

Visualization of large multivariate datasets with the **tabplot** package

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Abstract

The tableplot is a powerful visualization method to explore and analyse large multivariate datasets. In this vignette, the implementation of tableplots in R is described.

1 Introduction

The tableplot is a visualization method that is used to explore and analyse large datasets. Tableplots are used to explore the relationships between the variables, to discover strange data patterns, and to check the occurrence and selectivity of missing values.

A tableplot applied to the diamonds dataset of the **ggplot2** package (where some missing values were added) is illustrated in Figure 1. Each column represents a variable. The whole data set is sorted according to one column (in this case, carat), and then grouped into row bins. Algorithm ?? in Appendix ?? describes the creation of a tableplot into detail.

Tableplots are aimed to visualize multivariate datasets with several variables (up tot a dozen) and a large number of records, say at least one thousand. Tableplots can also be generated for datasets with less records, but they may be less useful. The maximum size of datasets that can be visualized with the **tabplot** package depends on the R's memory, or, when using the **ff** package, on the limitations of that package.

2 Getting started with the tableplot function

The diamonds dataset is very suitable to demonstrate the **tabplot** package. To illustrate the visualization of missing values, we add several NA's.

```
> require(ggplot2)
> data(diamonds)
> is.na(diamonds$price) <- diamonds$cut == "Ideal"
> is.na(diamonds$cut) <- (runif(nrow(diamonds)) > 0.8)
```

A tableplot is simply created by the function `tableplot`:

```
> tableplot(diamonds)
```

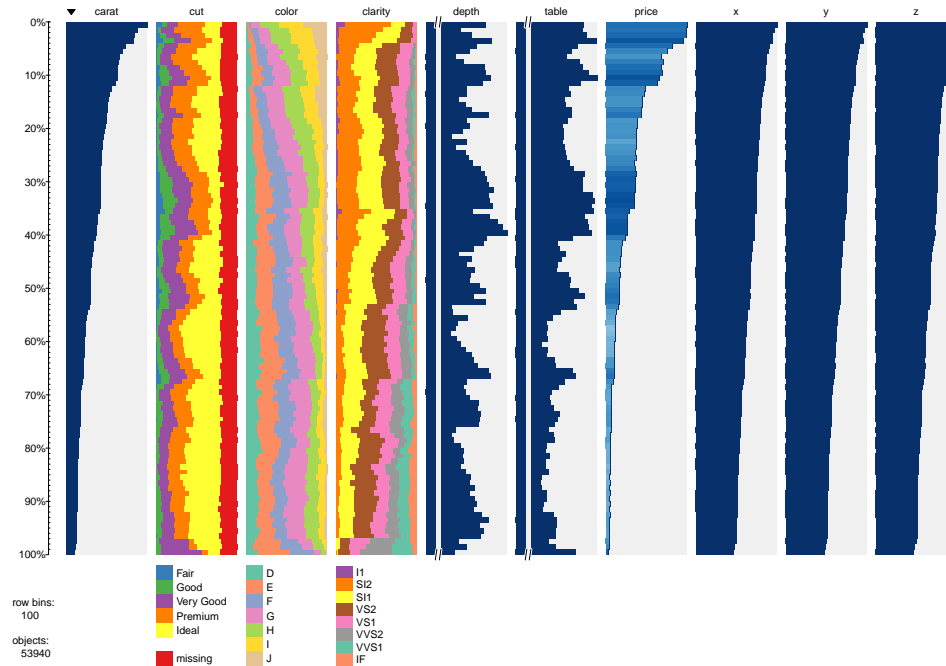


Figure 1: Tableplot of the diamonds dataset

The result is depicted in Figure 1. By default, all variables of the dataset are depicted. With the argument `colNames`, we can specify which variables are plotted. The dataset is by default sorted according to the values of the first variable. With the argument `sortCol`, we can specify on which variable(s) the data is sorted.

```
> tableplot(diamonds, colNames = c("carat", "price", "cut", "color",  
+ "clarity"), sortCol = "price")
```

The result is illustrated in Figure 2.

Setting an appropriate number of row bins (by the argument `nbins`) is important, like in a histogram. A good number of row bins is a trade of between good polished but meaningless data, and detailed, but noisy data. In practice, we found that the default number of 100 usually is a good starting point.

The percentages near the vertical axis indicate which subset of the data in terms of units (rows) is depicted. The range from 0% to 100% in Figure 2 means that all units of the data are plotted.

