Some Slider Functions

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Contents

1 Slider functions for exploratory data analysis **3**

2 Slider functions – overview and examples **4**
2.1 The functions of the paper 4
2.2 `slider.hist` 5
2.3 `slider.density` 6
2.4 `slider.brush.pairs` 7
2.5 `slider.brush.plot.xy` 8
2.6 `slider.split.plot.ts` 9
2.7 `slider.zoom.plot.ts` 10
2.8 `slider.smooth.plot.ts` 11
2.9 `slider.lowess.plot` 12
2.10 `slider.bootstrap.lm.plot` 13

3 General issues of the implementation **14**
3.1 The structure of slider functions 14
3.1.1 A very simple example 14
3.1.2 The main arguments of `slider` 15
3.1.3 Buttons and slider variables 16
3.2 General Rules 18
3.2.1 Names of the slider functions 18
3.2.2 Formal arguments for data sets 18
3.2.3 Passing additional arguments 20
3.3 Density Presenter 22

4 Histograms and Density Traces **24**
4.1 Class number of histograms – `slider.hist` 24
4.1.1 Test 25

4.2 Width and kernel of a density trace – `slider.density` 25
4.2.1 Test 26
4.2.2 Help Page 26

5 Brushing Functions **28**
5.1 A draftsman's display with Brushing – `slider.brush.pairs` . . 28
5.1.1 Test 29
5.2 Scatter plot brushing – `slider.brush.plot.xy` 29
5.2.1 Test 30
5.2.2 Help Page 30

6 Time Series Plots **31**
6.1 Splitted time series – `slider.split.plot.ts` 31
6.1.1 Test 33
6.1.2 Help Page 33
6.2 Zooming in Time Series – `slider.zoom.plot.ts` 34
6.2.1 Test 35
6.2.2 Help Page 35
6.3 Smoothing Time Series – `slider.smooth.plot.ts` 36
6.3.1 Test 37
6.3.2 Help Page 37

7 Regression **38**
7.1 Smoothing by lowess – `slider.lowess.plot` 38
7.1.1 Test 38
7.1.2 Help Page 38
7.2 Sensitivity of Regression Line – `slider.bootstrap.lm.plot` . . 39
7.2.1 Test 40
7.2.2 Help Page 40

8 Appendix **41**
8.1 Definition of `slider` 41

1 Slider functions for exploratory data analysis

In this paper we discuss a set of slider functions for constructing dynamical statistical plots. Some of the characteristics of these plots are controlled by sliders and you can modify the plots by the sliders. The sliders will be generated within Tcl/Tk widgets. Moving a slider results in changing the associated parameter and the graphics output is updated. For example, `slider.density()` plots a density trace and opens a Tcl/Tk widget with one slider that is linked to the `width` parameter of `density()`. After shifting the slider and releasing the mouse button the density trace is plotted again taking into account the new window width.

The next section contains a list of functions presented in this paper. Then you get some examples so you can see the function in action. Some special tricks are used to customize the behaviour of the slider functions. These programming pearls are discussed in section three. In the remaining sections you find the definitions of the slider function. We hope that the functions are useful for you in the way they are defined. However, you are invited to take a closer look at the code. Sometimes it will be very easy to enhance the proposals and you quickly get new slider functions.

2 Slider functions – overview and examples

2.1 The functions of the paper

The following list shows the functions available in this package:

1 ⟨*linux command to find the slider functions* 1⟩ ≡

```
fns<-readLines("sliderfns.rev")
fns<-fns[grep("^slider.*function",fns)]
sort(unique(sub("<-.*$","",fns)))
```

```
Wed Mar 25 10:12:18 2009
 [1] "slider"                      "slider.bootstrap.lm.plot"
 [3] "slider.brush.pairs"          "slider.brush.plot.xy"
 [5] "slider.density"              "slider.hist"
 [7] "slider.lowess.plot"          "slider.present.density"
 [9] "slider.show.density"         "slider.show.norm"
[11] "slider.show.normal.density" "slider.smooth.plot.ts"
[13] "slider.split.plot.ts"        "slider.trimmed.mean"
[15] "slider.trimmed.mean.plus"    "slider.trimmed.mean.simple"
[17] "slider.xyz"                  "slider.zoom.plot.ts"
```

The next subsections contain a sequence of screen shots showing the some of the slider functions in action.

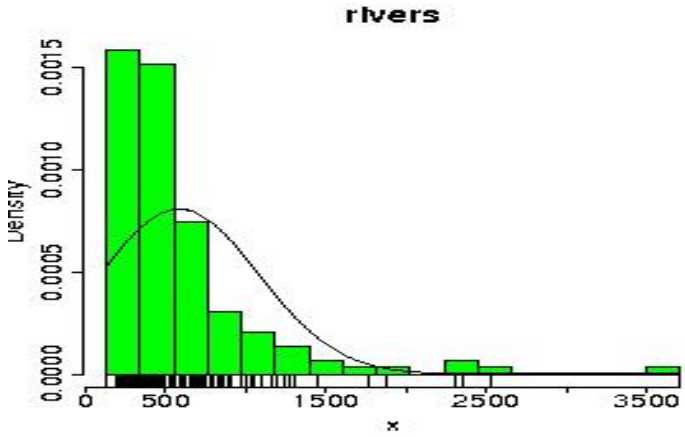
2.2 slider.hist

`slider.hist` computes histograms. The number of classes is controlled by a slider. As a special feature `slider.hist` has a `panel` argument. This argument allows you to deliver a panel function which draws some additional plotting elements. In the following example `panel` is used to add a normal density curve as well as a *rug*.

2 ⟨*show* `slider.hist` 2⟩ ≡
```
⟨define slider.hist 31⟩
slider.hist(rivers,xlab="x",col="green",probability=TRUE,
  panel=function(x){
    xx<-seq(min(x),max(x),length=100)
    yy<-dnorm(xx,mean(x),sd(x))
    lines(xx,yy); rug(x); print(summary(yy))
  }
)
```

After moving the slider to position 17 the control widget looks like this:

After releasing the mouse button the graphics device shows the following plot:



You see that the fit of the normal distribution is not very good. Perhaps an exponential distribution is a quite better model. Can you build a new call of `slider.hist` with a suitable exponential density curve? Hint: You have to exchange the line of code that computes the normal density values:
remove `yy<-dnorm(xx,mean(x),sd(x))`
write `yy<-dexp(xx,1/mean(x))`.

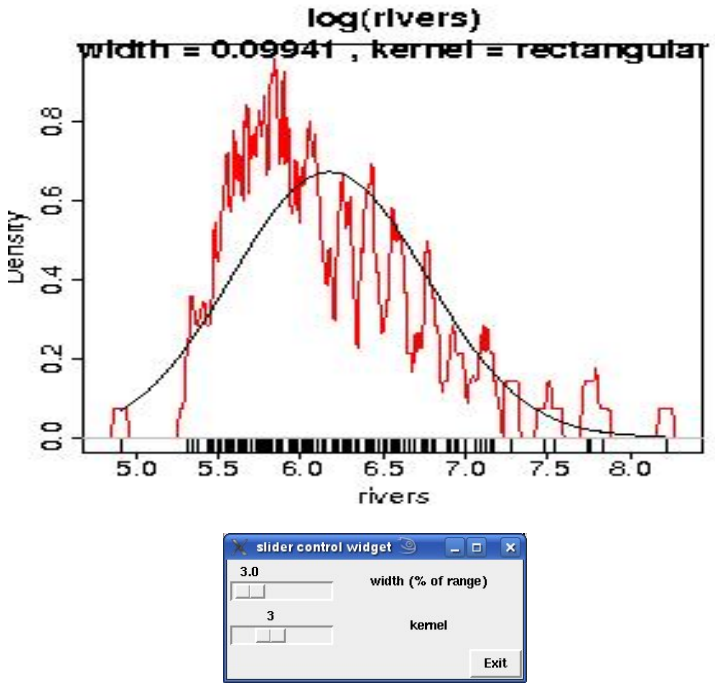
2.3 `slider.density`

`slider.density` computes density traces. The parameter `width` and the type of the kernel function are controlled by sliders. Like `slider.hist` the function `slider.density` has a panel argument to add further graphical elements. In the example `slider.density` a normal density curve and a rug are added by the `panel` function.

