Unsupervised Learning

```r
source(here::here("scripts","setup.R"))
```

```
here() starts at /Users/lodrik/Documents/GitHub/ML_Project


Attaching package: 'dplyr'


The following objects are masked from 'package:stats':

    filter, lag


The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union


-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v forcats   1.0.0     v stringr   1.5.1
v lubridate 1.9.3     v tibble    3.2.1
v purrr     1.0.2     v tidyr     1.3.1
v readr     2.1.5
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becom

Attaching package: 'plotly'


The following object is masked from 'package:ggplot2':
```

```
    last_plot


The following object is masked from 'package:stats':

    filter


The following object is masked from 'package:graphics':

    layout


Linking to GEOS 3.11.0, GDAL 3.5.3, PROJ 9.1.0; sf_use_s2() is TRUE


Attaching package: 'scales'


The following object is masked from 'package:purrr':

    discard


The following object is masked from 'package:readr':

    col_factor


Loading required package: NLP


Attaching package: 'NLP'


The following object is masked from 'package:ggplot2':

    annotate



Attaching package: 'kableExtra'
```

```
The following object is masked from 'package:dplyr':

    group_rows


Attaching package: 'summarytools'


The following object is masked from 'package:tibble':

    view


Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa


Attaching package: 'neuralnet'


The following object is masked from 'package:dplyr':

    compute
```

```
library(data.table)
```

```
Attaching package: 'data.table'

The following objects are masked from 'package:lubridate':

    hour, isoweek, mday, minute, month, quarter, second, wday, week,
    yday, year

The following object is masked from 'package:purrr':

    transpose

The following objects are masked from 'package:dplyr':

    between, first, last
```

```
data_cleaned <- fread(here::here("data", "data_cleaned.csv"))
```

In order to see the link between the features, we can use a dimension reduction technique such as the Principal Component Analysis, aiming to link the features according to their similarities accross instances and combine features in fewer dimensions.