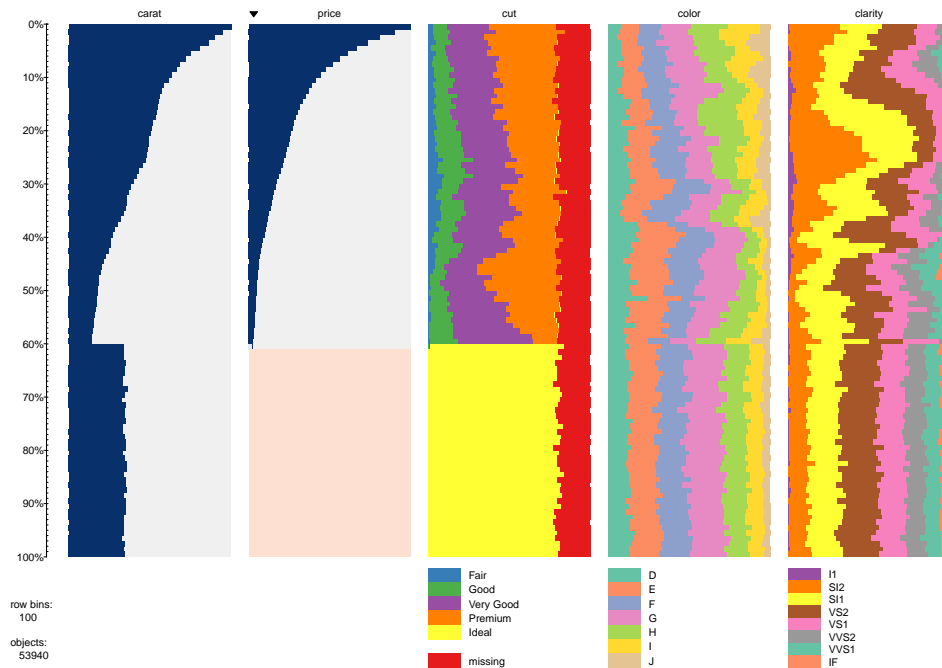


Figure 2: Tableplot of the diamonds dataset (2)

We can focus our attention to the 5% most expensive diamonds by setting the `from` argument to 0 and the `to` argument to 5:

```
> tableplot(diamonds, colNames = c("carat", "price", "cut", "color",
+   "clarity"), sortCol = "price", from = 0, to = 5)
```

Observe that in the obtained tableplot in Figure ??, the number of row bins is still 100, so that the number of units per row bin is now 27 instead of 540. Therefore, much more detail can be observed in this tableplot.

The vertical axis contains two sets of tick marks. The small tick marks correspond with the row bins and the large tick marks correspond with the percentages between `from` and `to`. The latter are determined by R's base function `pretty`.

3 Customizing the tableplot

3.1 Continuous variables

For each bin of a continuous variable, the mean value is calculated (see Algorithm ??). When the distribution of these mean values is exponential, it is useful to apply a logarithmic transformation (see ?). The argument `scales` can be set to linear mode `"lin"`, logarithmic mode `"log"`, or the

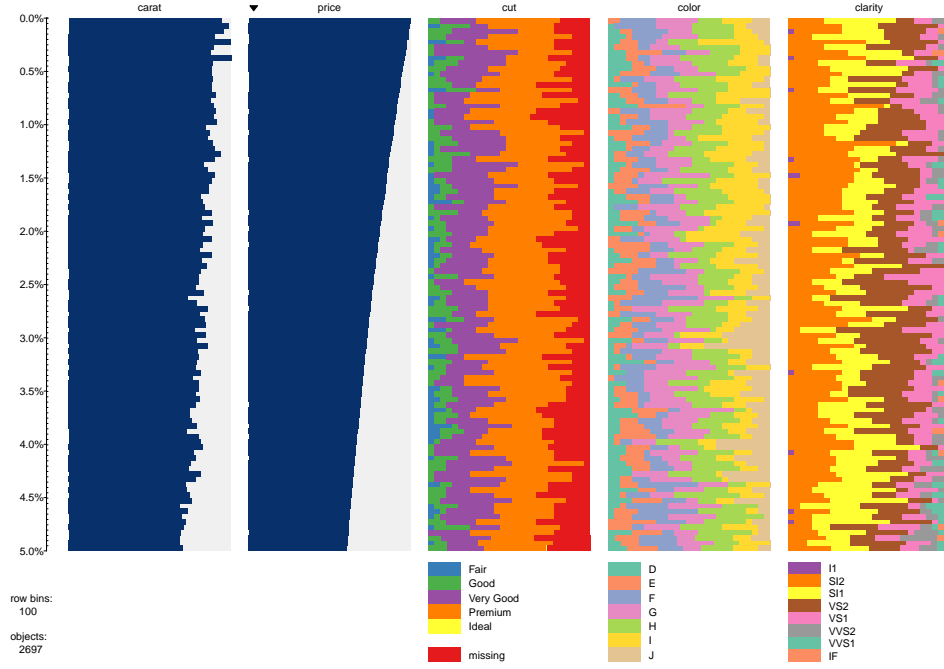


Figure 3: Tableplot of the diamonds dataset (3)

default value "auto", which automatically determines which of the former two modes is used.