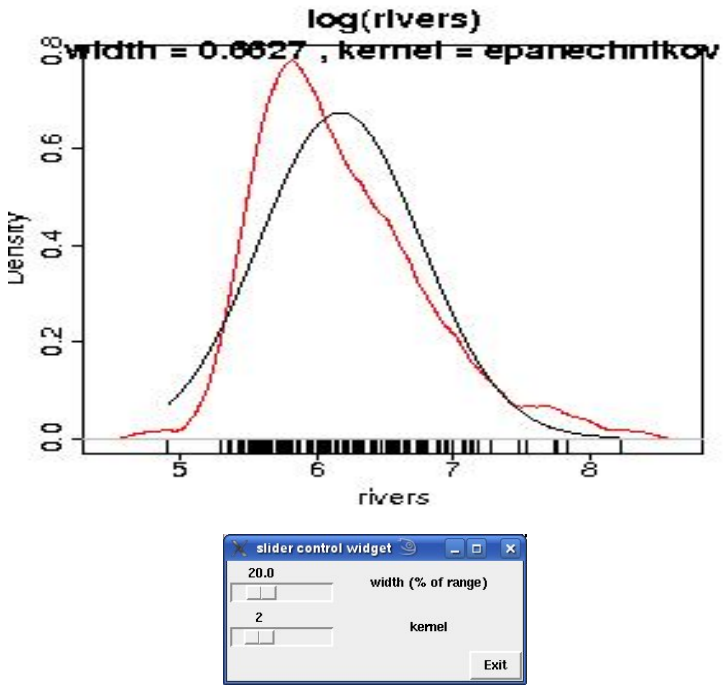
3 ⟨*show* `slider.density` 3⟩ ≡

```
⟨define slider.density 34⟩
slider.density(log(rivers),xlab="rivers",col="red",
  panel=function(x){
    xx<-seq(min(x),max(x),length=100)
    yy<-dnorm(xx,mean(x),sd(x))
    lines(xx,yy); rug(x); print(summary(yy))
  }
)
```

If you want to select a width of 3 percent of the range of the data and a rectangular kernel the slider control widget must have the following apearance. With these settings the graph will be very shaky.



The parameter settings `"width=20"`, `"kernel=epanechnikov"` result in a much smoother plot.

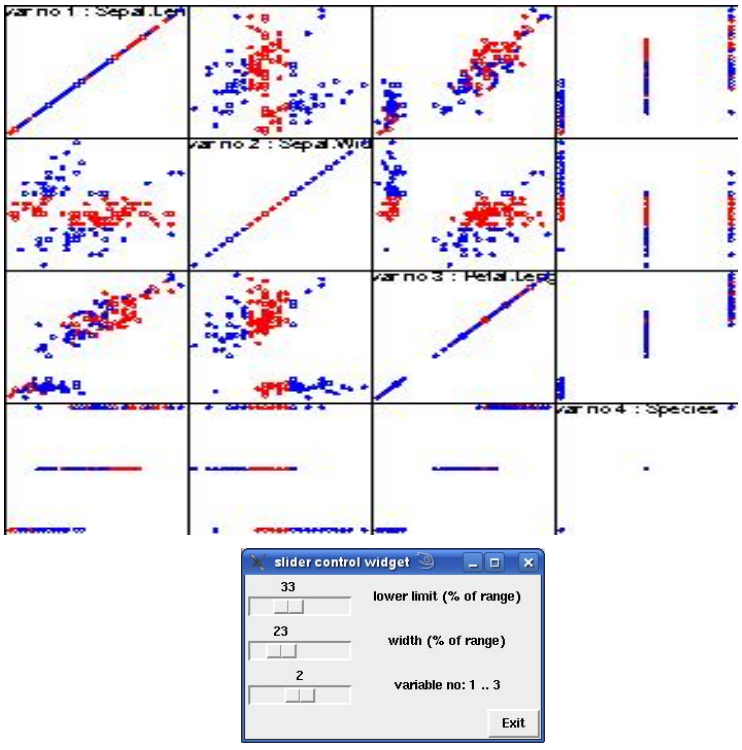


2.4 `slider.brush.pairs`

`pairs()` constructs a draftsman's display – a set of two dimensional scatterplots. This function is really useful for data sets with 3 to 10 variables because dependencies between a pair of variables can be seen at once.

However, sometimes it is very interesting to explore two dimensional dependencies of a subset of the data points that are defined by a third variable. This idea leads to the function `slider.brush.pairs` which computes a pairs plot and allows you to define an interval for the values of one variable. After changing the settings all data points of the visible interval are recolored using the color "red".

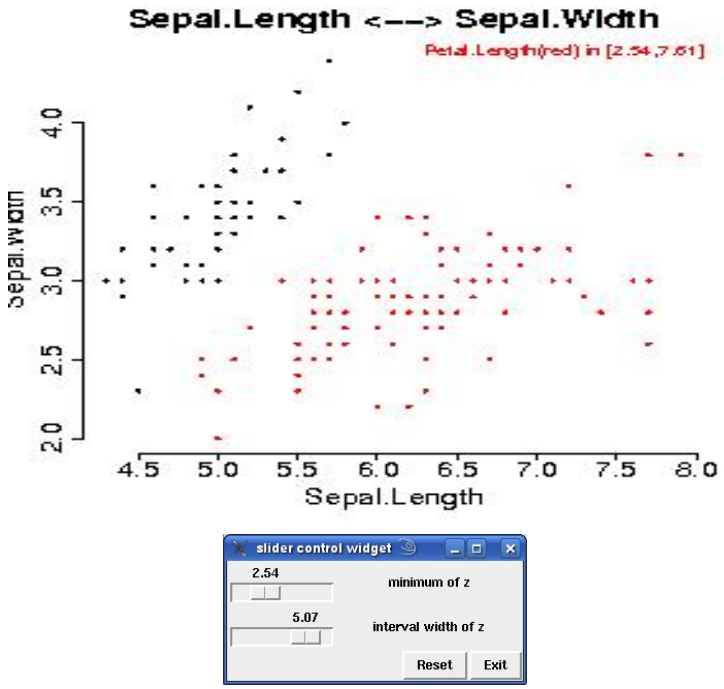
4 ⟨*show* `slider.brush.pairs` 4⟩ ≡
⟨*define* `slider.brush.pairs` 38⟩
```
slider.brush.pairs(iris[,-4])
```



2.5 `slider.brush.plot.xy`

The function `slider.brush.plot.xy` is a small version of `slider.brush.pairs()`. It is suitable for three dimensional data sets. `slider.brush.plot.xy()` computes a two dimensional scatterplot and chooses the color of the points conditional to a third variable. Therefore, you can start the exploration with `slider.brush.pairs()` and if you want to concentrate on one of the scatterplots — e. g. for the purpose of presentation — you can call `slider.brush.plot.xy()`.

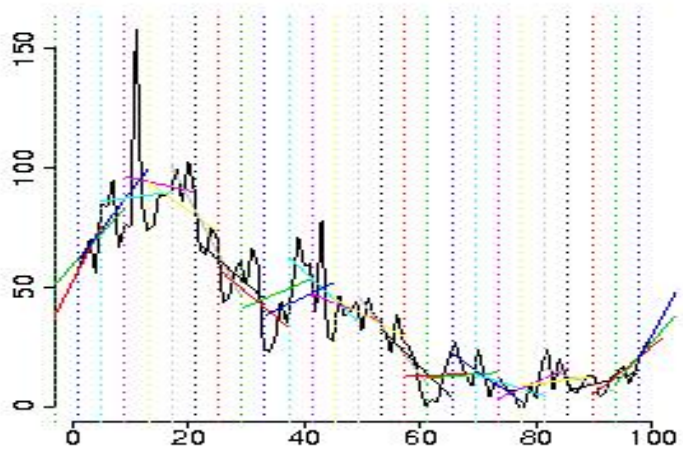
5 ⟨*show of* `slider.brush.plot.xy` 5⟩ ≡
⟨*define* `slider.brush.plot.xy` 40⟩
```
slider.brush.plot.xy(iris[,1:3])
```

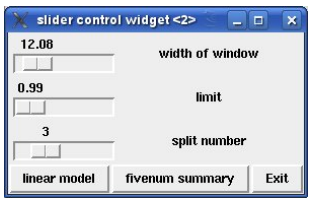


2.6 `slider.split.plot.ts`

Time series often have different structures in the distinct intervals. Then it may be interesting to inspect various subsets of the data. For comparing different intervals (in time) you can split the whole time series into pieces and fit linear regression models to the various regions. The function `slider.split.plot.ts` has been designed for doing this job. By sliders you are able to define a point on the time axis as well as the length of a time interval (strip). Then a time series plot of your data is computed and it is partitioned into stripes in a way that one limit between two strip is identical with the selected point. Furthermore, regression lines of fitted linear models are drawn within each of the intervals. Alternatively `slider.split.plot.ts` allows you to draw the main characteristics of the subsets of points. A mouse click on the button `fivenum summary` of the control widget will add graphical five number summaries of the data values of each region.

6 ⟨*show* `slider.split.plot.ts` 6⟩ ≡
⟨*define* `slider.split.plot.ts` 43⟩
```
slider.split.plot.ts(as.vector(sunspots)[1:100])
```

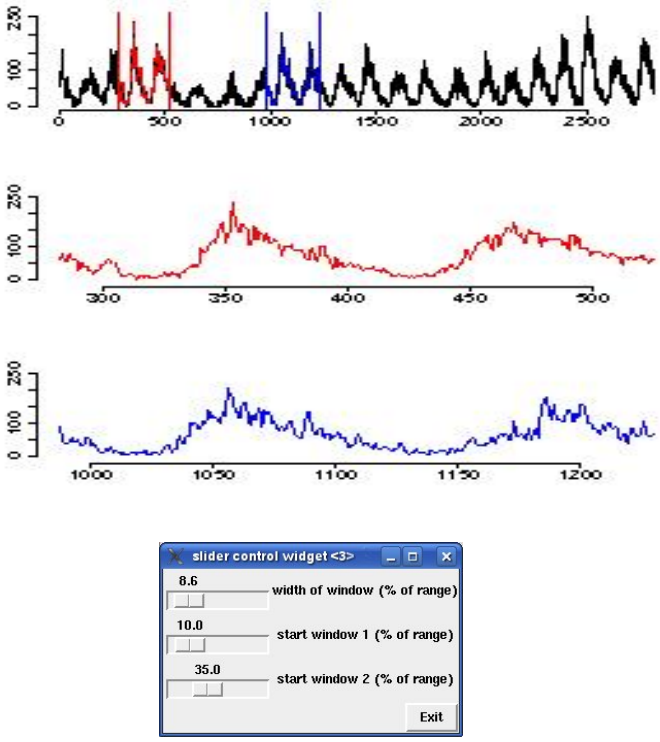




2.7 `slider.zoom.plot.ts`

Some time series are often very long. For inspection such a series you want to be able to view the data of selected intervals. `slider.zoom.plot.ts` enables you to choose two windows of the whole range of the data and the function computes two time series plots of the two sections. With this function it is easy to compare the structures of two different regions of a time series.

