cranvas: Interactive Statistical Graphics in R via Qt

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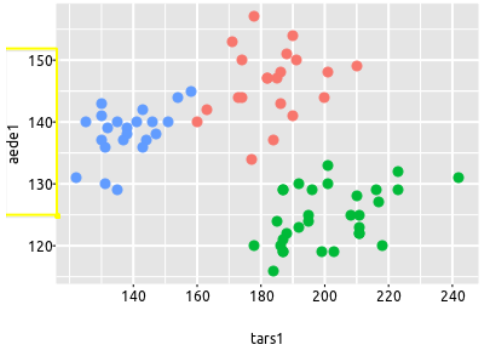
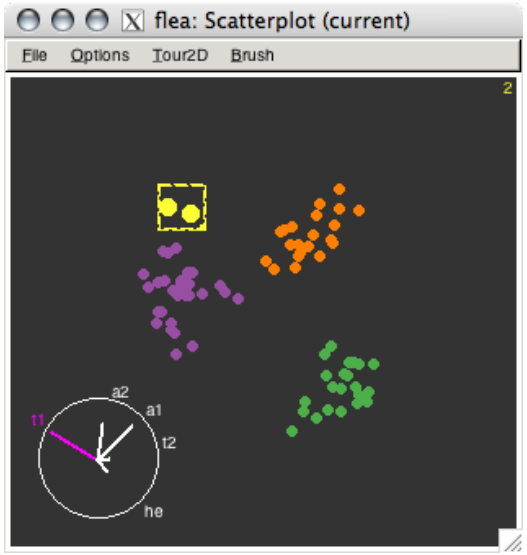


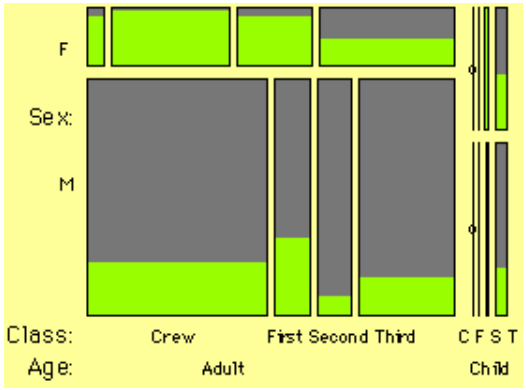
Appetizer

- the name (CRAN + canvas $\Rightarrow$ cranvas)
- demo
  - old problems (with new look) in cranvas
  - NRC rankings of statistics departments

Looking back

- standalone software packages: GGobi [Swayne et al., 2003], MANET [Unwin et al., 1996] and Mondrian [Theus, 2002], etc





- R itself has poor support for interactivity (ancient *locate()*? *getGraphicsEvent()*? no kidding! there is a **fun** package [Xie et al., 2011], and also **sudoku**)

- R packages: **iplots** [Urbanek and Wichtrey, 2011], **rggobi**, **playwith**, **rgl** (as I showed just now)...

Overview of cranvas

- next generation of GGobi (and more)
  - interactive statistical graphics in R
  - focus on speed, flexibility and elegance
- infrastructures (details later):
  - painting (drawing): **qtbase** & **qtpaint** (connect R with Qt)
  - data structure: **plumbr** & **objectSignals** (mutaframes, reference classes, signals)

  - aesthetics: **scales** (and other **ggplot2**'s offspring)

- all available at `http://github.com/ggobi` (to be released on Bioconductor & CRAN)
  - refer to the wiki for installation under Linux & Mac
  - Windows version not available at the moment

- usage
  - create a data object: `mf <- qdata(df)`
  - make a series of plots based on it: `qhist(x1, data = mf)`; `qscatter(x2, x3, data = mf)`

- cranvas is still under active development

- milestone 1.0: get basic plots working (almost done)
- milestone 2.0 scheduled in November (after R 2.14.0): new types of plots, speed, documentation