Observe that the x-axes of the variables depth and table in Figure ?? are broken. The x-axis of a variable i is broken if either

$$0 < \max(m_{i1}, m_{i2}, \dots, m_{in}) \quad \text{AND} \\ \text{bias_brokenX} \cdot \max(m_{i1}, m_{i2}, \dots, m_{in}) < \min(m_{i1}, m_{i2}, \dots, m_{in})$$

OR

$$0 > \min(m_{i1}, m_{i2}, \dots, m_{in}) \quad \text{AND} \\ \text{bias_brokenX} \cdot \min(m_{i1}, m_{i2}, \dots, m_{in}) > \max(m_{i1}, m_{i2}, \dots, m_{in}),$$

where **bias_brokenX** is a bias parameter that should be a number between 0 and 1. If **bias_brokenX**=1 then the above conditions are always false, which implies that the x-axes are never broken. On the other hand, if **bias_brokenX**=0 then the x-axes are always broken. By default, **bias_brokenX**=0.8, which mean that an x-axis is broken if (in case of a variable with positive values) the minimum value is at least 0.8 times the maximum value. In the diamonds dataset, this applies to the variables depth and table.

3.2 Categorical variables

The color palettes of categorical variables can be customized with the argument `pals`. Several qualitative palettes from literature (e.g., `tableplot`) are implemented. They are stored in the list `tableplotPalettes` and can be shown by

```
> tableplot_showPalettes()
```

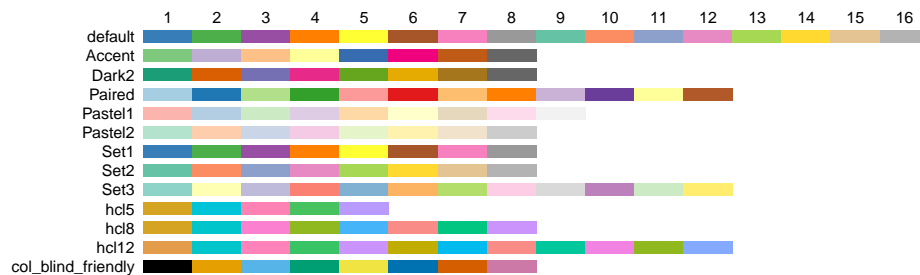


Figure 4: Color palettes

The default palette is a combination of Set1 and Set2. It has the advantage that each category has a unique color for variables with up to 16 categories.

Suppose we want to use the default palette for the variable `cut`, but starting with the seventh color, pink. Further we want the color blind friendly palette for the variable `color`, but without the first color (black), and a custom palette, say a rainbow palette, for the variable `clarity`:

```
> tableplot(diamonds, pals = list(7, "col_blind_friendly(2)", rainbow(8)))
```

3.3 The `tableplot` object

The function `tableplot` returns a `tableplot` object, that can be used to make minor changes to the tableplot, for instance the order of columns or the color palettes. Of course, these changes can also be made by generating a new tableplot, such as in the examples above. However, if it takes considerable time to generate a tableplot, then it is practical to make minor changes immediately.

The output of the `tableplot` function can be assigned to a variable. The graphical output can be omitted by setting the argument `plot` to `FALSE`.

```
> tab <- tableplot(diamonds, plot = FALSE)
```

