**Hand in ALL questions on 6th March, 2017**

1. In this question, we are required to replicate the interactive version of chord diagram on page 54 of Chapter 2. To construct this chord diagram, the following data files are used: (1) `migration2012.csv` which stores the migration figures among the states in the United States (2) `state_chord.csv` which stores the configuration of the states in the chord diagram. The screenshots of both files are given below:

`migration2012.csv`

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | To | Alabama | Alaska | Arizona | Arkansas | California | Colorado | Connectic | Delaware | District of | Florida | Georgia | Hawaii | Idaho | Illinois | Indiana | Iowa | Kansas | Kentucky |
| 2 | Alabama | NA | 1004 | 962 | 660 | 3077 | 1386 | 284 | 42 | 162 | 11244 | 19920 | 627 | 493 | 2722 | 1347 | 345 | 865 | 2495 |
| 3 | Alaska | 1097 | NA | 1520 | 196 | 3494 | 556 | 0 | 0 | 356 | 1991 | 928 | 1376 | 538 | 58 | 260 | 13 | 221 | 161 |
| 4 | Arizona | 1331 | 3717 | NA | 1214 | 44889 | 13790 | 417 | 246 | 36 | 5553 | 2263 | 2491 | 2934 | 10744 | 2930 | 2702 | 2498 | 1328 |
| 5 | Arkansas | 374 | 855 | 1677 | NA | 3525 | 603 | 185 | 0 | 205 | 2682 | 1525 | 0 | 0 | 3576 | 1172 | 409 | 1033 | 1310 |
| 6 | California | 2509 | 6995 | 38916 | 3472 | NA | 15150 | 6764 | 474 | 3199 | 21004 | 10790 | 11906 | 5331 | 21251 | 5891 | 2284 | 2790 | 3763 |
| 7 | Colorado | 3108 | 3457 | 10589 | 1043 | 22152 | NA | 1317 | 70 | 488 | 8615 | 5834 | 2536 | 2660 | 6374 | 4336 | 2776 | 5283 | 2500 |
| 8 | Connectic | 46 | 439 | 3167 | 200 | 3161 | 367 | NA | 22 | 288 | 6578 | 1702 | 408 | 97 | 912 | 53 | 0 | 0 | 124 |
| 9 | Delaware | 119 | 692 | 188 | 0 | 2221 | 0 | 1489 | NA | 11 | 715 | 179 | 0 | 32 | 567 | 62 | 30 | 113 | 0 |
| 10 | District of | 79 | 1247 | 902 | 35 | 4999 | 677 | 618 | 78 | NA | 1705 | 1079 | 38 | 46 | 795 | 469 | 133 | 164 | 112 |
| 11 | Florida | 18599 | 10704 | 6473 | 3321 | 20386 | 8766 | 8975 | 1099 | 780 | NA | 42754 | 3177 | 1268 | 22565 | 13803 | 3864 | 5661 | 6912 |
| 12 | Georgia | 13864 | 2654 | 6657 | 1041 | 14174 | 4710 | 1829 | 226 | 1352 | 42870 | NA | 1409 | 936 | 7143 | 5972 | 1687 | 1497 | 6172 |
| 13 | Hawaii | 608 | 1417 | 1865 | 24 | 9756 | 1216 | 191 | 278 | 230 | 2780 | 1448 | NA | 404 | 318 | 292 | 84 | 1135 | 485 |
| 14 | Idaho | 575 | 1198 | 2424 | 291 | 10280 | 1186 | 44 | 120 | 116 | 2014 | 583 | 206 | NA | 532 | 283 | 90 | 63 | 83 |
| 15 | Illinois | 883 | 2250 | 7139 | 1587 | 14940 | 3036 | 955 | 234 | 1066 | 12687 | 8745 | 869 | 1384 | NA | 16907 | 8529 | 2009 | 2923 |
| 16 | Indiana | 1625 | 479 | 2763 | 564 | 6033 | 1225 | 823 | 639 | 1045 | 11472 | 2258 | 856 | 186 | 28436 | NA | 1678 | 1624 | 11177 |
| 17 | Iowa | 503 | 951 | 1590 | 451 | 3268 | 3252 | 112 | 0 | 151 | 4335 | 596 | 521 | 290 | 11969 | 1716 | NA | 918 | 819 |
| 18 | Kansas | 853 | 333 | 3094 | 2158 | 5411 | 3746 | 210 | 0 | 456 | 3118 | 1896 | 149 | 456 | 1702 | 1679 | 1527 | NA | 617 |

