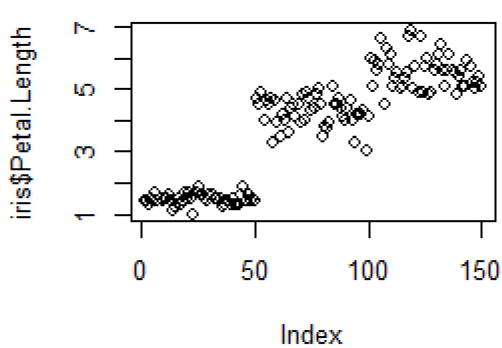
4. Scatter Plot (including 3D and other features)

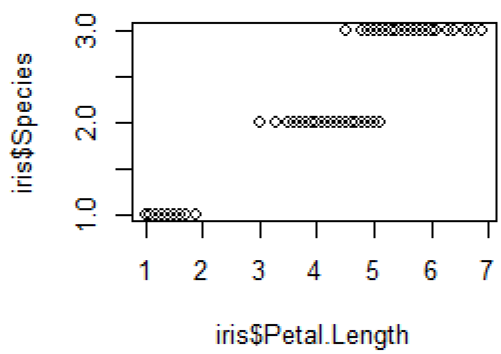
Scatter plots help in visualizing data easily and for simple data inspection. Here's the code for simple scatter and multivariate scatter plot:

PROGRAM:

```
plot(x=iris$Petal.Length) #Simple Scatter Plot
plot(x=iris$Petal.Length,y=iris$Species) #Multivariate Scatter Plot
```

OUTPUT:





5. Heat Map

One of the most innovative data visualizations in R, the heat map emphasizes color intensity to visualize relationships between multiple variables. The result is an attractive 2D image that is easy to interpret. As a basic example, a heat map highlights the popularity of competing items by ranking them according to their original market launch date. It breaks it down further by providing sales statistics and figures over the course of time.

PROGRAM:

 # simulate a dataset of 10 points

x<-rnorm(10,mean=rep(1:5,each=2),sd=0.7)

y<-rnorm(10,mean=rep(c(1,9),each=5),sd=0.1)

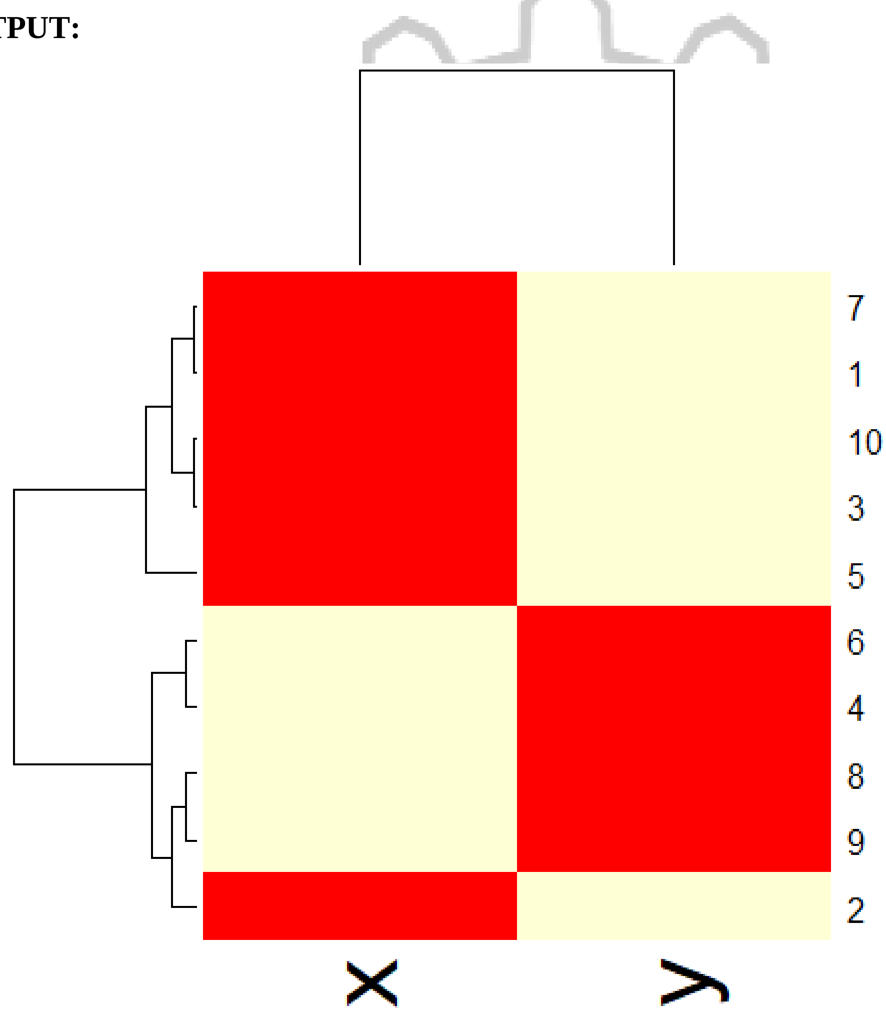
dataFrame<-data.frame(x=x,y=y)

set.seed(143)

dataMatrix<-as.matrix(dataFrame)[sample(1:10),] *# convert to class 'matrix', then shuffle the rows of the matrix*

heatmap(dataMatrix) *# visualize hierarchical clustering via a heatmap*

OUTPUT:



6. Correlogram

Correlated data is best visualized through corrplot. The 2D format is similar to a heat map, but it highlights statistics that are directly related.

Most correlograms highlight the amount of correlation between datasets at various points in time. Comparing sales data between different months or years is a basic example.

PROGRAM:

```
#data("mtcars")
corr_matrix <- cor(mtcars)
# with circles
corrplot(corr_matrix)
# with numbers and lower
corrplot(corr_matrix,method = 'number',type = "lower")
```

OUTPUT:

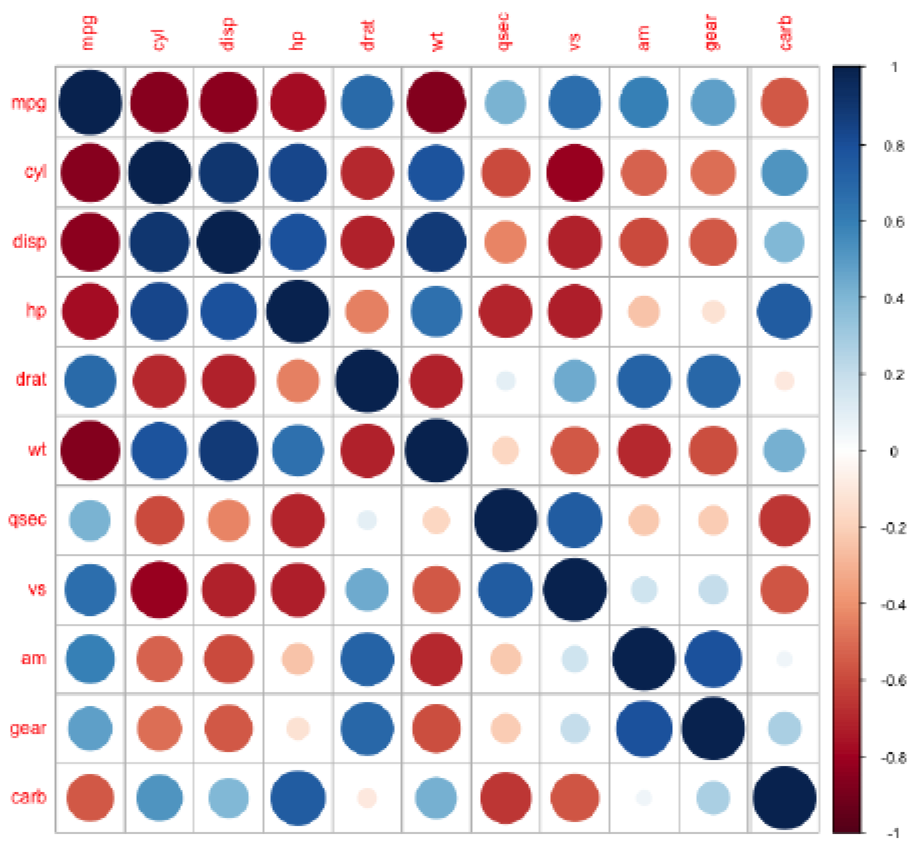


Fig 6. Correlogram with circles (courtesy of Abdul Majed Raja)

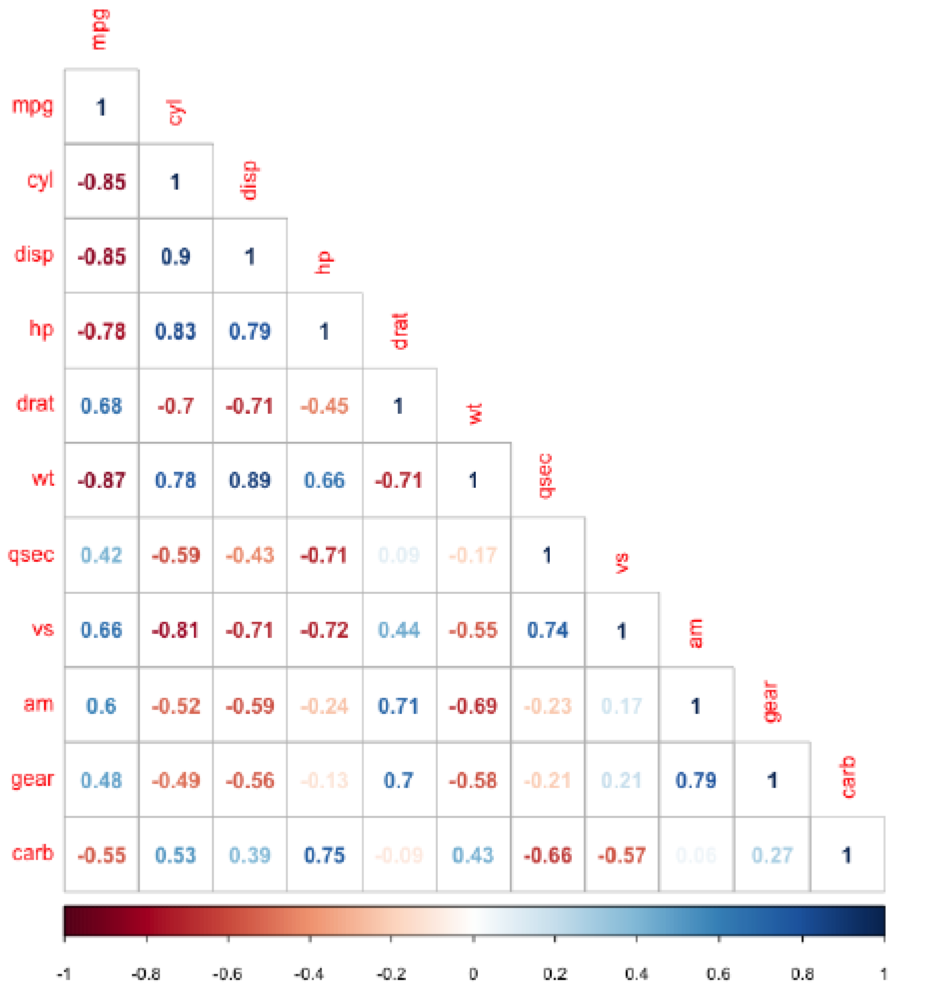


Fig 7. Correlogram with numbers (courtesy of Abdul Majed Raja)

7. Area Chart

Area charts express continuity between different variables or data sets. It's akin to the traditional line chart you know from grade school and is used in a similar fashion.

Most area charts highlight trends and their evolution over the course of time, making them highly effective when trying to expose underlying trends whether they're positive or negative.

PROGRAM:

```
data("airquality") #dataset used
airquality %>%
  group_by(Day) %>%
  summarise(mean_wind = mean(Wind)) %>%
  ggplot() +
```

```
geom_area(aes(x = Day, y = mean_wind)) +
labs(title = "Area Chart of Average Wind per Day",
    subtitle = "using airquality data", y = "Mean Wind")
```

OUTPUT:

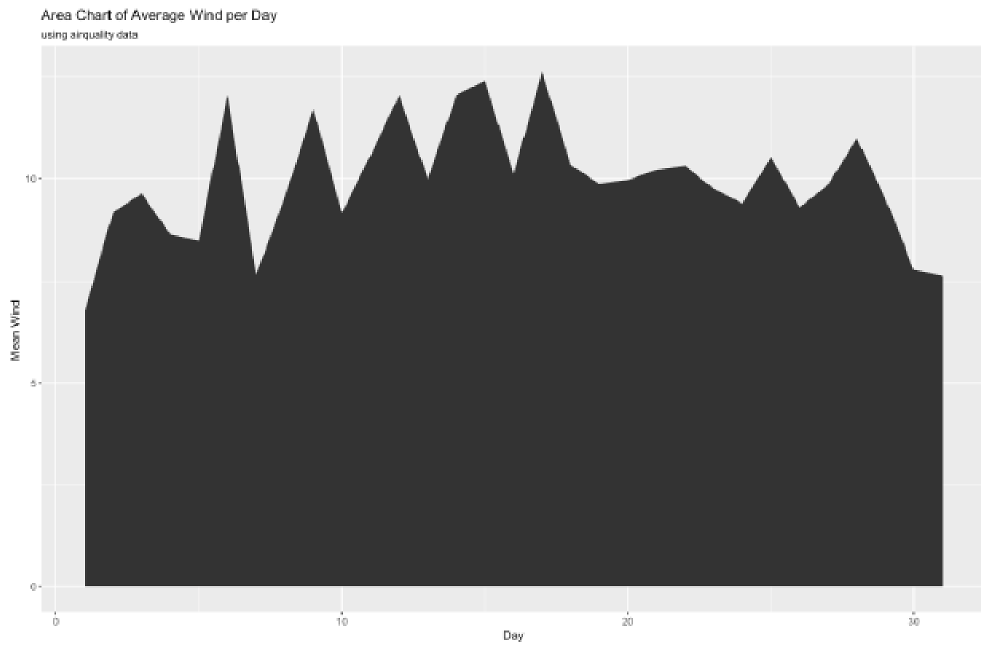


Fig 8. Area chart (courtesy of Abdul Majed Raja)