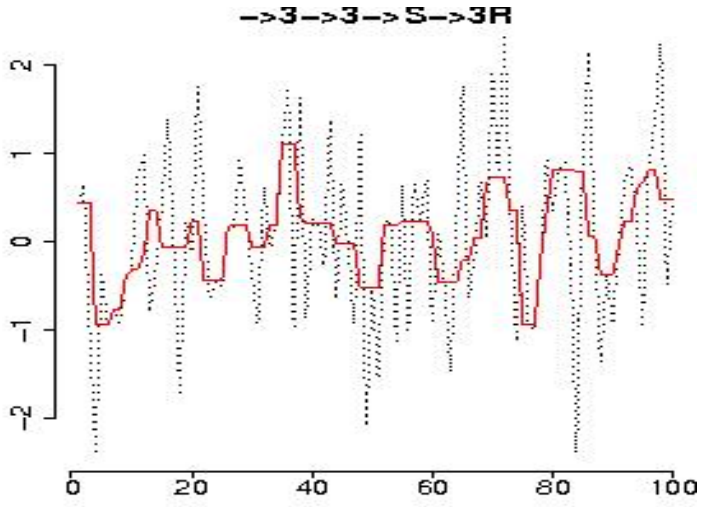
7 ⟨*show* `slider.zoom.plot.ts` 7⟩ ≡
⟨*define* `slider.zoom.plot.ts` 46⟩
```
slider.zoom.plot.ts(as.vector(sunspots),2)
```



2.8 `slider.smooth.plot.ts`

The function `slider.smooth.plot.ts` allows you to smooth a time series by running medians or some other operations which has been proposed by Tukey. The implementation is based on `smooth()` and the operation is applied by clicking one of the buttons of the control widget.

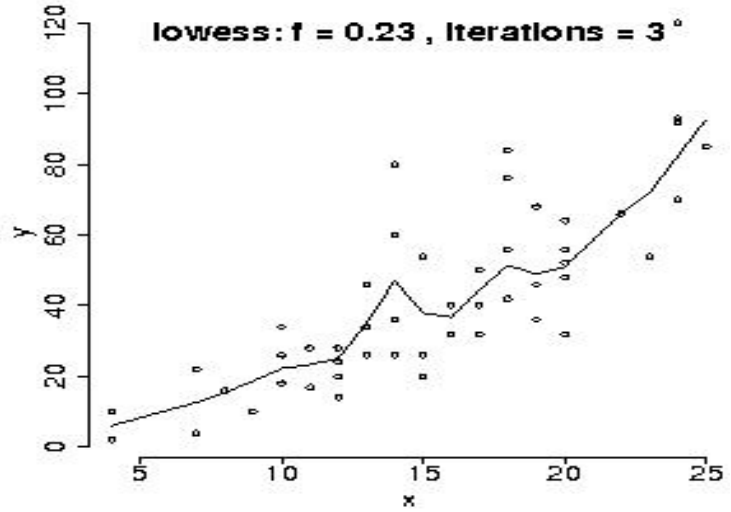
8 ⟨*show* `slider.smooth.plot.ts` 8⟩ ≡
⟨*define* `slider.smooth.plot.ts` 50⟩
```
slider.smooth.plot.ts(rnorm(100))
```

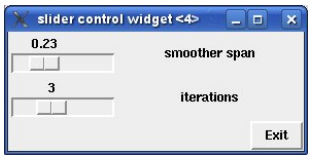


2.9 `slider.lowess.plot`

`lowess()` is an R function for analyzing the trend of points in a scatterplot. The smoothness of the computed line depends on a span parameter. Because of the algorithm is time consuming `lowess` has a parameter to fix the number of iterations to be done. The function `slider.lowess.plot()` computes a scatterplot of a data set and lets you select these two parameters by an control widget.

9 ⟨*show* `slider.lowess.plot` 9⟩ ≡
⟨*define* `slider.lowess.plot` 53⟩
```
slider.lowess.plot(cars)
```

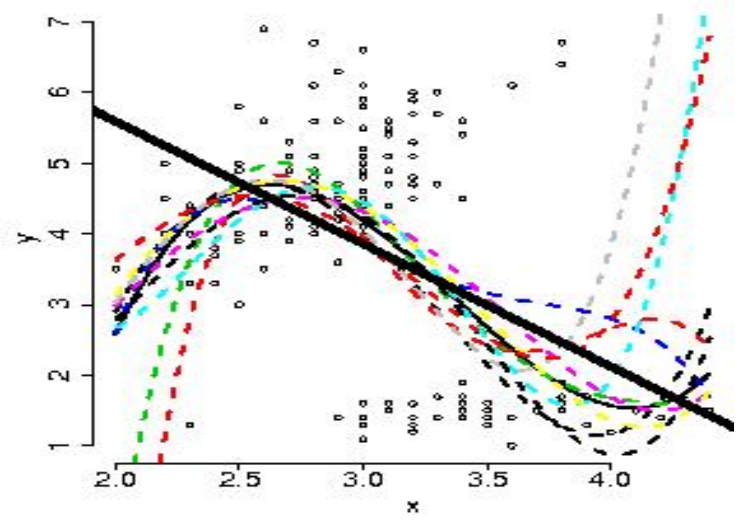


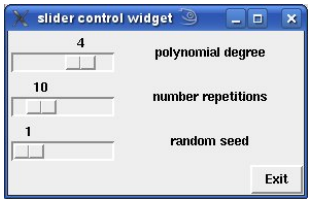


2.10 `slider.bootstrap.lm.plot`

Sometimes you have fitted a model curve on the base of a data set and you wonder how sensitive the result is against changes of the data. The function `slider.bootstrap.lm.plot()` draws a scatterplot containing the curve of a fitted model as well as some curves that have been computed on samples of the original data points. The user is allowed to select the degree of the polynom to be fitted, the number of bootstrap samples and the random seed.

10 ⟨*show* `slider.bootstrap.lm.plot` 10⟩ ≡
⟨*define* `slider.bootstrap.lm.plot` 56⟩
```
daten<-iris[,2:3]
slider.bootstrap.lm.plot(daten)
```





3 General issues of the implementation

3.1 The structure of slider functions

The last section discusses some slider functions and the reader has got examples of their application. Now we will explore the structure of the slider functions. All of them call the function `slider` to create and to control Tcl/TK widgets. The widgets consist of sliders and buttons that are linked to R functions describing the actions to be performed.

To demonstrate the usage of `slider` within the slider functions we discuss some examples now. As a very simple one let us build a slider function that prints the trimmed mean of a data set depending on the trim fraction which is controlled by a slider.

3.1.1 A very simple example

In this paragraph we define the function `slider.trimmed.mean.simple`. It shows the usage of the function `slider()` for doing the jobs

- create a control widget with one slider
- define the effect or the action to be done in case of a slider movement
- link the slider with the action.

Before going into details activate the following code chunk, please. It will define the function `"slider.trimmed.mean.simple"` and it will call the new function with the data set `"rivers[1:50]"`:

11 ⟨*define* `slider.trimmed.mean` 11⟩ ≡

```
slider.trimmed.mean.simple<-function(x)
{
  # general initialisations
  if(missing(x)) return("Error: no data found!")
  # function to update result
  compute.trimmed.mean<-function(...){
    # get slider
    alpha <- slider(no=1)
    # print result
    cat(paste("trim fraction",alpha,":",mean(x,trim=alpha),"\n"))
  }
  # definition of slider widget
  slider(compute.trimmed.mean,"trim fraction",0,0.5,0.01,0)
  # initial computation
  compute.trimmed.mean()
}
slider.trimmed.mean.simple(rivers[1:50])
```

Move the slider named `"trim fraction"` and observe what happens! Now let's take a look at the definition of `slider.trimmed.mean.simple`. The function consists of four instructions:

- The first statement is an input check – business as usual.

- The second one defines the effect of a movement of the slider in form of an *action function* although the slider hasn't been defined yet.
- Then the function `slider` is called to build the control widget and the action function is passed by the first parameter.
- At last the action function is called and a trimmed mean will be printed.

You see `slider.trimmed.mean.simple()` mainly consists of the definition of the action function `compute.trimmed.mean()` and a call of `slider()`.