`state_chord.csv`

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | ID | Region | States | Color | | | |
| 2 | 1 | Northeast | Connecticut | #4D4D4D | | | |
| 3 | 2 | Northeast | Maine | #4D4D4D | | | |
| 4 | 3 | Northeast | Massachusetts | #4D4D4D | | | |
| 5 | 4 | Northeast | New Hampshire | #4D4D4D | | | |
| 6 | 5 | Northeast | Rhode Island | #4D4D4D | | | |
| 7 | 6 | Northeast | Vermont | #4D4D4D | | | |
| 8 | 7 | Northeast | New Jersey | #4D4D4D | | | |
| 9 | 8 | Northeast | New York | #4D4D4D | | | |
| 10 | 9 | Northeast | Pennsylvania | #4D4D4D | | | |
| 11 | 10 | Midwest | Illinois | #009900 | | | |
| 12 | 11 | Midwest | Indiana | #009900 | | | |
| 13 | 12 | Midwest | Michigan | #009900 | | | |
| 14 | 13 | Midwest | Ohio | #009900 | | | |
| 15 | 14 | Midwest | Wisconsin | #009900 | | | |
| 16 | 15 | Midwest | Iowa | #009900 | | | |
| 17 | 16 | Midwest | Kansas | #009900 | | | |
| 18 | 17 | Midwest | Minnesota | #009900 | | | |

Refer to the `migration2012.csv`, we observed that 1004 people migrated from Alaska to Alabama, for example. Similarly, 1331 people migrated from Alabama to Arizona. To construct the interactive chord diagram, the following procedures are required:

   (a) Read the data values of data files `migration2012.csv` and `state_chord.csv` into data frames `dat` and `states` respectively.

   (b) Convert the data frame `dat` into a matrix in which the migration figures of states are arranged in the order of regions in the United States.

      (i) Since the migration figures in `dat` are arranged in the format of matrix, you are required to rearrange the data values into the following format by the function `melt()` in the package `reshape`.

| | To | From | value |
|---|---|---|---|
| 1 | Alabama | Alabama | NA |
| 2 | Alaska | Alabama | 1097 |
| 3 | Arizona | Alabama | 1331 |
| 4 | Arkansas | Alabama | 374 |
| 5 | California | Alabama | 2509 |
| 6 | Colorado | Alabama | 3108 |
| 7 | Connecticut | Alabama | 46 |
| 8 | Delaware | Alabama | 119 |
| 9 | District of Columbia | Alabama | 79 |
| 10 | Florida | Alabama | 18599 |

Note that the variable names of columns are required to change as well.

(ii) Based on the data frames in (i), the states name in the columns `From` and `To` may contain the punctuation `:`. Then, the function `gsub()` can be considered to replace all colons by blanks.

(iii) In the data frame `states`, the states are categorized into four regions in the United States. Then, based on the data frame in (ii), construct two new columns `ID_From` and `ID_To` which are indeed the values of `ID` in the data frame `states`.

| | To | From | value | ID_From | ID_To |
|---|---|---|---|---|---|
| 1 | Alabama | Florida | 11244 | 23 | 31 |
| 2 | Alabama | Tennessee | 10539 | 34 | 31 |
| 3 | Alabama | Oregon | 200 | 50 | 31 |
| 4 | Alabama | Arizona | 962 | 39 | 31 |
| 5 | Alabama | Montana | 101 | 42 | 31 |
| 6 | Alabama | Vermont | 0 | 6 | 31 |
| 7 | Alabama | Maryland | 1513 | 25 | 31 |
| 8 | Alabama | Hawaii | 627 | 49 | 31 |
| 9 | Alabama | Utah | 579 | 45 | 31 |
| 10 | Alabama | Idaho | 493 | 41 | 31 |

Hint: You may use the `merge()` function and `colnames()` function to construct the above data frame.

(iv) Using the package `dplyr`, sort the observations of the data frame in (iii) in the ascending order of `ID_From` and then `ID_To`. [Hint: Use `arrange()` function.]