Data structure: augmented data

```
> library(cranvas)
> data(flea, package = "tourr")
> head(flea)  # first 6 rows of flea
```

	tars1	tars2	head	aede1	aede2	aede3	species
1	191	131	53	150	15	104	Concinna
2	185	134	50	147	13	105	Concinna
3	200	137	52	144	14	102	Concinna
4	173	127	50	144	16	97	Concinna

```
5    171    118    49    153     13    106 Concinna
6    160    118    47    140     15     99 Concinna
```

```
> str(flea)
```

```
'data.frame':        74 obs. of  7 variables:
 $ tars1  : int  191 185 200 173 171 160 188 186 174 163
 $ tars2  : int  131 134 137 127 118 118 134 129 131 115
 $ head   : int  53 50 52 50 49 47 54 51 52 47 ...
 $ aede1  : int  150 147 144 144 153 140 151 143 144 142
 $ aede2  : int  15 13 14 16 13 15 14 14 14 15 ...
 $ aede3  : int  104 105 102 97 106 99 98 110 116 95 ...
 $ species: Factor w/ 3 levels "Concinna ","Heikert. ",..
```

```
> qflea <- qdata(flea, color = species)
> head(qflea)  # what is the difference?

  tars1 tars2 head aede1 aede2 aede3   species .brushed
1   191   131   53   150    15   104 Concinna    FALSE
2   185   134   50   147    13   105 Concinna    FALSE
3   200   137   52   144    14   102 Concinna    FALSE
4   173   127   50   144    16    97 Concinna    FALSE
5   171   118   49   153    13   106 Concinna    FALSE
6   160   118   47   140    15    99 Concinna    FALSE
  .visible  .color .border .size
1     TRUE #F8766D #F8766D     4
2     TRUE #F8766D #F8766D     4
```

```
3      TRUE #F8766D #F8766D      4
4      TRUE #F8766D #F8766D      4
5      TRUE #F8766D #F8766D      4
6      TRUE #F8766D #F8766D      4
```

- the augmented data contains information about each observation (row)
  - `.brushed`: logical vector – whether a row is brushed or not
  - `.visible`: similar – visible or not?
  - `.color`, `.border`, `.size` – aesthetics of graphical elements

Data structure: mutaframe

- what we created by *qdata()* was a mutaframe (using **plumbr**)
- a mutaframe is like a data frame, but is mutable (technically, it is an environment)

```
> str(qflea, max.level = 1)

Classes 'mutaframe', 'environment' <environment: 0x589cb2
 - attr(*, "col.names")= chr [1:12] "tars1" "tars2" "head
 - attr(*, "row.names")= chr [1:74] "1" "2" "3" "4" ...
```

```
 - attr(*, "changed")=Formal class 'Signal' [package "obj
 - attr(*, "Brush")=Formal class 'BRUSH' [package "cranva
 - attr(*, "Link")=Classes 'mutalist', 'environment' <env
  ..- attr(*, "envNames")= chr "linkid"
  ..- attr(*, "userNames")= chr "linkid"
 - attr(*, "Scales")=Formal class 'Scales_meta' [package
 - attr(*, "Generator")= chr "d38bbe46dae5fa45758f3609f5d
```

- modification to a mutaframe is always "global", which enables us to pass and modify a mutaframe anywhere in functions
  - application to tour (projections always changing, and the plot needs to know this)

```
> a <- 10  # ordinary R object
> b <- a
> b <- 5
> a  # certainly a is not modified

[1] 10

> ## but mutaframes are different
> x <- qflea  # assign qflea to x
> qflea$tars1[1]  # first element of tars1

[1] 191

> x$tars1[1]  # same element in x
```

```
[1] 191

> x$tars1[1] <- 300  # modify it
> x$tars1[1]

[1] 300

> qflea$tars1[1]  # original copy also modified!

[1] 300
```

Data structure: listeners

- how does interaction work?
  - interaction does not modify the plot directly
  - instead, it modifies data and triggers listeners on data, which do the job of updating the plot
  - it makes developers' life a lot easier
- what is a listener?
  - it is a function attached to a mutaframe

  - (roughly speaking) whenever the mutaframe is modified, the function is executed

- which part of the mutaframe is modified?
  - we should not abuse the listeners, hence comes the concept of the "data pipeline"
  - `.brushed` changed? update the brush layer!
  - `.visible` changed? update the main plot layer!
  - original data changed? go back to the beginning and re-calculate everything, then update all the layers!