`compute.trimmed.mean()` fulfills two tasks: fetching the actual value of the slider variable (trim fraction `alpha`) and printing the trimmed mean. `slider(no=1)` reads the value of slider number `"no=1"` and then the value is assigned to the local variable `alpha`. The computation of the trimmed mean by `mean()` and its printing follows.

3.1.2 The main arguments of `slider`

A slider of a slider control widget is declared by six parameters. The meaning of them is found in following list.

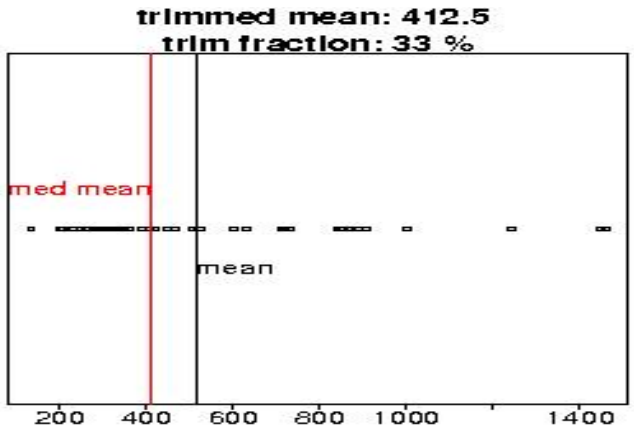
1. `sl.functions`: an effect function which is called after moving the slider
2. `sl.names`: a text for labeling the slider
3. `sl.mins`: the minimum of the range of the slider
4. `sl.maxs`: the maximum of the range of the slider
5. `sl.deltas`: the increment of the scale of the slider
6. `sl.defaults`: the default value of the slider

These parameters are arguments of the function `slider`. The following example has the same structure as `slider.trimmed.mean.simple()`. However, the action function computes a plot and in the call of `slider()` the names of the formal parameters are used.

12 ⟨*define* `slider.trimmed.mean` 11⟩+ ≡

```
slider.trimmed.mean<-function(x)
{
  # general initialisations
  if(missing(x)) return("Error: no data found!")
  # function to update plot
  refresh<-function(...){
    # get slider
    alpha <- slider(no=1)
    # compute mean
    tm <- mean(x,trim=alpha); m <- mean(x)
    # construct plot
    plot(as.data.frame(x))
    abline(v=tm,col="red")
    text(tm,1.1,adj=1,"trimmed mean",col="red")
    abline(v=m,col="black")
    text( m,0.9,adj=0,"mean")
    title(paste("trimmed mean:", format(tm,signif=4),
```

```
                "\ntrim fraction:",round(alpha*100),"%"))
  }
  # definition of slider widget
  slider(sl.functions=refresh,
         sl.names=    "trim fraction",
         sl.mins=     0,
         sl.maxs=     0.5,
         sl.deltas=   0.01,
         sl.defaults= 0
  )
  # initial plot
  refresh()
}
slider.trimmed.mean(rivers[1:50])
```



It may be astonishing that the argument names are in plural form. This indicates that more than one slider can be defined in the same way. The following section will show you an example with two sliders.

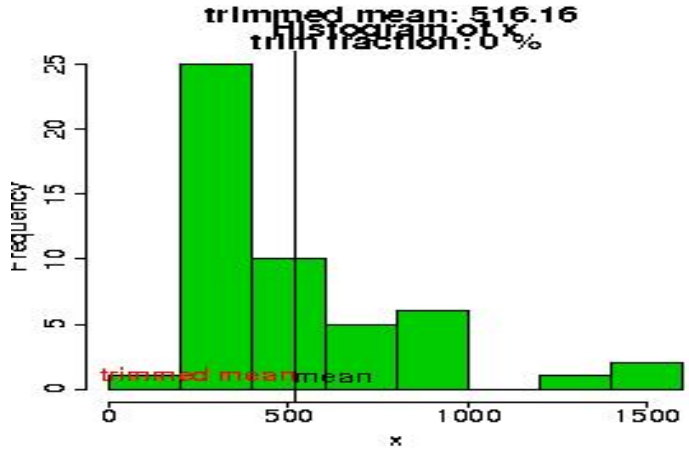
3.1.3 Buttons and slider variables

The next version of the running example — `slider.trimmed.mean.plus()` — demonstrates how two sliders are implemented. To keeps things simple a second slider is defined. It allows the user to change the color of the plot. In addition three *buttons* are generated to switch between three graphical representations of the data: dotplot, histogram or boxplot. The code is a little bit longer. However, we are shure that it isn't very difficult to understand it.

13 ⟨*define* `slider.trimmed.mean` 11⟩+ ≡

```
slider.trimmed.mean.plus<-function(x)
{
  # general initialisations
  if(missing(x)) return("Error: no data found!")
  slider(obj.name="ptype",obj.value="hist")
  # function to update plot
  refresh<-function(...){
    # get settings
    alpha <- slider(no=1)
```

```
    mycol <- slider(no=2)
    ptype <- slider(obj.name="ptype")
    # computation
    tm <- mean(x,trim=alpha); m <- mean(x)
    # construct high level plot
    if(ptype=="dotplot") plot(as.data.frame(x),col=mycol)
    if(ptype=="hist")    hist(x,col=mycol)
    if(ptype=="boxplot") boxplot(x,col=mycol,horizontal=TRUE)
    # perform some lower level jobs
    abline(v=tm,col="red")
    text(tm,1.1,adj=1,"trimmed mean",col="red")
    abline(v=m,col="black")
    text( m,0.9,adj=0,"mean")
    title(paste("trimmed mean:", format(tm,signif=4),
                "\ntrim fraction:",round(alpha*100),"%"))
  }
  # three functions to react on buttons
  b1<-function(...){slider(obj.name="ptype",obj.value="dotplot");refresh()}
  b2<-function(...){slider(obj.name="ptype",obj.value="hist");   refresh()}
  b3<-function(...){slider(obj.name="ptype",obj.value="boxplot");refresh()}
  # definition of slider widget
  slider(sl.functions= refresh,
         sl.names=     c("trim fraction","color"),
         sl.mins=      c(0,1),
         sl.maxs=      c(0.5,13),
         sl.deltas=    c(0.01,1),
         sl.defaults=  c(0,1),
         but.functions=c(b1,b2,b3),
         but.names=    c("dotplot","histogram","boxplot")
  )
  # initial plot
  refresh()
}
slider.trimmed.mean.plus(rivers[1:50])
```



In this example vectors of length two are assigned to the arguments `sl.names`, `sl.mins`, `sl.maxs`, `sl.deltas`, and `sl.defaults`. The first elements of the vectors describe the settings of the first slider whereas the second ones fix the parameters of the other slider.

The buttons are implemented by a vector of threee names (`but.names`) and by a vector of three effect functions (`but.functions`). To handle the state of the selected plot type a slider variable (`ptype`) is created. During updating the plot the actual value of `ptype` is found by the statement `slider(obj.name="ptype")`. After changing `ptype` it is stored by statements like `slider(obj.name="ptype", obj.value="dotplot")`. In this example the effect functions of the buttons only consist of a statement to store the plot type and to update the plot by calling the effect function `refresh()`.

In summary there is a simple structure for implementing sliders and buttons. Slider variables can be used to communicate states, values and other information.

3.2 General Rules

In the last section the reader learned the syntax of the function `slider` and he will be able to write slider function of his own. To achieve a similar structure of the slider functions introduced in this paper we propose some general rules now.

3.2.1 Names of the slider functions

The names of the slider functions of this paper always start with the character string `"slider"` and end with a string indicating the job to be done, e.g. a statistical procedure or function like `hist`, `pairs` or `smooth`.

3.2.2 Formal arguments for data sets

One dimensional data sets are passed to a `slider*` function by the argument `x`. If the data set is of two dimensions there are two types of calls: Either argument `x` is a matrix or a data frame with two columns or the argruments `x` and `y` are used for the first and the second variable. If `x` is a vector and `y` not available then `x` is used as the second dimension and `seq(x)` as the first one. Three dimensional data sets are managed in an analogous way: A $(n \times 3)$-matrix has to be assigned to `x` or the arguments `x`, `y` and `z` must be used. These rules enable us to write some general statements for checking and for preparation of some local variables containing the data.

Checking the one dimensional case is simple. Besides `x.name` stores how the `x` argument has been assigned by the user.

14 ⟨*check if* `x` *is a vector* 14⟩ ≡ ⊂ 31, 34, 38, 66

```
x.name<-deparse(substitute(x))
```

```
if(missing(x)||length(x)<2) return("Error: x must be a vector")
```

To check a two dimensional data input the two cases described above has to be handled. After checking the data are assigned to two local variables `x` and `y`.

15 ⟨*check if* `x` *is a matrix or* `x` *and* `y` *are vectors* 15⟩ ≡ ⊂ 53, 56

```
x.name<-deparse(substitute(x))
y.name<-deparse(substitute(y))
if(length(x)<2) return("Error: x is of length 0 or 1")
if(!is.null(y)){
  if(length(y)<2) return("Error: y must be a vector")
  if(length(x)!=length(y))
    return("Error: x and y must have the same length")
  x<-cbind(x,y)
}
if(!is.matrix(x) && !is.data.frame(x)){
  x<-cbind(seq(x),x)
  y.name<-x.name; x.name<-"index"
}
if(is.null(y.name)){x.name<-colnames(x)[1]; y.name<-colnames(x)[2]}
y<-x[,2]; x<-x[,1]
```

In the case of three dimensions the arguments `y` and `z` are dealt like `y` in the two dimensional case.