RESULT:

EX. NO:9 DATE:	**Implement an application that stores big data in Hbase / MongoDB / Pig using Hadoop / R**

MongoDB with R

1) To use MongoDB with R, first, we have to download and install MongoDB Next, start MongoDB. We can start MongoDB like so:

mongod

2) Inserting data

Let's insert the crimes data from data.gov to MongoDB. The dataset reflects reported incidents of crime (with the exception of murders where data exists for each victim) that occurred in the City of Chicago since 2001.

```
library (ggplot2)
library (dplyr)
library (maps)
library (ggmap)
library (mongolite)
library (lubridate)
library (gridExtra)
crimes=data.table::fread("Crimes_2001_to_present.csv")
names (crimes)
```

Output:

```
ID' 'Case Number' 'Date' 'Block' 'IUCR' 'Primary Type' 'Description' 'Location
Description' 'Arrest''Domestic' 'Beat' 'District' 'Ward' 'Community Area' 'FBI Code' 'X
Coordinate' 'Y Coordinate' 'Year' 'Updated On' 'Latitude' 'Longitude' 'Location'
```

3) Let's remove spaces in the column names to avoid any problems when we query it from MongoDB.

names(crimes) = gsub(" ","",names(crimes))

names(crimes)

```
'ID' 'CaseNumber' 'Date' 'Block' 'IUCR' 'PrimaryType' 'Description
'LocationDescription' 'Arrest' 'Domestic' 'Beat' 'District' 'Ward' 'CommunityArea
'FBICode' 'XCoordinate' 'YCoordinate' 'Year' 'UpdatedOn' 'Latitude' 'Longitude
'Location'
```

4) Let's use the insert function from the mongolite package to insert rows to a collection in MongoDB.Let's create a database called Chicago and call the collection crimes.

my_collection = mongo(collection = "crimes", db = "Chicago") # create connection, database and collection

my_collection$insert(crimes)

5) Let’s check if we have inserted the “crimes” data.

my_collection$count()

```
6261148
```

We see that the collection has 6261148 records.

6) First, let’s look what the data looks like by displaying one record:

my_collection$iterate()$one()

```
$ID
1454164
$Case Number
 G185744'
$Date
 04/01/2001 06:00:00 PM'
$Block
 049XX N MENARD AV'
$IUCR
```

```
 0910'
$Primary Type
 MOTOR VEHICLE THEFT'
$Description
 AUTOMOBILE'
$Location Description
 STREET'
$Arrest
 false'
$Domestic
 false'
$Beat
1622
$District
16
$FBICode
 07'
$XCoordinate
1136545
```

```
$YCoordinate

1932203

$Year

2001

$Updated On

 08/17/2015 03:03:40 PM'

$Latitude

41.970129962

$Longitude

87.773302309

$Location

(41.970129962, -87.773302309)'
```


7) How many distinct “Primary Type” do we have?

length(my_collection$distinct("PrimaryType"))

```
35
```

As shown above, there are 35 different crime primary types in the database. We will see the patterns of the most common crime types below.

8) Now, let's see how many domestic assaults there are in the collection.

my_collection$count('{"PrimaryType":"ASSAULT", "Domestic" : "true" }')

```
82470
```

9) To get the filtered data and we can also retrieve only the columns of interest.

query1= my_collection$find('{"PrimaryType" : "ASSAULT", "Domestic" : "true" }')

query2= my_collection$find('{"PrimaryType" : "ASSAULT", "Domestic" : "true" }',

fields = '{"_id":0, "PrimaryType":1, "Domestic":1}')

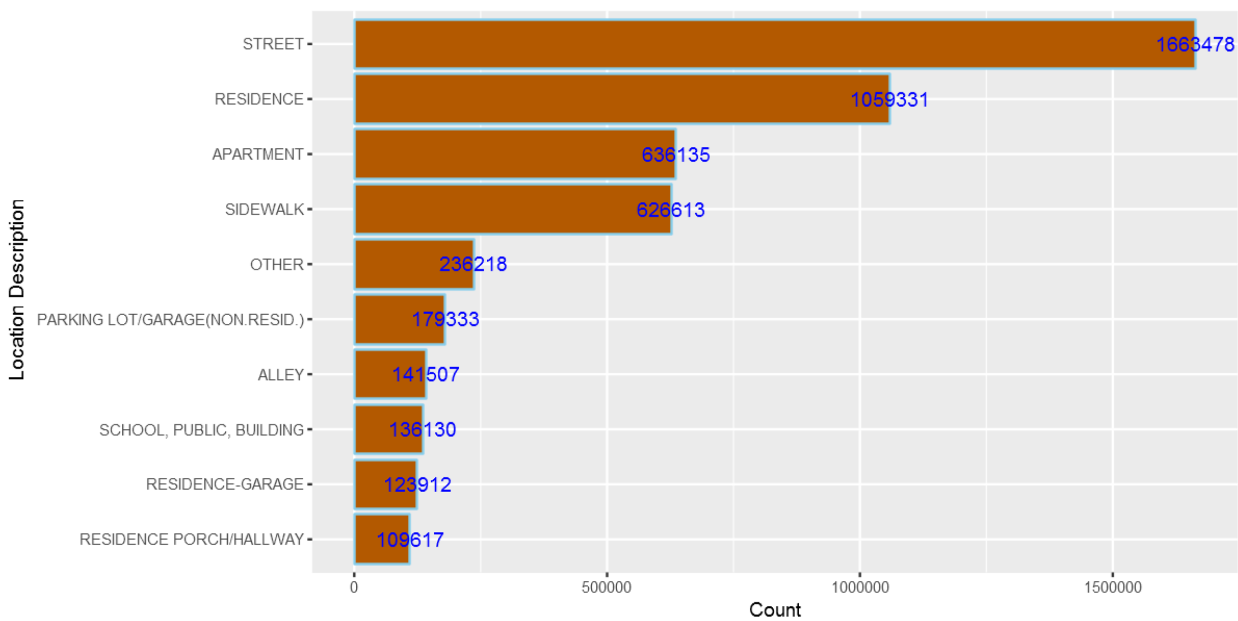
ncol(query1) # with all the columns

ncol(query2) # only the selected columns


```
22

2
```

10) To find out "Where do most crimes take place?" use the following command.

```
my_collection$aggregate('[{"$group":{"_id":"$LocationDescription", "Count": {"$sum":1}}}]')%>%na.omit()%>%

arrange(desc(Count))%>%head(10)%>%

ggplot(aes(x=reorder(`_id`,Count),y=Count))+

geom_bar(stat="identity",color='skyblue',fill='#b35900')+geom_text(aes(label = Count), color = "blue") +coord_flip()+xlab("Location Description")
```