- each time we create a plot, a listener is attached to the mutaframe

– so the `.brushed` column can update several plots at the same time

Data structure: a summary

- a data object is sitting behind the scene
- interactions change the data
- listeners on the data update the plot(s)

Interaction: brushing or selection

- mouse interactions
  - left click and move the brush; right click to resize the brush; middle button to toggle between brush and selection
  - brush mode and identify mode (use ? to toggle)
- selection mode
  - `AND`, `OR`, `XOR`, `NOT`, `COMPLEMENT` (use the initial letters)
- related keyboard interactions

– `Delete` makes elements invisible; `F5`: all visible

Interaction: linking

- one-to-one linking
  - brush one observation in this plot, highlight the same observation in other plots
- categorical linking
  - ..., all observations in the same category are brushed too
- kNN linking

– ..., k nearest neighbors are brushed

Interaction: misc

- + and - changes the alpha transparency
- `PageDown` and `PageUp` navigates through brush history
- ...

Examples: plots in cranvas now, and what's new

- histogram (and spine plot): change binwidth with $\uparrow$ and $\downarrow$; shift bins with $\leftarrow$ and $\rightarrow$
- density plot: similar to histogram
- bar plot: application to missing value plot
- scatter plot: change size of points with $\uparrow$ and $\downarrow$

- boxplot: also show small boxplots for brushed observations inside original boxplots (not actually new)
- mosaic plot: dynamically change variables in the plot and layout
- parallel coordinates plot: rearrange order of variables (not new); show data ranges
- map: also cartograms
- time series plot: many, many new features (as a result of GSoC project)

Examples: flea and states demographics

- flea beetles
  - tour
  - categorical linking by species
- US states demographics
  - selection mode
  - kNN linking

Limitations

- suffers from Qt flaws and bugs
  - can be slow (mainly in scatter plots) due to changes in BSP tree algorithm and cache failure; I was told it WAS extremely fast
  - mysterious clipping (aggressive: points clipped into halves; imprecise: no clipping even when points reach beyond boundary)
- Qt is big (in size) and installation of **qtbase** / **qtpaint** under Windows may be difficult

Future plans

- automatic and *interactive* legend
- conditioning (faceting) like Trellis
- more types of plots (e.g. hexagons)
- a lot to learn from **ggplot2** and **iplots** (**ix**?)

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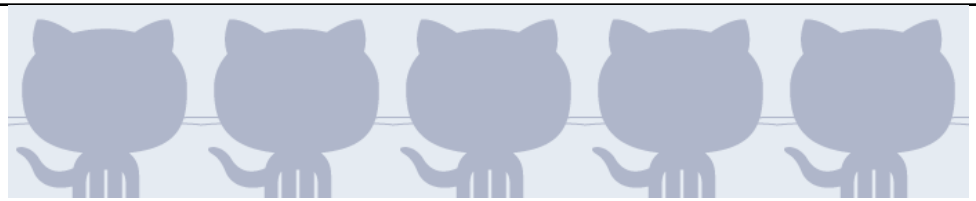
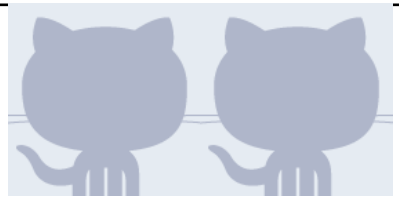
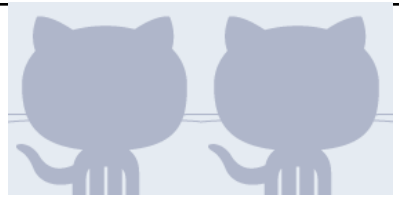
Looking at the acknowledgement list

cranvas developers	iplots developer
	
	
	

Questions & Comments?

- Testing and bug reports (`https://github.com/ggobi/cranvas/issues`) are welcome
- Thanks!

References

[Swayne et al., 2003] Swayne, D. F., Temple Lang, D., Buja, A.,

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