16 ⟨*check if* `x, y,z` *are vectors or* `x` *is matrix with >2 columns* 16⟩ ≡ ⊂ 40

```
x.name<-deparse(substitute(x))
y.name<-deparse(substitute(y))
z.name<-deparse(substitute(z))
if(length(x)<2) return("Error: x is of length 0 or 1")
if(!is.null(y)){
  if(length(y)<2) return("Error: y must be a vector")
  if(length(x)!=length(y))
    return("Error: x and y must have the same length")
  x<-cbind(x,y)
}
if(!is.null(z)){
  if(length(z)<2) return("Error: z must be a vector")
  if(length(x)!=length(z))
    return("Error: x and z must have the same length")
  x<-cbind(x,z)
}
if(!is.matrix(x)&& !is.data.frame(x) && ncol(x)<3)
  return("Error: not enough variables")
if("NULL"==y.name){x.name<-colnames(x)[1]; y.name<-colnames(x)[2]}
if("NULL"==z.name){x.name<-colnames(x)[1]; z.name<-colnames(x)[3]}
z<-x[,3]; y<-x[,2]; x<-x[,1]
```

Time series are different from a one dimensional data set because data points are connected with times. Therefore, we need a code chunk for checking time series.

17 ⟨*check if* `x` *is a time series* 17⟩ ≡ ⊂ 43, 46, 50

```
x.name<-deparse(substitute(x))
if(missing(x)||length(x)<2) return("Error: x must be a vector")
y<-x; if(is.ts(x)) { x<-time(x) } else { x<-seq(x) }
```

3.2.3 Passing additional arguments

Remark: This section should be skipped during the first reading of the text!

You know that high level plotting function have the formal parameter `"..."`. This argument allows the user to pass additional settings to the graphics device. At once the question arises: Can we manage to pass such arguments to plotting functions that are called by a slider function? For example: a histogram is computed in the `refresh` function and the user wants to produce *green* bars.

There are different answers to tackle this problem. At first you can consider which of the graphics parameters are relevant to be set by the user. Then we can introduce these parameter in the header of a slider function. But the list of parameters will be very long because the user may be want to modify attributes of scale, point size, type, color, etc.

A second way is to define a `"..."` argument for passing additional parameters.

```
slider.xyz<-function(x,...)
```

But there will be some difficulties to be managed if you use the `"..."` construction. How do we handle the `"..."` argument, how do we set default values for some parameter and how can we remove parameters that must not be changed at all? In the initialization part of the `slider.*` functions it is possible to modify the list of the additional arguments. To demonstrate this step we show how you can remove a `breaks` argument and then append a `"main"` argument. If `main` is not available it is set to `x.name` . (Cleary there is no graphics parameter with name `breaks` but users used to set breaks in their calls of `hist` may try to deliver a `breaks` argument.)

18 ⟨*modification of the* `"..."` *argument, not for evaluation* 18⟩ ≡

```
args<-list(...)
args<-args[names(args)!="breaks"] # remove "breaks"
if(!any("main"==names(args)))     # set default "main"
  args<-c(args,list(main=x.name))
```

Now the argument list `args` has to be passed to the function `hist` within the action or refresh function. Writing `hist(x,args)` doesn't work because the second argument of `hist` is the `break` argument and not a slot for further arguments.

The second idea will be to use the `"..."` of `hist`: `hist(x,...=args)`. But the `"..."` argument of `hist` is passed to the functions `title` and `axis` and so we don't get green bars at all. Our answer to this problem is to describe the call by its elements: the function `hist` should be called with the argument list consisting of the additional arguments stored in `args` and other arguments specifying the data set and the breaks, for example. Then the function `do.call` is called with theses elements. Keep in mind that `do.call` needs the arguments as an `alist`.

To summarize the following construction will work and is used in the function `slider.hist`:

19 ⟨*some details of a slider function, not for evaluation* 19⟩ ≡

```
slider.xyz<-function(x,...)
{
  ⟨initialisation statements NA⟩
  args<-list(...)
```

```
  args<-args[names(args)!="breaks"] # remove "breaks"
  if(!any("main"==names(args)))     # set default "main"
     args<-c(args,list(main=x.name))
  ⟨more initialisation statements NA⟩
  refresh<-function(...){
    ⟨some computations for the refresh task NA⟩
    do.call("hist",c(alist(x=x,breaks=breaks),args))
    ⟨further refreshing statements NA⟩
  }
  ⟨tail of function slider.xyz NA⟩
}
```

Before we close this section we will present a further proposal to deal with the arguments. In the game there are four sets of information:

- the set of default settings coded in the slider function
- the set of additional parameters defined by the user
- the set of forbidden arguments that must not be used
- the set of important settings that must not be changed by the user

We can save these sets on suitable list objects:

20 ⟨* 20⟩ ≡

```
# defaults (these are allowed to be changed by users)
defaults<-list(main=x.name)
# graphics parameter of the user
args<-list(...)
# forbidden (these must not be passed to a slider function)
set.of.forbidden.args<-list(probability=TRUE)
# important (these are passed and must not to be changed by users)
important<-alist(bty="n",sub="graphics computed by slider")
```

Now the sets have to be combined. At first we remove the forbidden elements from the argument list of the user. Then we concatenate the important ones, the user arguments and the default settings. Finally, we remove elements whose names occur on the list earlier.

21 ⟨* 20⟩+ ≡

```
# remove not allowed
args<-args[!names(args) %in% set.of.forbidden.args]
# set of all parameters
defaults<-c(important,args,defaults)
# removing of double ones
args<-defaults[unique(names(defaults))]
```

The refresh function has a very simple structure now.

22 ⟨* 20⟩+ ≡

```
refresh<-function(...){
    xrange<-range(x); num<-slider(no=1)
    breaks<-seq(xrange[1],xrange[2],length=num+1)
    do.call("hist",c(alist(x=x,breaks=breaks),args ))
    panel(x)
}
```

In the following we have not implemented these ideas completely. Sometimes we pass ... arguments without further checks.

3.3 Density Presenter

In this paragraph we discuss some tools for plotting densities of distributions. The parameters of the distribution are controlled by sliders. These functions allow the user to study how the shapes of the densities depend on the parameter settings. It is a very easy exercise to find an implementation for a special distribution, e.g., the normal distribution.

23 ⟨*define* `slider.show.normal.density` 23⟩ ≡ ⊂ 24, 30

```
slider.show.normal.density<-function(name,...)
{
  x<-seq(-10,10,length=200)
  args<-list(...)
  refresh<-function(...){
    par1<-slider(no=1); par2<-slider(no=2)
    f.x<-dnorm(x,par1,par2)
    main=paste("normal distribution\n",
               "E(X) =",format(par1,digits=3),
            ", sd(X) =",format(par2,digits=3))
#    plot(x,f.x,type="l",main=main)
    do.call("plot",c(alist(x=x,y=f.x,type="l",main=main),args))
  }
  slider(refresh,
    c("expectation","standard deviation"),
    c(-20,.001),c(20,20),c(.1,.1),c(0.1,1)
  )
  refresh()
  cat("use slider to select parameters!\n")
}
```

Here comes a check.

24 ⟨* 20⟩+ ≡

```
⟨define slider.show.normal.density 23⟩
slider.show.normal.density(col="red",bty="n")
```

A more interesting idea is to write a function that operates as a general presenter. The function `slider.show.density()` shows the shapes of the densities of various distributions.

After the user has collected some experiences she or he will like to write a improved version. Before you start programming your own presenter analyze the following function:

25 ⟨*define* `slider.show.density` 25⟩ ≡ ⊂ 30

```
slider.show.density<-function(
  distribution="norm",
  mins=c(-100,-100,-50,.001),
  maxs=c(100,100,50,100),
  deltas=c(1,1,.1,.1),
  defaults=c(-5,5,0,1),type="l",...)
{
  args<-list(...)
  refresh<-function(...){
    lim1<-slider(no=1); lim2<-slider(no=2)
```

```
    par1<-slider(no=3); par2<-slider(no=4)
    x<-seq(min(lim1,lim2),max(lim1,lim2),length=200)
    ddist<-paste("d",distribution,sep="")
    f.x<-do.call(ddist,alist(x=x,par1,par2))
    main=paste("distribution:",distribution,"\n",
               "parameter 1: ",format(par1,digits=3),
               ", parameter 2: =",format(par2,digits=3))
#    plot(x,f.x,type=type,main=main)
    do.call("plot",c(alist(x=x,y=f.x,type=type,main=main),args))
  }
  slider(refresh,
     c("x limit (min)","x limit (max)",
       "parameter 1","parameter 2")[1:length(mins)],
       mins,maxs,deltas,defaults)
  refresh()
  cat("use sliders to select parameters!\n")
}
```

Here are a few examples to show that the idea works:

- gamma distribution

26 ⟨*show the density of the gamma distribution* 26⟩ ≡ ⊂ 30

```
slider.show.density("gamma",mins=c(0,0,.01,.01),
                            maxs=c(100,100,50,50),
                            deltas=c(.1,.1,.01,.01),
                            defaults=c(0,10,4,1), bty="n")
```

- beta distribution

27 ⟨*show the density of the beta distribution* 27⟩ ≡ ⊂ 30

```
slider.show.density("beta",mins=c(0,0,0,0),
                            maxs=c(1,1,10,10),
                            deltas=c(.1,.1,.01,.01),
                            defaults=c(0,1,1,1),col="blue")
```

- binomial distribution

28 ⟨*show the density of the binomial distribution* 28⟩ ≡ ⊂ 30

```
slider.show.density("binom",mins=c(0,0,1,0),
                            maxs=c(100,100,100,1),
                            deltas=c(1,1,1,.01),
                            defaults=c(0,20,5,0.5),type="h")
```

- Poisson distribution

29 ⟨*show the density of the Poisson distribution* 29⟩ ≡ ⊂ 30

```
slider.show.density("pois",mins=c(0,0,.01),
                            maxs=c(100,100,50),
                            deltas=c(1,1,.1),
                            defaults=c(0,20,5),type="h")
```

The different presenter functions could be collected in central function.