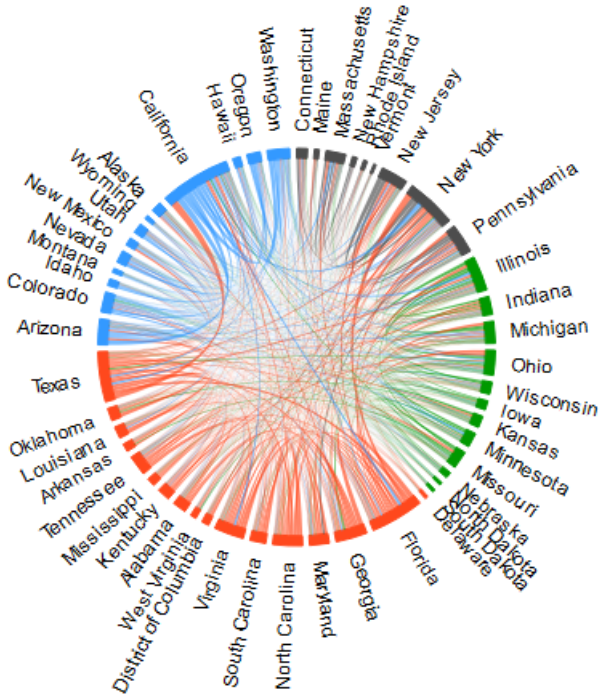
(v) Convert the data frame in (iv) into a matrix and the column names and row names are changed to the state names.

| | Connecticut | Maine | Massachusetts | New Hampshire | Rhode Island | Vermont | New Jersey | Ne Yo |
|---|---|---|---|---|---|---|---|---|
| Connecticut | NA | 1468 | 10525 | 1345 | 4170 | 1626 | 3466 | |
| Maine | 1224 | NA | 3907 | 6118 | 279 | 883 | 430 | |
| Massachusetts | 8743 | 3887 | NA | 18990 | 11253 | 3318 | 4907 | |
| New Hampshire | 1009 | 3655 | 13331 | NA | 611 | 2893 | 126 | |
| Rhode Island | 1558 | 1024 | 6863 | 1248 | NA | 341 | 429 | |
| Vermont | 709 | 349 | 2534 | 2960 | 53 | NA | 35 | |
| New Jersey | 5665 | 405 | 8046 | 591 | 1219 | 833 | NA | |
| New York | 23310 | 2519 | 19467 | 2905 | 3603 | 4780 | 40495 | |
| Pennsylvania | 2214 | 976 | 8236 | 890 | 735 | 935 | 23597 | |
| Illinois | 912 | 195 | 2886 | 673 | 385 | 230 | 2052 | |

(c) Display the interactive chord diagram using the function `chorddiag()` in the package `chorddiag` which can be installed by the following command:

```
devtools::install_github('mattflor/chorddiag')
```

The usage of the function `chorddiag()` can be found in the documentation. If the visualization is generated appropriately, the following output will be produced.