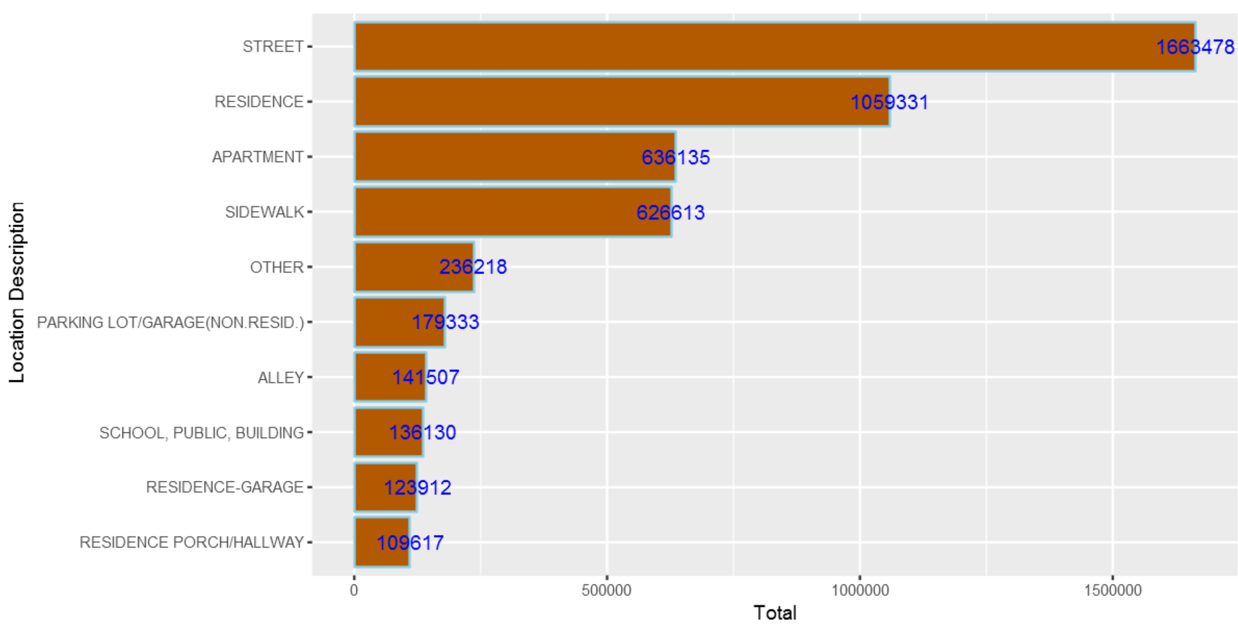


11)If loading the entire dataset we are working with does not slow down our analysis, we can use data.table or dplyr but when dealing with big data, using MongoDB can give us performance boost as the whole data will not be loaded into memory. We can reproduce the above plot without using MongoDB, like so:

crimes%>%group_by(`LocationDescription`)%>%summarise(Total=n())%>%
arrange(desc(Total))%>%head(10)%>%

ggplot(aes(x=reorder(`LocationDescription`,Total),y=Total))+

geom_bar(stat="identity",color='skyblue',fill='#b35900')+geom_text(aes(label = Total), color = "blue") +coord_flip()+xlab("Location Description")



12) What if we want to query all records for certain columns only? This helps us to load only the columns we want and to save memory for our analysis.

query3= my_collection$find('{}', fields = '{"_id":0, "Latitude":1, "Longitude":1,"Year":1}')

13) We can explore any patterns of domestic crimes. For example, are they common in certain days/hours/months?

domestic=my_collection$find('{"Domestic":"true"}', fields = '{"_id":0, "Domestic":1,"Date":1}')

domestic$Date= mdy_hms(domestic$Date)

domestic$Weekday = weekdays(domestic$Date)

domestic$Hour = hour(domestic$Date)

domestic$month = month(domestic$Date,label=TRUE)

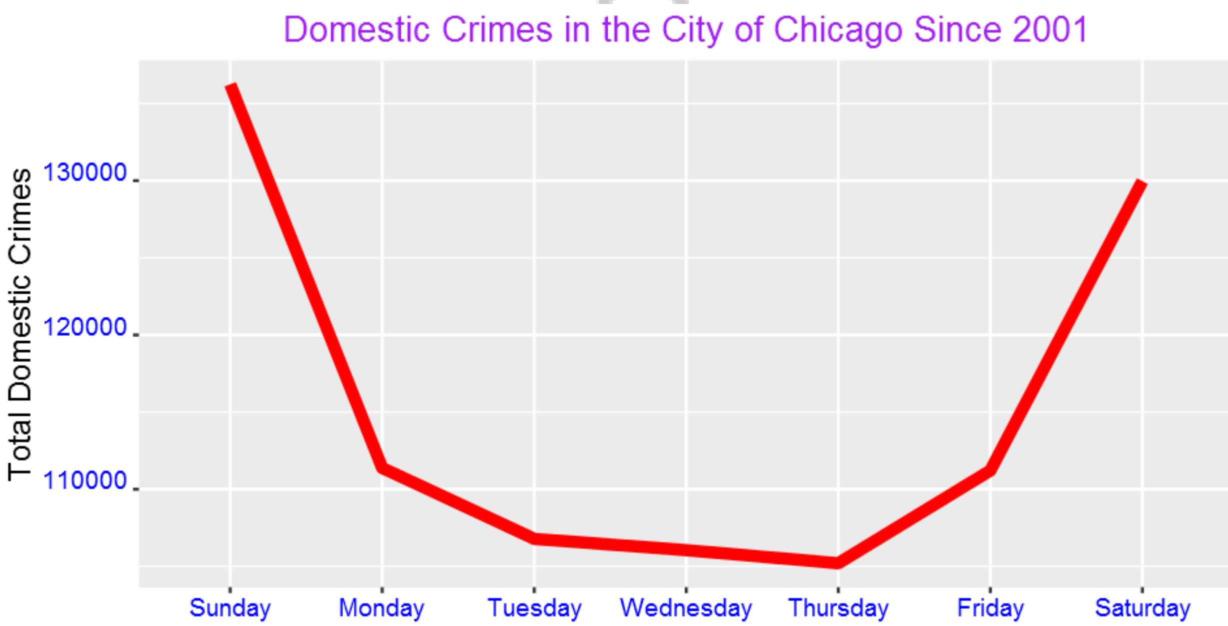
WeekdayCounts = as.data.frame(table(domestic$Weekday))