30 ⟨* 20⟩+ ≡

```
slider.present.density<-function()
{
  ⟨define slider.show.density 25⟩
  f0<- ⟨define slider.show.normal.density 23⟩
  f1<- function(...){ ⟨show the density of the gamma distribution 26⟩ }
  f2<- function(...){ ⟨show the density of the beta distribution 27⟩ }
  f3<- function(...){ ⟨show the density of the binomial distribution 28⟩ }
  f4<- function(...){ ⟨show the density of the Poisson distribution 29⟩ }

  slider(but.functions=c(f0,f1,f2,f3,f4),
         but.names=c("show NORMAL","show GAMMA","show BETA",
                     "show BINOMIAL","show POISSON"))
}
slider.present.density()
```

Now the reader is prepared to take a further look at the implementations of the slider functions of this paper.

4 Histograms and Density Traces

4.1 Class number of histograms – `slider.hist`

In this section we propose a function which allows you to study the effect of the number of classes on the shape of a histogram. For this purpose a widget with a slider controlling the number of classes is opened and a histogram is computed. By moving the slider the user changes the number of classes and the histogram is redrawn. The implementation uses two special features: 1.) Sometimes we want to add further graphical elements like a density curve to the histogram. For this job `slider.hist` has a slot to deliver a *panel* function. This panel function will be called after updating the histogram. 2.) Additional graphics parameter can be transfered by the `"..."` argument of `slider.hist` to the call of `hist` which constructs the histogram.

Remarks: The default number of breaks is computed by `hist`. If a `breaks` argument is found in the call of `slider.hist` it will be removed.

31 ⟨define slider.hist 31⟩ ≡ ⊂ 2, 32, 33, 60

```
slider.hist<-function(x,panel=rug,...)
{
  ⟨check if x is a vector 14⟩
  args<-list(...)
  args<-args[names(args)!="breaks"]
  ClassNumber<-length(hist(x,plot=FALSE)$breaks)
  if(!any("main"==names(args)))args<-c(args,list(main=x.name))
  refresh<-function(...){
    xrange<-range(x); num<-slider(no=1)
    breaks<-seq(xrange[1],xrange[2],length=num+1)
    do.call("hist",c(alist(x=x,breaks=breaks),args))
    panel(x)
  }
  slider(refresh,"ClassNumber",1,100,1,ClassNumber);  refresh()
  "use slider to select number of classes"
}
```

4.1.1 Test

Here is a check to test whether we can change the color.

32 ⟨*check* 32⟩ ≡
```
⟨define slider.hist 31⟩
slider.hist(log(islands),col="green")
```

To test the panel feature we add a normal density curve to the histogram.

33 ⟨*check* 32⟩+ ≡
```
⟨define slider.hist 31⟩
slider.hist(rivers,xlab="RIVERS",col="red",probability=TRUE,
  pa=function(x){
    xx<-seq(min(x),max(x),length=100)
    yy<-dnorm(xx,mean(x),sd(x))
    lines(xx,yy); rug(x); print(summary(yy))
  }
)
```

4.2 Width and kernel of a density trace – `slider.density`

The main parameters of density traces are width and kernel type. In the function `slider.density()` both of them are selected by sliders. The alternative idea to implement the selection of the kernel function by buttons would have required seven buttons. Therefore, a slider solution seems to be a little bit smarter. To be able to add further graphical elements a panel function has been included.

Technical Remarks: 1.) The kernel type is stored in the slider variable `kno`. 2.) In `slider.density()` we have two different effect functions where the second one `set.kernel()` calls the first slider function (`refresh()`).

34 ⟨*define* `slider.density` 34⟩ ≡ ⊂ 3, 35, 36, 60
```
slider.density<-function(x,panel=rug,...)
{
  ⟨check if x is a vector 14⟩
  args<-list(...)
  if(!any("main"==names(args))) args<-c(args,list(main=x.name))
  kernel<-c("gaussian",  "epanechnikov","rectangular",
            "triangular","biweight",    "cosine",     "optcosine")
  slider(obj.name="kno",obj.value=1)
  refresh<-function(...){
    width<-slider(no=1)*diff(range(x))/100
    kno<-slider(obj.name="kno"); kernel<-kernel[kno]
    xy<-density(x,width=width,kernel=kernel)
    do.call("plot",c(alist(x=xy),args))
    title(paste("\n\nwidth =",signif(width,4),", kernel =",kernel))
    panel(x)
  }
  set.kernel<-function(...){
    kernel<-slider(no=2)
    slider(obj.name="kno",obj.value=kernel)
    refresh()
```

```
  }
  bw.default<-diff(range(x))/density(x)$bw
  nt <- slider(c(refresh,set.kernel),
         c("width (% of range)","kernel"),
         c(.1,1),c(100,7),c(.1,1),c(bw.default,1)
  )
  # tkwm.minsize(nt, "300", "110") # set width, height to prevent to small sizes
  refresh()
  cat("use slider to select width of window and to select kernel:\n")
  print(cbind("no"=1:7,"kernel"=kernel))
}
```

4.2.1 Test

At first we test `slider.density` without a panel function.

35 ⟨*check of* `slider.density` 35⟩ ≡

```
⟨define slider.density 34⟩
slider.density(rivers,xlab="RIVERS",col="red")
```

Now we test a call of `slider.density` with a panel function to plot a fitted normal density curve.

36 ⟨*check of* `slider.density` 35⟩+ ≡

```
⟨define slider.density 34⟩
slider.density(log(rivers),xlab="rivers",col="red",
  panel=function(x){
    xx<-seq(min(x),max(x),length=100)
    yy<-dnorm(xx,mean(x),sd(x))
    lines(xx,yy); rug(x); print(summary(yy))
  }
)
```

4.2.2 Help Page

37 ⟨*define help of* `slider.hist` 37⟩ ≡

```
\name{slider.hist}
\title{interactive histogram and density traces}
\alias{slider.hist}
\alias{slider.density}

\description{
  The functions \code{slider.hist} and \code{slider.density}
  compute histograms and density traces
  whereas some parameter are controlled by sliders.

  \code{slider.hist} computes a histogram; the number of classes is
  defined by a slider.

  \code{slider.density} computes a density trace; width and
  type of the kernel are defined by sliders.
}
\usage{
```

```
  slider.hist(x, panel, ...)
  slider.density(x, panel, ...)
}
\arguments{
  \item{x}{ data set to be used for plotting }
  \item{panel}{ function constructing additional graphical elements to the plot}
  \item{\dots}{ additional (graphics) parameters which are passed to
               the invoked high level plotting function }
}
\details{
  \code{slider.hist} draws a histogram of the data set \code{x} by
  calling \code{hist} and opens a Tcl/Tk widget with one slider.
  The slider defines the number of classes of the histogram. Changing the
  slider results in redrawing of the plot. For further
  details see the help page of \code{hist}. \code{rug} is used as the
  default panel function.

  \code{slider.density} draws a density trace of the data set \code{x}
  by \code{plot(density(...))} and opens a Tcl/Tk-widget with two
  sliders. The first slider defines the width of the density trace
  and the second one the kernel function:
   \code{"1-gaussian",  "2-epanechnikov", "3-rectangular",
         "4-triangular","5-biweight",     "6-cosine",     "7-optcosine"}
  Changing one of the sliders results in a redrawing of the plot.
  For further details see the help page of \code{density}.
  \code{rug} is used as the default panel function.
}
\value{
  a message about the usage
}
\references{ ~~ }
\author{ Hans Peter Wolf }
  \seealso{ \code{\link{hist}}, \code{slider}}
\examples{
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  slider.hist(log(islands))
}
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
slider.density(rivers,xlab="rivers",col="red")
}
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
slider.density(log(rivers),xlab="rivers",col="red",
  panel=function(x){
    xx<-seq(min(x),max(x),length=100)
    yy<-dnorm(xx,mean(x),sd(x))
    lines(xx,yy)
    rug(x)
    print(summary(yy))
  }
)
```

```
}
}
\keyword{ univar }
\keyword{ iplot }
```

5 Brushing Functions

5.1 A draftsman's display with Brushing – `slider.brush.pairs`

A draftsman's display is a nice graphics to show two dimensional dependencies of the variables of a multivariate data set. Brushing allows you to mark a subset of the data points. The subset of the points is defined by the condition that the coordinate of a selected variable has to lie within a fixed interval. By the function `slider.brush.pairs()` the user can select a variable (dimension) as well as an interval for recoloring the points satisfying a condition with color `"red"`. The function `pairs()` is not used in the refresh function avoiding computational overhead. So the complexity of code is mostly caused by constructing the plot.