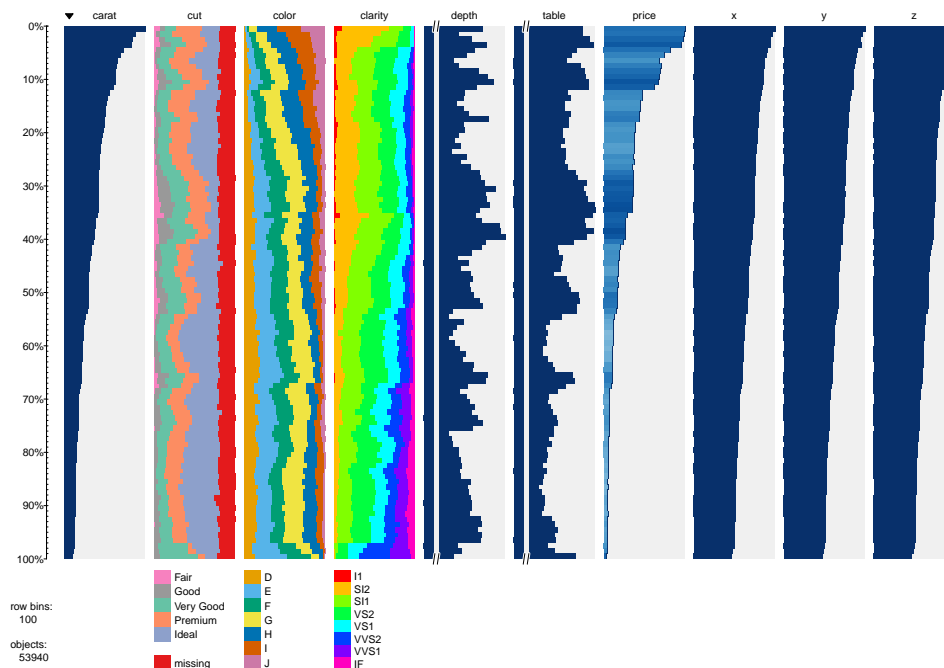


Figure 5: Tableplot of the diamonds dataset (4)

The `tabplot` object is a list that contains all information to depict a tableplot. The generic functions `summary` and `plot` can be applied to the `tabplot` object.

```
> summary(tab)
```

general		variable1		variable2	
variables:	10	name	:carat	name	:cut
objects	:53940	type	:numeric	type	:categorical
bins	:100	sort	:decreasing	sort	:NA
from	:0%	scale_init	:auto	categories:	6
to	:100%	scale_final:	lin		

variable3		variable4		variable5	
name	:color	name	:clarity	name	:depth
type	:categorical	type	:categorical	type	:numeric
sort	:NA	sort	:NA	sort	:NA
categories:	7	categories:	8	scale_init	:auto
				scale_final:	lin

variable6		variable7		variable8	
name	:table	name	:price	name	:x
type	:numeric	type	:numeric	type	:numeric
sort	:NA	sort	:NA	sort	:NA
scale_init	:auto	scale_init	:auto	scale_init	:auto
scale_final:	lin	scale_final:	lin	scale_final:	lin

variable9		variable10	
name	:y	name	:z
type	:numeric	type	:numeric
sort	:NA	sort	:NA
scale_init	:auto	scale_init	:auto
scale_final	:lin	scale_final	:lin

```
> plot(tab)
```

The function `changeTabplot` is used to make minor changes to a `tabplot` object. Suppose we want the columns in the order of `??`, and we want to change all color palettes to default starting with the first color.

```
> tab2 <- changeTabplot(tab, colNames = c("carat", "price", "cut",
+     "color", "clarity"), pals = list(1))
> plot(tab2)
```

4 Graphical User Interface tableGUI

The function `tableGUI` starts a Graphical User Interface (GUI).

```
> tableGUI()
```

5 Final remarks

Conclusions

A Tableplot creation algorithm

A tabplot is basically created by Algorithm ??.

Algorithm 1 Create tableplot

Input: Tabular dataset t , column i_s of which the distribution is of interest.^a

```
1:  $t' \leftarrow$  sort  $t$  according to the values of column  $i_s$ .
2: Divide  $t'$  into  $n$  row bins according to the order of  $t'$ .
3: for each column  $i$  do
4:   if  $i$  is numeric then
5:      $m_{ib} \leftarrow$  mean value per bin  $b$ 
6:      $c_{ib} \leftarrow$  fraction of missing values per bin  $b$ 
7:   end if
8:   if  $i$  is categorical then
9:      $f_{ijb} \leftarrow$  frequency of each category  $j$  (including missing values)
       per bin  $b$ 
10:  end if
11: end for
12: for each column  $i$  do
13:   if  $i$  is numeric then
14:     Plot a bar chart of the mean values  $\{m_{i1}, m_{i2}, \dots, m_{in}\}$ , option-
       ally with a logarithmic scale. The fraction of missing values  $\{c_{i1},$ 
        $c_{i2}, \dots, c_{in}\}$  determines the lightness of the bar colour. The light-
       er the colour, the more missing values occur in bin  $b$ . If all values
       are missing, a light red bar of full length is drawn.
15:   end if
16:   if  $i$  is categorical then
17:     Plot a stacked bar chart according to the frequencies  $\{f_{i1b}, f_{i2b},$ 
        $\dots\}$  for each bin  $b$ . Each category is shown as a distinct colour.
       If there are missing values, they are depicted by a red colour.
18:   end if
19: end for
```

^aThe dataset t can also be sorted according to multiple columns.

B Second appendix