WeekdayCounts$Var1 = factor(WeekdayCounts$Var1, ordered=TRUE, levels=c("Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday","Saturday"))

ggplot(WeekdayCounts, aes(x=Var1, y=Freq)) + geom_line(aes(group=1),size=2,color="red") + xlab("Day of the Week") + ylab("Total Domestic Crimes")+

ggtitle("Domestic Crimes in the City of Chicago Since 2001")+

```
theme(axis.title.x=element_blank(),axis.text.y =
element_text(color="blue",size=11,angle=0,hjust=1,vjust=0),
 axis.text.x = element_text(color="blue",size=11,angle=0,hjust=.5,vjust=.5),
 axis.title.y = element_text(size=14),
 plot.title=element_text(size=16,color="purple",hjust=0.5))
```



14) Domestic crimes are common over the weekend than in weekdays? What could be the reason?

We can also see the pattern for each day by hour:

```
DayHourCounts = as.data.frame(table(domestic$Weekday, domestic$Hour))
DayHourCounts$Hour = as.numeric(as.character(DayHourCounts$Var2))
```

ggplot(DayHourCounts, aes(x=Hour, y=Freq)) + geom_line(aes(group=Var1, color=Var1), size=1.4)+ylab("Count")+

ylab("Total Domestic Crimes")+ggtitle("Domestic Crimes in the City of Chicago Since 2001")+

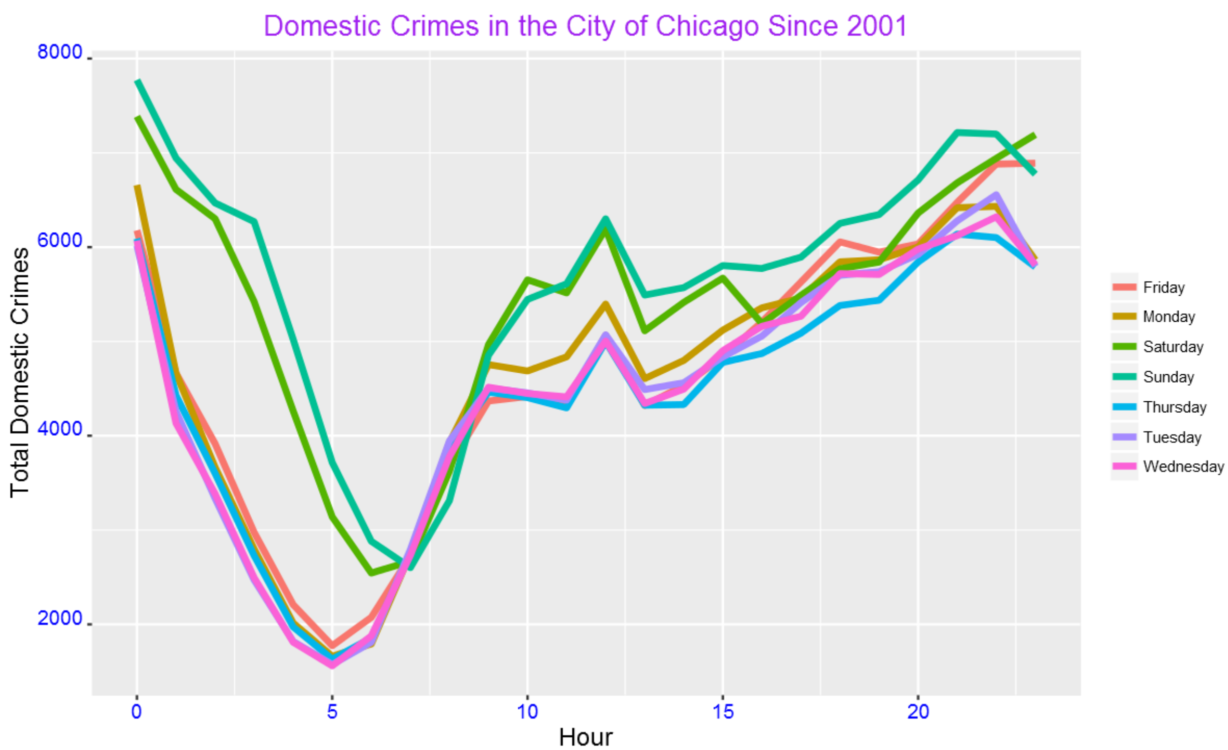
theme(axis.title.x=element_text(size=14),axis.text.y = element_text(color="blue",size=11,angle=0,hjust=1,vjust=0),

axis.text.x = element_text(color="blue",size=11,angle=0,hjust=.5,vjust=.5),

axis.title.y = element_text(size=14),

legend.title=element_blank(),

plot.title=element_text(size=16,color="purple",hjust=0.5))



15) The crimes peak mainly around mid-night. We can also use one color for weekdays and another color for weekend as shown below.

DayHourCounts$Type = ifelse((DayHourCounts$Var1 == "Sunday") | (DayHourCounts$Var1 == "Saturday"), "Weekend", "Weekday")

ggplot(DayHourCounts, aes(x=Hour, y=Freq)) + geom_line(aes(group=Var1, color=Type), size=2, alpha=0.5) +

ylab("Total Domestic Crimes")+ggtitle("Domestic Crimes in the City of Chicago Since 2001")+