38 ⟨*define* `slider.brush.pairs` 38⟩ ≡ ⊂ 4, 39, 60

```
slider.brush.pairs<-function(x,...)
{
  args<-list(...)
  ⟨check if x is a vector 14⟩
  # preparation of data
  m<-dim(x)[2]; for(j in 1:m) x[,j]<-as.numeric(x[,j])
  mins<-apply(x,2,min); maxs<-apply(x,2,max)
  delta<-(maxs-mins)/100
  # initial plot
  varnames<-paste("var ",1:m,": ",colnames(x),sep="")
  dev.new(); par(mfrow=c(m,m),oma=c(0,0,0,0),mai=c(0,0,0,0),...)
  usr.array<-array(0,c(m,m,4)); axes<-FALSE
  for(i in 1:m){
    for(j in 1:m){
      # plot(x[,j],x[,i],axes=axes,type="p")
      do.call("plot",c(alist(x=x[,j],y=x[,i],type="p",axes=axes,xlab="",ylab=""),args))
      usr.array[i,j,] <- usr<-par()$usr
      if(i==j) text(usr[1],usr[4],varnames[i],adj=c(0,1),cex=5)
      rect(usr[1],usr[3],usr[2],usr[4])
    }
  }
  # update function
  refresh<-function(...){
    vmin<-slider(no=1)/100; vmax<-vmin+slider(no=2)/100
    vno <-slider(no=3)
    vmin<-mins[vno]*(1-vmin)+maxs[vno]*(vmin)
    vmax<-mins[vno]*(1-vmax)+maxs[vno]*(vmax)
    ind <-vmin<=x[,vno] & x[,vno]<=vmax
    for(i in 1:m){
      for(j in 1:m){
        par(mfg=c(i,j),usr=usr.array[i,j,])
        points(x[ ,j],x[ ,i],col=0,cex=2,pch=19)
        points(x[ ind,j],x[ ind,i],col="red",pch=1)
        points(x[!ind,j],x[!ind,i],col="blue",pch=19)
```

```
    }
  }
}
# slider definition
nt <- slider(refresh,
       c("lower limit (% of range)","width (% of range)",
         paste("variable no: 1 ..",m)),
       c(0,0,1), c(100,100, m), c(1,1,1), c(0,30,1)
)
# tkwm.minsize(nt, "450", "150") # set width, height to prevent to small sizes
refresh()
cat("use sliders to select variable and interval width\n")
}
```

5.1.1 Test

We will use the famous `iris` data to test the brushing function.

39 ⟨*test of slider.brush.pairs* 39⟩ ≡
```
⟨define slider.brush.pairs 38⟩
usr.array<-slider.brush.pairs(iris,cex=.2)
```

5.2 Scatter plot brushing – `slider.brush.plot.xy`

The function `slider.brush.plot.xy()` computes an xy-plot and recolors a data point `"red"` if the value of its third variable is in the fixed interval.

40 ⟨*define* `slider.brush.plot.xy` 40⟩ ≡ ⊂ 5, 41, 60
```
slider.brush.plot.xy<-function(x,y=NULL,z=NULL,...)
{
  ⟨check if x, y,z are vectors or x is matrix with >2 columns 16⟩
  args<-list(...)
  if(!any("main"==names(args)))
    args<-c(args,list(main=paste(x.name,"<-->",y.name)))
  if(!any("xlab"==names(args)))args<-c(args,list(xlab=x.name))
  if(!any("ylab"==names(args)))args<-c(args,list(ylab=y.name))
  do.call("plot.default",c(alist(x=x,y=y,pch=19),args))
  refresh<-function(...){
    zrange<-range(z); z1<-slider(no=1); z2<-slider(no=2)
    zmin<-z1; zmax<-z1+z2; ind<-zmin<=z&z<=zmax; pos<-par()$usr
    rect(pos[2],pos[4],pos[1]*.5+pos[2]*.5,pos[3]*.1+pos[4]*.9,
         col="white",border=NA)
    txt<-paste(z.name,"(red) in [",format(zmin,digits=4),",",
               format(zmax,digits=4),"]",sep="")
    text(pos[2],pos[4],txt,adj=c(1,1),col="red",cex=0.7)
    col<-c("black","red")[1+ind]
    points(x,y,col=col,pch=19,
           cex=if("cex" %in% names(args)) args$cex else 1)
  }
  z.min<-min(z); z.max<-max(z); delta<-(z.max-z.min)/100
  reset<-function(...){
    do.call("plot",c(alist(x=x,y=y,col="red",pch=19),args)); pos<-par()$usr #090216
```

```
    rect(pos[2],pos[4],pos[1]*.4+pos[2]*.6,pos[3]*.1+pos[4]*.9,
         col="white",border=NA)
  }
  slider(refresh,
         c("minimum of z","interval width of z"),
         c(z.min,0),c(z.max+delta,(z.max-z.min)+delta),
         c(delta,delta),c(z.min-delta,(z.max-z.min)/2),
         reset.function=reset
  )
  refresh()
  cat("use sliders to select interval for inking points\n")
}
```

5.2.1 Test

41 ⟨*test of* slider.brush.plot.xy 41⟩ ≡

```
⟨define slider.brush.plot.xy 40⟩
# data<-matrix(rnorm(900), 300,3)
# slider.brush.plot.xy(data[,1],data[,2],sqrt(data[,1]^2+data[,2]^2),
#                   main="hallo")
# slider.brush.plot.xy(iris[,1],iris[,2],iris[,3])
slider.brush.plot.xy(iris[,1:3],cex=1.5)
```

5.2.2 Help Page

42 ⟨*define help of* slider.brush.pairs *and of* slider.brush.plot.xy 42⟩ ≡

```
\name{slider.brush}
\title{interactive brushing functions}
\alias{slider.brush.pairs}
\alias{slider.brush.plot.xy}

\description{
  These functions compute a pairs plot or a simple xy-plot and
  open a slider control widget for brushing.

  \code{slider.brush.pairs} computes a pairs plot; the user defines an
  interval for one of the variables and in effect all data points
  in this interval will be recolored.

  \code{slider.brush.plot.xy} computes an xy-plot; the user defines a
  interval for a third variable \code{z} and all points
  \code{(x,y)} will be recolored red if the \code{z} value is in the inter-
val.
}
\usage{
  slider.brush.pairs(x, ...)
  slider.brush.plot.xy(x, y, z, ...)
}
\arguments{
  \item{\dots}{ new settings for global graphics parameters }
  \item{x}{ matrix or data frame or vector }
```

```
  \item{y}{ vector of y values if \code{x} is not a matrix }
  \item{z}{ vector of z values if \code{x} is not a matrix }
}
\details{
  \code{slider.brush.pairs} draws a pairs plot of the data set \code{x}.
  The first slider defines the lower limit of the interval and the
  second its width. By the third slider a variable is selected.
  All data points for which the selected variable is in the interval
  are recolored red.

  \code{slider.brush.plot.xy} draws an xy-plot of the data set \code{x}.
  The first slider defines the lower limit of the interval of z values
  and the second one its width. All data points for which the variable z
  is in the interval are recolored red.
}
\value{
  a message about the usage
}
\references{ W. S. Cleveland, R. A. Becker, and G. Weil. The Use of
  Brushing and Rotation for Data Analysis. InW. S. Cleveland
  and M. E. McGill, editors, Dynamic Graphics for
  Statistics. Wadsworth and Brooks/Cole, Pacific Grove,
  CA, 1988. }
\author{ Hans Peter Wolf }
 \seealso{ \code{\link{pairs}}, \code{\link{plot}} }
\examples{
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  slider.brush.pairs(iris)
}
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  slider.brush.plot.xy(iris[,1:3])
}
}
\keyword{ iplot }
```

6 Time Series Plots

6.1 Splitted time series – `slider.split.plot.ts`

Often there is a periodical structure in time series of a fixed period. Then you will like to have a tool to separate and compare the sections defined by the season. The function `slider.split.plot.ts` lets you select the length of a saison and one of the limits between two saisons. Then in the time series plot `fivenum` summary statistics or a regression lines are added to each of the sections.