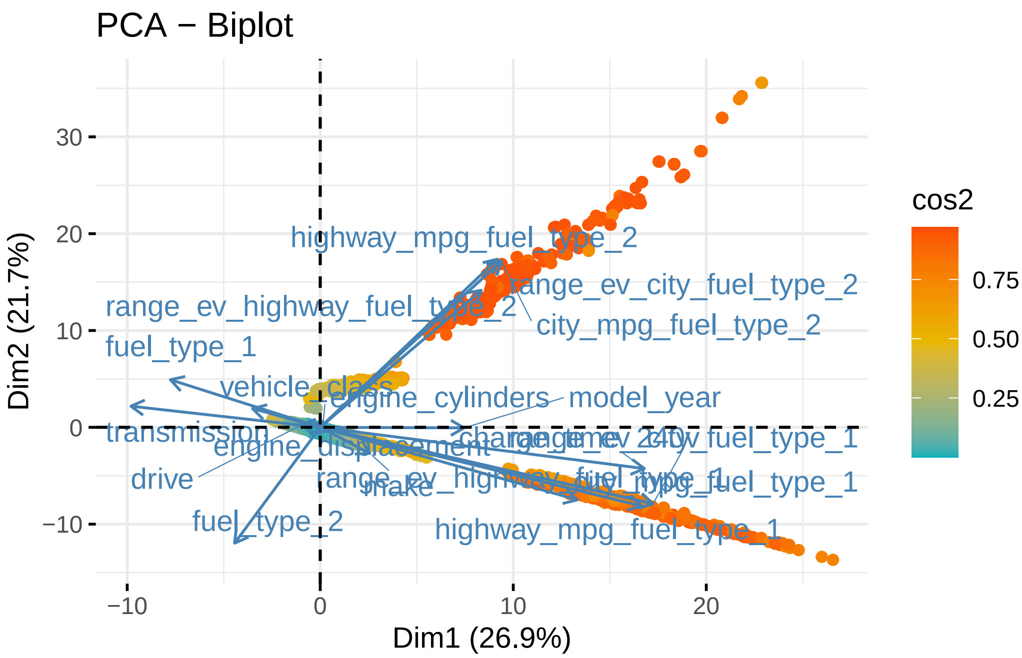
PCA

```
# Assuming your data frame is named data_cleaned
data_prepared <- data_cleaned %>%
  mutate(across(where(is.character), as.factor)) %>%
  mutate(across(where(is.factor), as.numeric)) %>%
  scale()  # Standardizes numeric data including converted factors

pca_results <- PCA(data_prepared, graph = FALSE)
summary(pca_results)
```

```
Call:
PCA(X = data_prepared, graph = FALSE)


Eigenvalues
                       Dim.1   Dim.2   Dim.3   Dim.4   Dim.5   Dim.6   Dim.7
Variance               4.844   3.900   2.106   1.222   0.993   0.866   0.855
% of var.             26.913  21.666  11.700   6.790   5.519   4.811   4.750
Cumulative % of var.  26.913  48.579  60.279  67.069  72.588  77.399  82.149
                       Dim.8   Dim.9  Dim.10  Dim.11  Dim.12  Dim.13  Dim.14
Variance               0.827   0.725   0.539   0.460   0.309   0.179   0.131
% of var.              4.595   4.028   2.996   2.557   1.718   0.992   0.729
Cumulative % of var.  86.744  90.773  93.769  96.326  98.044  99.036  99.765
                      Dim.15  Dim.16  Dim.17  Dim.18
Variance               0.034   0.008   0.000   0.000
% of var.              0.188   0.047   0.000   0.000
Cumulative % of var.  99.953 100.000 100.000 100.000

Individuals (the 10 first)
                              Dist    Dim.1    ctr   cos2    Dim.2    ctr
1                         |  3.335 | -1.044  0.001  0.098 |  0.068  0.000
2                         |  3.410 | -1.208  0.001  0.125 |  0.197  0.000
```

```
3                           |  3.544 | -1.448  0.001  0.167 |  0.268  0.000
4                           |  2.789 | -1.245  0.001  0.199 |  0.155  0.000
5                           |  2.742 | -1.166  0.001  0.181 |  0.112  0.000
6                           |  2.742 | -1.166  0.001  0.181 |  0.112  0.000
7                           |  2.855 | -1.129  0.001  0.156 |  0.029  0.000
8                           |  2.903 | -1.317  0.001  0.206 |  0.126  0.000
9                           |  4.943 | -2.152  0.002  0.190 |  0.605  0.000
10                          |  3.448 | -2.115  0.002  0.376 |  0.596  0.000
                              cos2    Dim.3    ctr   cos2
1                            0.000 | -0.285  0.000  0.007 |
2                            0.003 |  2.415  0.007  0.502 |
3                            0.006 |  2.351  0.006  0.440 |
4                            0.003 |  0.439  0.000  0.025 |
5                            0.002 |  0.407  0.000  0.022 |
6                            0.002 |  0.407  0.000  0.022 |
7                            0.000 |  0.239  0.000  0.007 |
8                            0.002 |  0.285  0.000  0.010 |
9                            0.015 | -0.393  0.000  0.006 |
10                           0.030 |  1.207  0.002  0.123 |

Variables (the 10 first)
                               Dim.1    ctr   cos2    Dim.2    ctr   cos2
make                        |  0.129  0.345  0.017 | -0.135  0.469  0.018 |
model_year                  |  0.375  2.900  0.141 | -0.003  0.000  0.000 |
vehicle_class               | -0.176  0.643  0.031 |  0.098  0.244  0.010 |
drive                       | -0.048  0.047  0.002 |  0.013  0.004  0.000 |
engine_cylinders            |  0.007  0.001  0.000 |  0.000  0.000  0.000 |
engine_displacement         |  0.025  0.013  0.001 | -0.017  0.007  0.000 |
transmission                | -0.494  5.028  0.244 |  0.110  0.310  0.012 |
fuel_type_1                 | -0.391  3.149  0.153 |  0.247  1.568  0.061 |
city_mpg_fuel_type_1        |  0.868 15.542  0.753 | -0.397  4.047  0.158 |
highway_mpg_fuel_type_1     |  0.838 14.497  0.702 | -0.409  4.284  0.167 |
                             Dim.3    ctr   cos2
make                        -0.445  9.407  0.198 |
model_year                  -0.033  0.053  0.001 |
vehicle_class                0.431  8.813  0.186 |
drive                        0.148  1.044  0.022 |
engine_cylinders             0.772 28.267  0.595 |
engine_displacement          0.877 36.535  0.769 |
transmission                -0.129  0.795  0.017 |
fuel_type_1                 -0.282  3.771  0.079 |
city_mpg_fuel_type_1        -0.116  0.634  0.013 |
highway_mpg_fuel_type_1     -0.221  2.326  0.049 |
```

```r
fviz_pca_biplot(pca_results,
                geom.ind = "point",  # To show data points
                geom.var = c("arrow", "text"),  # To show variable vectors and labels
                col.ind = "cos2",  # Color by the quality of representation
                gradient.cols = c("#00AFBB", "#E7B800", "#FC4E07"),  # Colors
                repel = TRUE  # Avoid text overlapping
)
```