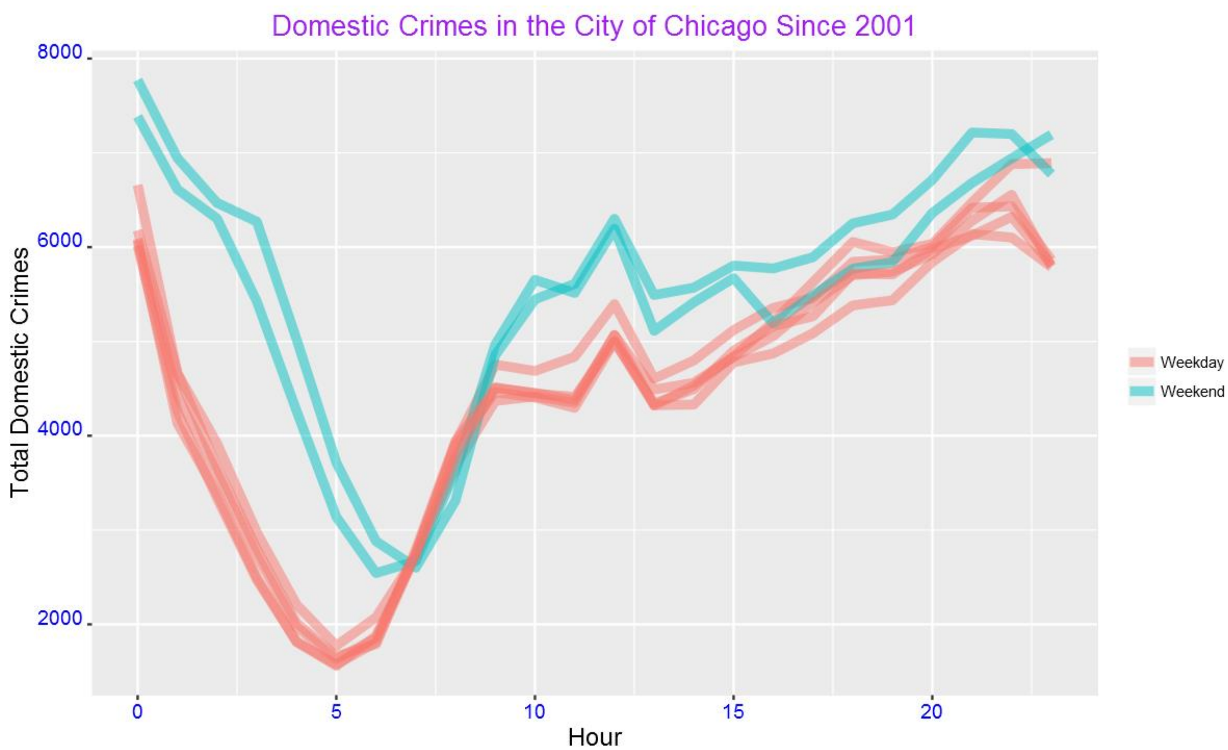
theme(axis.title.x=element_text(size=14),axis.text.y = element_text(color="blue",size=11,angle=0,hjust=1,vjust=0),

axis.text.x = element_text(color="blue",size=11,angle=0,hjust=.5,vjust=.5),

axis.title.y = element_text(size=14),

legend.title=element_blank(),

plot.title=element_text(size=16,color="purple",hjust=0.5))



16) The difference between weekend and weekdays are clearer from this figure than from the previous plot. We can also see the above pattern from a heat map.

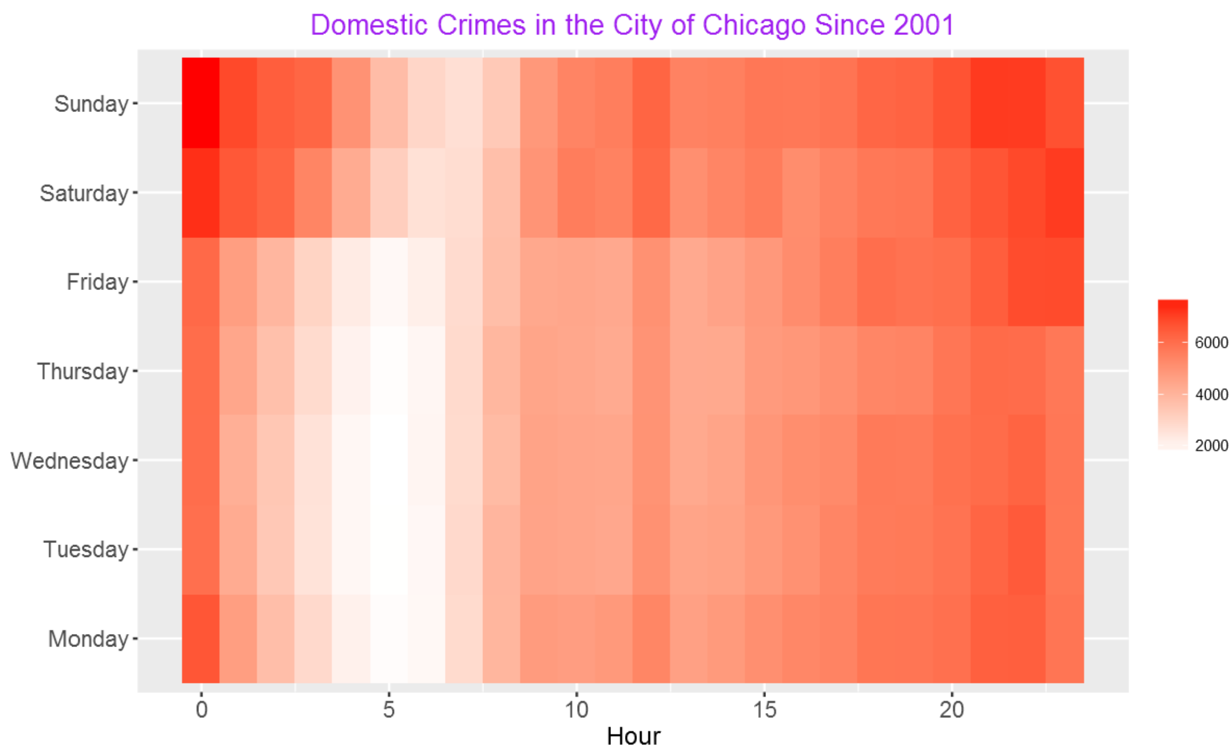
DayHourCounts$Var1 = factor(DayHourCounts$Var1, ordered=TRUE, levels=c("Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday", "Sunday"))

ggplot(DayHourCounts, aes(x = Hour, y = Var1)) + geom_tile(aes(fill = Freq)) + scale_fill_gradient(name="Total MV Thefts", low="white", high="red") +

ggtitle("Domestic Crimes in the City of Chicago Since 2001")+theme(axis.title.y = element_blank())+ylab("")+theme(axis.title.x=element_text(size=14),axis.text.y = element_text(size=13),axis.text.x = element_text(size=13), axis.title.y =

element_text(size=14),

legend.title=element_blank(),plot.title=element_text(size=16,color="purple",hjust=0.5))



17) Let's see the pattern of other crime types. Let's focus on four of the most common ones.

crimes=my_collection$find('{}', fields = '{"_id":0, "PrimaryType":1,"Year":1}')

crimes%>%group_by(PrimaryType)%>%summarize(Count=n())%>%arrange(desc(Count))%>%head(4)