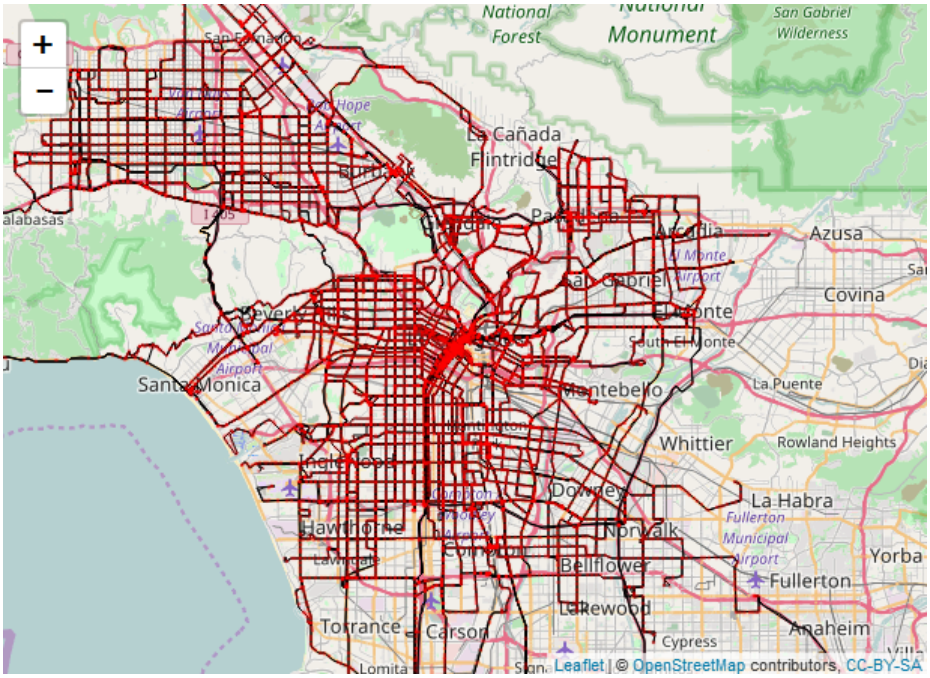

2. In Example Class 3, the bus map of New York City was constructed. In that process, the shapefiles of bus stops and bus lines are re-projected to the same coordinate reference system (CRS) WGS84. The `SpatialLineDataFrame` of all bus lines was reconstructed and stored in `SLDF`. Then, the bus lines and bus stops are overlaid on the map of New York City using the `leaflet()` function of the package `leaflet`.

   In this question, you are required to repeat this exercise to map of Los Angeles. However, the bus lines in Los Angeles are far more complicated. Information of bus stops and bus routes can be found in the following website:

   ```
   http://developer.metro.net/introduction/gis-data/download-gis-data/
   ```

   The GIS data of bus stops is stored in the file `BusStops1216.zip` which contains two shapefiles: one is for "Lines Serving Stops" which shows what Lines serve each stop and the other is for "Stops On Lines" which shows the stops on a given Line; it is sorted by Line, Direction and Stop Number. Then, we can choose the "Stops On Lines" shapefile for our purpose. On the other hand, the GIS data of bus lines are stored in the files `LimExp1216.zip`, `RapidBRT1216.zip`, `ComCir1216.zip`, `LocalCBD1216.zip`, `Individuals1216.zip` and `LocalNonCBD1216.zip`. All of them can be downloaded from the above link.

   Basically, the techniques of generating the bus map of Los Angeles is similar to those of New York City. One major difference is the concatenation of all GIS data of bus lines into one `SpatialLineDataFrame`. Then, the map of Los Angeles is overlaid with the GIS data of bus stops and bus routes. Therefore, the map centered at Los Angeles is also required during the process. For the simplicity, all bus lines in Los Angeles are represented by the same color and they are shown as follows:




3. In Example Class 2, the package `highcharter` was considered to demonstrate the time series plot of exchange rates USD/JPY and AUD/JPY. Since both measurement scales of both exchange rates are rather similar, the same vertical axis can be used. Now, you are required to produce a time series plot of exchange rate AUD/JPY and GBP/USD using `highcharter` package. Here are the requirement of this chart:

   (a) Two individual vertical axes are used for plotting these two times series.

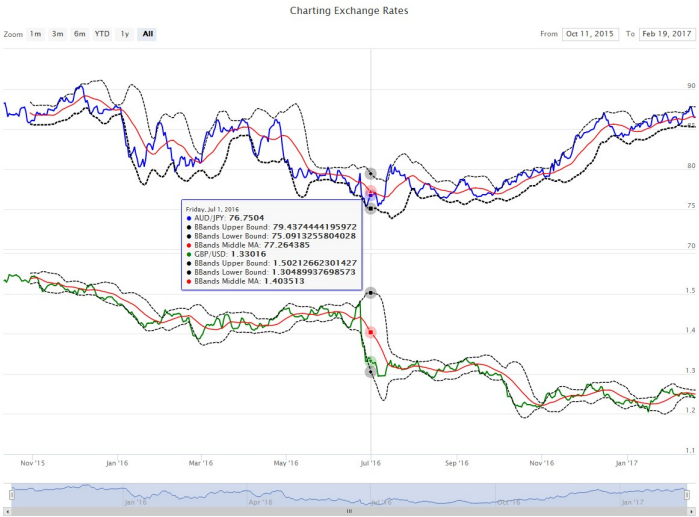
   (b) Labels of both vertical axes appear on the same side.

   (c) Each vertical axis shares the same proportion of height.

   (d) The lines of AUD/JPY and GBP/USD are indicated by blue line and green line respectively.