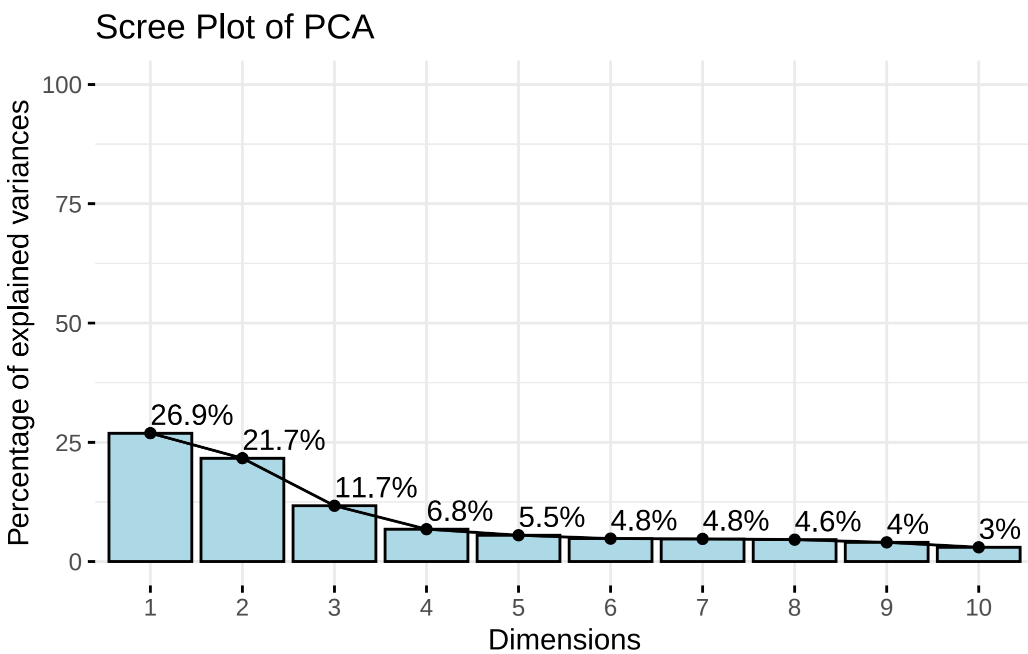


The biplot shows several information. - The colored dots represent the numerical observations of the dataset. - The cos2 gradient shows the representation of the feature by the dimension, so the higher the cos2 (tending to red), the better the representation of the observation in the dimension. - The arrows represent the features in the form of the circle of correlation. Here, we have 2 dimensions which represent almost 49% of the observations. - Looking at the arrows, it shows that most of variables are stongly linked to dimension 2. We can also see that the arrows that go in opposite directions (such as fuel_type_1 and highway_mpg_fuel_type_1) are negatively correlated. From another view, fuel_type_1 and fuel_type_2 are uncorrelated.