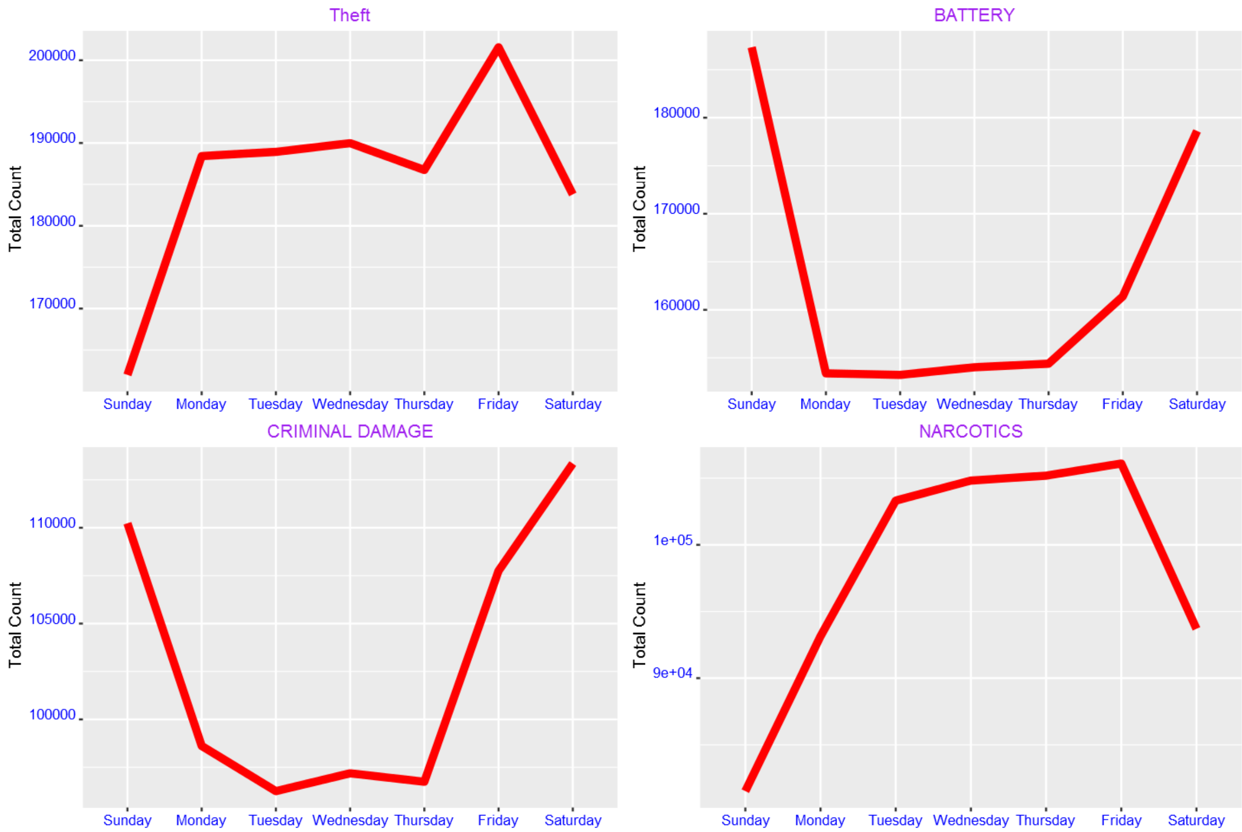
Imported 6261148 records. Simplifying into dataframe...
PrimaryType Count

THEFT	**1301434**
BATTERY	**1142377**
CRIMINAL DAMAGE	**720143**
NARCOTICS	**687790**

18) As shown in the table above, the most common crime type is theft followed by battery. Narcotics is fourth most common while criminal damage is the third most common crime type in the city of Chicago.
Now, let’s generate plots by day and hour.

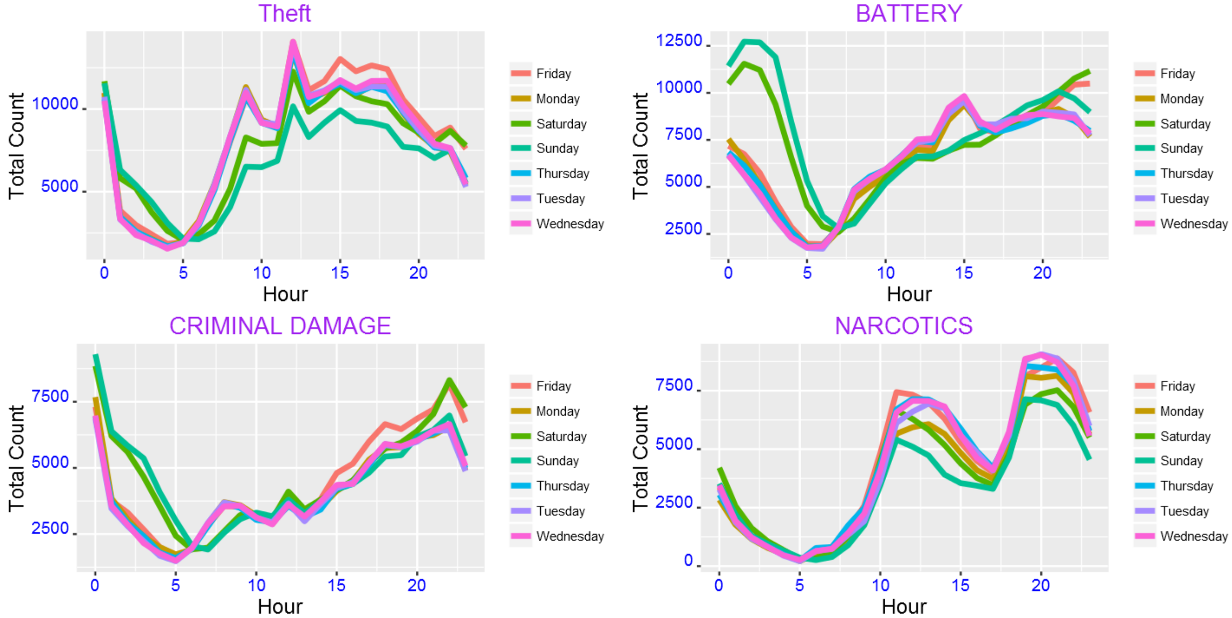
```
four_most_common=crimes%>%group_by(PrimaryType)%>%summarize(Count=n())%>%arrange(desc(Count))%>%head(4)

four_most_common=four_most_common$PrimaryType

crimes=my_collection$find('{}', fields = '{"_id":0, "PrimaryType":1,"Date":1}')

crimes=filter(crimes,PrimaryType %in%four_most_common)

crimes$Date= mdy_hms(crimes$Date)

crimes$Weekday = weekdays(crimes$Date)

crimes$Hour = hour(crimes$Date)

crimes$month=month(crimes$Date,label = TRUE)


g = function(data){WeekdayCounts = as.data.frame(table(data$Weekday))
```

```
WeekdayCounts$Var1 = factor(WeekdayCounts$Var1, ordered=TRUE, levels=c("Sunday", "Monday", "Tuesday", "Wednesday", "Thursday", "Friday","Saturday"))

ggplot(WeekdayCounts, aes(x=Var1, y=Freq)) + geom_line(aes(group=1),size=2,color="red") + xlab("Day of the Week") + theme(axis.title.x=element_blank(),axis.text.y = element_text(color="blue",size=10,angle=0,hjust=1,vjust=0),

 axis.text.x = element_text(color="blue",size=10,angle=0,hjust=.5,vjust=.5),

 axis.title.y = element_text(size=11),

  plot.title=element_text(size=12,color="purple",hjust=0.5)) }

g1=g(filter(crimes,PrimaryType=="THEFT"))+ggtitle("Theft")+ylab("Total Count")

g2=g(filter(crimes,PrimaryType=="BATTERY"))+ggtitle("BATTERY")+ylab("Total Count")

g3=g(filter(crimes,PrimaryType=="CRIMINAL DAMAGE"))+ggtitle("CRIMINAL DAMAGE")+ylab("Total Count")

g4=g(filter(crimes,PrimaryType=="NARCOTICS"))+ggtitle("NARCOTICS")+ylab("Total Count")

grid.arrange(g1,g2,g3,g4,ncol=2)
```