   (e) The Bollinger's band will be used as the technical indicator of both exchange rates. The moving average in the middle will be red in color while the lower bound and upper bound will be black in color and dashed.

   (f) Each line in the plot should be labeled.



4. The `flights` data frame in the package `nycflights13` contains 336,776 observations related to On-time data for all flights that departed NYC in 2013. The columns in this data frame are described below:

| Variables | Description |
|---|---|
| `year`, `month`, `day` | Date of departure |
| `dep_time`, `arr_time` | Actual departure and arrival times, local time zone |
| `sched_dep_time`, `sched_arr_time` | Scheduled departure and arrival times, local time zone |
| `dep_delay`, `arr_delay` | Departure and arrival delays, in minutes. Negative times represent early departures/arrivals |
| `hour`, `minute` | Time of scheduled departure broken into hour and minutes |
| `carrier` | Two letter carrier abbreviation, e.g. CX = Cathay Pacific |
| `tailnum` | Plane tail number |
| `flight` | Flight number |
| `origin`, `dest` | Origin and destination |
| `air_time` | Amount of time spent in the air, in minutes |
| `distance` | Distance between airports, in miles |
| `time_hour` | Scheduled date and hour of the flight as a POSIXct date |

In this question, the packages `ffbase`, `ffbase2`, `biglm` and `pROC` are required. Since the package `ffbase2` is not available in CRAN, you may install this package by the following command:

```
devtools::install_github('edwindj/ffbase2')
```

From the package `ffbase2`, the internal functions in `dplyr` can be used.

(a) Transform the data frame `flights` into the data frame of type `ffdf` and store the result to `flightff`. [Hint: Use the expression `nycflights13::flights` to access data frame `flights`.]

(b) Construct the following variables in the data frame `fflightff`:

(i) `Delay` = 1 when `dep_delay` $>$ 0 or = 0 otherwise

(ii) `DepHour` = `hour`

(iii) `Car` = 1 if `Carrier` = 'DL', 'US', 'DH' or 'UA' or = 0 otherwise

(iv) `Night` = 1 when (`hour` $\geq$ 18 or `hour` $\leq$ 6) or = 0 otherwise

(v) `Weekend` = 1 when the departure date is Saturday, or = 0 otherwise

(c) Construct the data frame `logitff` of type `ffdf` to include the variables constructed in (b). Note that the records with missing `Delay` are excluded in the data frame.

(d) Construct the training and test data frames `trainset` and `testset` respectively by the following commands:

```
indx <- ff(1:nrow(logitff))
p <- 0.7
trainIndx <- ff(indx[1:trunc(length(indx)*p)])
trainset <- logitff[trainIndx,]
testIndx <- ff(indx[(trunc(length(indx)*p)+1):length(indx)])
testset <- logitff[testIndx,]
```

(e) Fit the binary logistic regression model with data frame `trainset` using the `bigglm()` function where the response is `Delay` and the predictors are `DepHour`, `Car`, `Night` and `Weekend`.

(f) Compute the results of predicted respone for both `trainset` and `testset`. The results are stored in the `train_pred` and `test_pred` respectively.

(g) Construct the confusion matrices for both training and test data sets separately using `table()` function. Note that the cutoff probability 0.5 is specified to identify predicted positive outcomes.

(h) Construct the ROC curve for the prediction results of test data using the `roc()` function and plot the ROC curve using the `plot()` function.

5. In this question, the NYC motor vehicle accidents during 2013-2016 will be be considered and the observations are stored in the data file `NYPD_Motor_Vehicle_Collisions.csv`. You are required to use the package `sparklyr` to finish the following tasks:

(a) Transform the observations in the data file into a `Spark DataFrame` and store the result to `nypd_tbl`.

(b) Using functions in the package `dplyr`, remove those records whose `LATITUDE` or `LONGITUDE` is missing or their values are zero or `BOROUGH` is missing. Then, sort the records in the descending order of `UNIQUE_KEY`.

(c) After the cleaning process in (b), partition the data frame into training and test data by the `sdf_partition()` function. The resulting data sets are stored in `train` and `test` respectively.

(d) Consider the training data in (c) only, apply the decision tree model with `BOROUGH` as the response and `LATITUDE` and `LONGITUDE` as the predictors. [Hint: Use `ml_decision_tree()` function with parameters `max.bin=200L`, `max.depth=10L` and `seed=123L`.]