Screeplot

```r
# Generating the scree plot from PCA results
fviz_eig(pca_results,
```

```
        addlabels = TRUE,  # Adds labels to the plot indicating the percentage of variance
        ylim = c(0, 100),  # Optional: Sets the limits of the y-axis to make the plot easie
        barfill = "lightblue",  # Color of the bars
        barcolor = "black",  # Color of the borders of bars
        main = "Scree Plot of PCA")  # Title of the plot
```



Taking the screeplot into account, 6 dimensions are needed to reach at least 75%, meaning the features might be relatively independent. It is alredy shown in the biplot above, as most arrows in the middle seem to be shorter and the cos2 are low, meaning that the features might be more linked to other dimensions than the first 2 dimensions. To check further the correlation, we can use a heatmap.

Heatmap

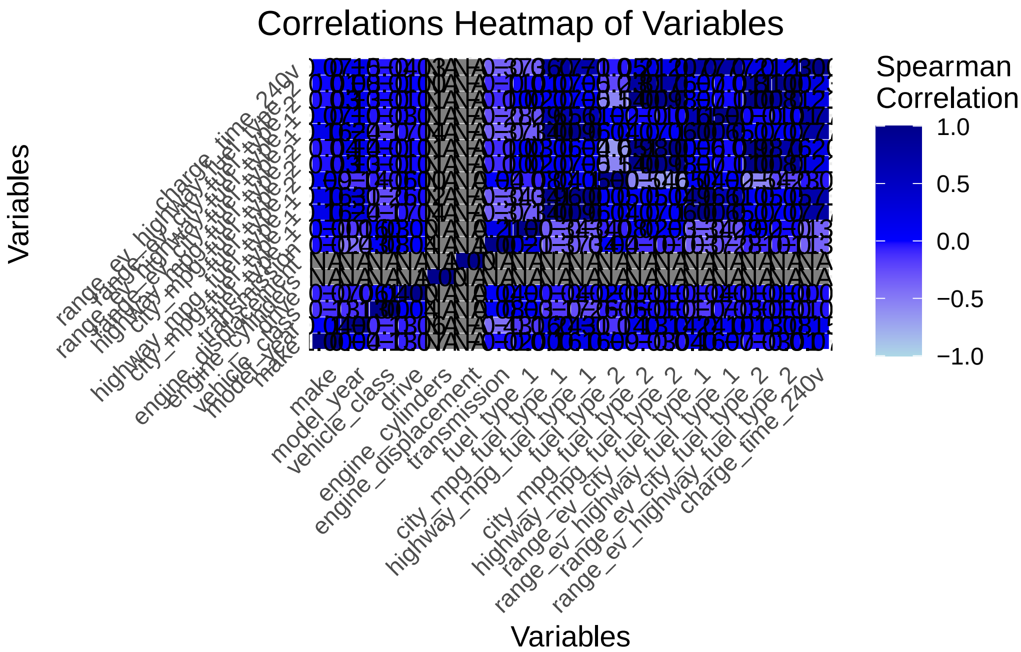
```
library(reshape2)
```

```
Attaching package: 'reshape2'

The following objects are masked from 'package:data.table':
```

```
    dcast, melt
```

```
The following object is masked from 'package:tidyr':

    smiths
```

```
# Assuming data_prepared has been previously defined and standardized
cor_matrix <- cor(data_prepared)  # Calculate correlation matrix

# Melt the correlation matrix for ggplot2
melted_cor_matrix <- melt(cor_matrix)

# Heatmap with all correlation coefficients displayed
ggplot(melted_cor_matrix, aes(Var1, Var2, fill = value)) +
  geom_tile(color = "white") +  # Add white lines to distinguish the tiles
  geom_text(aes(label = sprintf("%.2f", value)), color = "black", size = 3.5) +  # Always dis
  scale_fill_gradient2(low = "lightblue", high = "darkblue", mid = "blue", midpoint = 0, limi
                       name = "Spearman\nCorrelation") +  # Use gradient2 for a diverging col
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1),
        axis.text.y = element_text(angle = 45, hjust = 1),
        plot.title = element_text(hjust = 0.5),  # Center the title
        plot.title.position = "plot") +
  labs(x = 'Variables', y = 'Variables',
       title = 'Correlations Heatmap of Variables')  # Adjust the title and labels as needed
```



This heatmap indicates the correlation between the variables. It shows that the correlations aren't that strong between variables, expect for a few such as mighway_mpg_fuel and city_mpg_fuel.