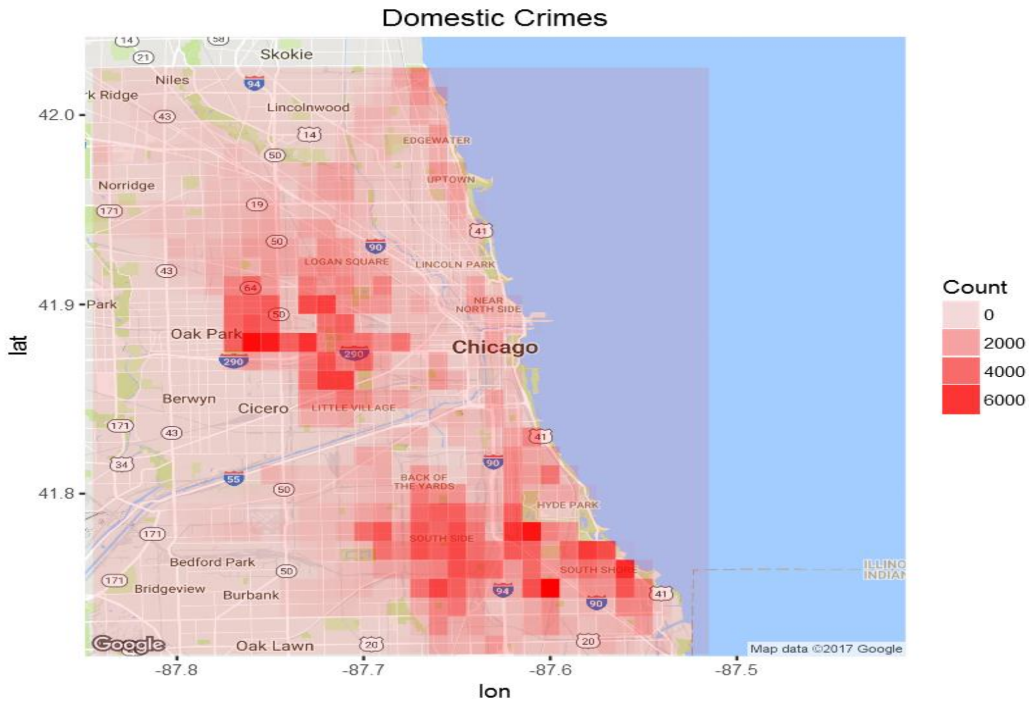
From the plots above, we see that theft is most common on Friday. Battery and criminal damage, on the other hand, are highest at weekend. We also observe that narcotics decreases over weekend.

We can also see the pattern of the above four crime types by hour:

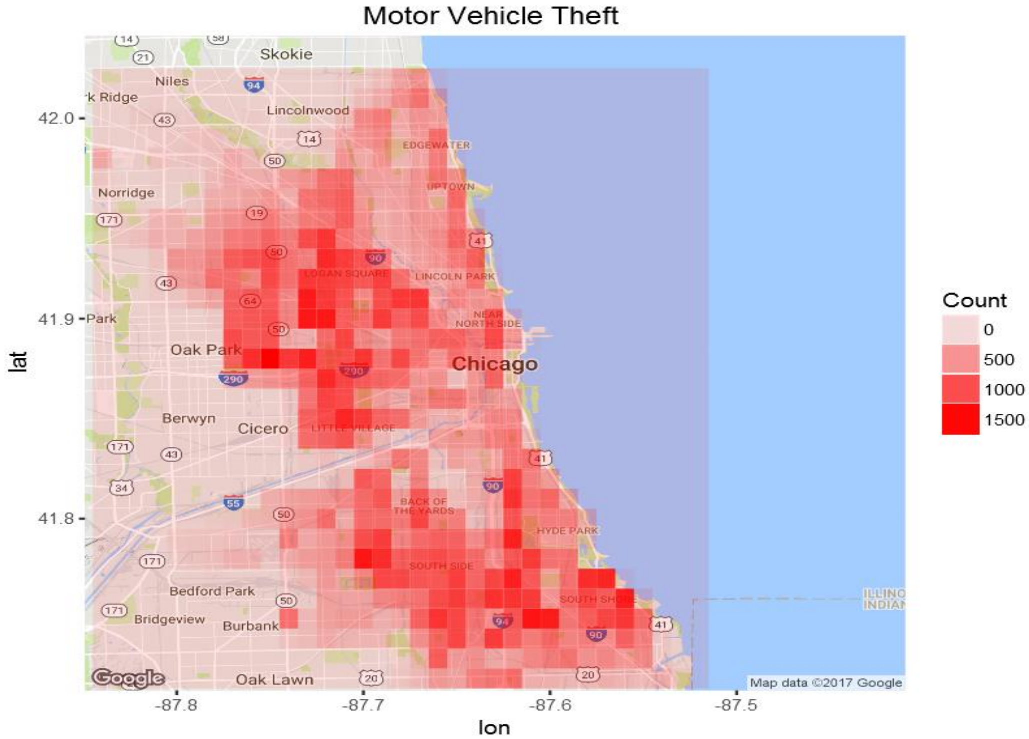


19) We can also see a map for domestic crimes only:

```
domestic=my_collection$find('{"Domestic":"true"}', fields = '{"_id":0,
"Latitude":1, "Longitude":1,"Year":1}')

LatLonCounts=as.data.frame(table(round(domestic$Longitude,2),round(domestic$Latitude,2)))

LatLonCounts$Long = as.numeric(as.character(LatLonCounts$Var1))

LatLonCounts$Lat = as.numeric(as.character(LatLonCounts$Var2))

ggmap(chicago) + geom_tile(data = LatLonCounts, aes(x = Long, y = Lat, alpha
= Freq), fill="red")+

ggtitle("Domestic Crimes")+labs(alpha="Count")+theme(plot.title =
element_text(hjust=0.5))
```



20) Let's see where motor vehicle theft is common:



Domestic crimes show concentration over two areas whereas motor vehicle theft is wide spread over large part of the city of Chicago.