43 ⟨*define* `slider.split.plot.ts` 43⟩ ≡ ⊂ 6, 44, 60

```
slider.split.plot.ts<-function(x,type="l",...)
{
```

⟨*check if* x *is a time series* 17⟩
```
args<-list(...)
n<-length(x); xmin<-min(x); xmax<-max(x)
xdelta<-xmax-xmin
slider(obj.name="summary.type",obj.value="linear")
refresh<-function(...){
# initialization
  summary.type<-slider(obj.name="summary.type")
  width<-slider(no=1)
  limit<-slider(no=2)
  n.sec<-1
  limit<-limit-width*ceiling((limit-xmin)/width)
# plot: # plot(x,y,type=type,bty="n",xlab="",ylab="")
  do.call("plot",c(alist(x,y,type=type),args))
  limit<-limit-width-width/n.sec; j<-0
#   abline(v=limits,lwd=0.5,lty=3)
  while(limit<xmax){ j<-j+1
    limit<-limit+width/n.sec; limit2<-limit+width
    ind<-limit<=x & x<=limit2
    xx<-x[ind]; yy<-y[ind]; if(length(xx)<2) next
    abline(v=limit,lwd=0.5,lty=3,col=1)
    if(summary.type=="linear"){
      coef<-lm(yy~xx)$coef
      segments(limit, coef[1]+coef[2]*limit,
               limit2,coef[1]+coef[2]*limit2,col=j)
    }
    if(summary.type=="five.number"){
      five<-fivenum(yy)
      xx<-0.5*(limit+limit2)
      points(xx,five[3],pch=19,cex=1,col="red")
      segments(xx,five[1],xx,five[2],lwd=3,col="red")
      segments(xx,five[4],xx,five[5],lwd=3,col="red")
    }
  }
  abline(v=slider(no=2),lwd=0.5,lty=1,col=1)
}
f1<-function(...){
  slider(obj.name="summary.type",obj.value="linear")
  refresh()
}
f2<-function(...){
  slider(obj.name="summary.type",obj.value="five.number")
  refresh()
}
slider(refresh,c("width of window","limit"),
     c(xdelta/length(x)*3,xmin),c(xdelta,xmax),
     c(xdelta/1000,xdelta/1000),c(xdelta/4,xmin),
     but.functions=c(f1,f2),
     but.names=c("linear model","fivenum summary")
)
refresh()
cat("select window and summary type and look at time series!\n")
}
```

6.1.1 Test

The test call uses the time series co2.

44 ⟨*test of* slider.split.plot.ts 44⟩ ≡
```
⟨define slider.split.plot.ts 43⟩
slider.split.plot.ts(co2,col="red",main="co2")
```

6.1.2 Help Page

45 ⟨*define help of* slider.split.plot.ts 45⟩ ≡
```
\name{slider.split.plot.ts}
\title{interactive splitting of time series}
\alias{slider.split.plot.ts}

\description{
  \code{slider.split.plot.ts} plots linear fitted lines or
  summary statistics in sections of a time series.
  The sections are controlled by sliders.
}
\usage{
  slider.split.plot.ts(x, type="l", ...)
}
\arguments{
  \item{x}{ time series or vector}
  \item{type}{ plotting type: \code{type} will be forwarded to function \code{plot}}
  \item{\dots}{ additional graphics parameters }
}
\details{
  \code{slider.split.plot.ts} draws a time series plot and let you define
  sections of the series by fixing a limit on the time scale as well as
  a window width.
  The whole range of the series is partitioned in pieces of the same
  length in a way that the fixed limit will be one of the section limits.
  Then linear models are fitted and plotted in the sections.
  Alternatively -- by pressing the button \code{fivenum summary} --
  summary statistics are drawn instead of the model lines.

  The first slider fixes the width of the sections and
  the second one the limit between two of them.

  By clicking on button \code{linear model} or \code{fivenum summary}
  the user switches between drawing model curves and five number summary.
}
\value{
  a message about the usage
}
\author{ Hans Peter Wolf }
 \seealso{ \code{\link{plot}} }
\examples{
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  slider.split.plot.ts(as.vector(sunspots)[1:100])
}
```

```
}
\keyword{ iplot }
```

6.2 Zooming in Time Series – `slider.zoom.plot.ts`

Some times time series happen to be very long — for example `sunspots` has a length of 2820. For exploring a section of a series it is helpful to have a zooming function. The function `slider.zoom.plot.ts` allows you to define a time window interactively and it computes a time series plot of the selected region. As a second feature the function extracts the data of two windows and computes two time series plots one below the other. With this feature you are able to compare different regions of the series by eye.

46 ⟨*define* `slider.zoom.plot.ts` 46⟩ ≡ ⊂ 7, 47, 48, 60

```
slider.zoom.plot.ts<-function(x,n.windows=1,...)
{
 ⟨check if x is a time series 17⟩
 args<-list(...)
 tmin<-1; tmax<-length(x)
 refresh<-function(...){
 # initialization
   width <- slider(no=1); tstart1 <- slider(no=2); tend1 <- width+tstart1
   if(n.windows>1){
     tstart2 <- slider(no=3); tend2 <- width+tstart2
   }
 # plot
   par(mfrow=c(2+(n.windows>1),1),mai=c(.5,0.5,.1,0))
   # plot(x,y,type="l",bty="n",xlab="",ylab="")
   do.call("plot",c(alist(x,y,type="l",bty="n"),args))
   abline(v=c(x[tstart1],x[tend1]),col="red")
   lines(x[tstart1:tend1],y[tstart1:tend1],col="red",lty=2)
   if(n.windows>1){
     abline(v=c(x[tstart2],x[tend2]),col="blue")
     lines(x[tstart2:tend2],y[tstart2:tend2],col="blue",lty=3)
   }
   usr<-par()$usr
   ind<-tstart1:tend1
   plot(x[ind],y[ind],type="b",col="red",bty="n", # ylim=usr[3:4],
        xlim=c(x[tstart1],x[tstart1]+width*diff(x[1:2])))
   if(n.windows>1){
   ind<-tstart2:tend2
     plot(x[ind],y[ind],type="b",col="blue",bty="n", # ylim=usr[3:4],
        xlim=c(x[tstart2],x[tstart2]+width*diff(x[1:2])))
   }
   par(mfrow=c(1,1))
 }
 if(n.windows<2){
   slider(refresh,c("width of window","start of window"),
          c(1,1),c(tmax,tmax),c(1,1),c(ceiling(tmax/4),1))
 }else{
   slider(refresh,
      c("width of window","start window 1","start window 2"),
      c(1,1,1),c(tmax,tmax,tmax),c(1,1,1),c(ceiling(tmax/4),1,ceiling(tmax/2)))
 }
```

```
 refresh()
 cat("select window and look at time series!\n")
}
```

6.2.1 Test

The first test will be done with co2.

47 ⟨*test of* slider.zoom.plot.ts 47⟩ ≡
```
 ⟨define slider.zoom.plot.ts 46⟩
 slider.zoom.plot.ts(co2,2,main="co2")
```

For comparing two sections of a series take a look at sunspots.

48 ⟨*test of* slider.zoom.plot.ts 47⟩+ ≡
```
 ⟨define slider.zoom.plot.ts 46⟩
 slider.zoom.plot.ts(sunspots,2)
```

6.2.2 Help Page

49 ⟨*define help of* slider.zoom.plot.ts 49⟩ ≡
```
 \name{slider.zoom.plot.ts}
 \title{interactive zooming of time series}
 \alias{slider.zoom.plot.ts}

 \description{
   This function shows one or two sections of a time series. The window(s) is
   (are) controlled by sliders.
 }
 \usage{
   slider.zoom.plot.ts(x, n.windows, ...)
 }
 \arguments{
   \item{x}{ time series }
   \item{n.windows}{ \code{if(n.windows>1} two sections are defined }
   \item{\dots}{ additional graphical parameters }
 }
 \details{
   \code{slider.zoom.plot.ts} plots the original time series and it lets you
   select one or two sections of the series by fixing the width(s) and the
   starting point(s) of the region(s). Then the section(s) of the series is (are)
   plotted separately one below the other.

   The first slider defines the width of the section(s).
   The second (third) one sets the start of the first (second) section.
 }
 \value{
   a message about the usage
 }
 \author{ Hans Peter Wolf }
  \seealso{ \code{\link{plot}} }
 \examples{
 \dontrun{
```

```
 ## This example cannot be run by examples() but should be work in an inter-
active R session
   slider.zoom.plot.ts(co2,2)
 }
 }
 \keyword{ iplot }
```

6.3 Smoothing Time Series – `slider.smooth.plot.ts`

Tukey has proposed a set of smoothing operations for time series. Some of them are implemented by the function `smooth()`. `slider.smooth.plot.ts` supports the user to find the suitable combination of smoothing operations. Interactively he is able to smooth a time series step by step. The filter that should be used in the next step is selected by Tcl/Tk control panel.

50 ⟨*define* `slider.smooth.plot.ts` 50⟩ ≡ ⊂ 8, 51, 60

```
 slider.smooth.plot.ts<-function(x,...)
 {
  ⟨check if x is a time series 17⟩
  t.x<-x; x<-y
  args<-list(...)
  kind<-c("3RS3R", "3RSS", "3RSR", "3R", "3", "S")
  slider(obj.name="nts",obj.value=x)
  slider(obj.name="kind",obj.value="3")
  slider(obj.name="history.kind",obj.value="")
  refresh<-function(...){
  # initialization
    choice<-slider(obj.name="kind"); print(choice)
    history.kind<-slider(obj.name="history.kind")
    history.kind<-c(history.kind,choice)
    slider(obj.name="history.kind",obj.value=history.kind)
    xx<-slider(obj.name="nts")
    xx<-smooth(xx,kind=choice)
    # plot(t.x,x,type="l",lty=3,bty="n",xlab="",ylab="")
    do.call("plot",c(alist(t.x,x,type="l",lty=3,bty="n"),args))
    title(paste(history.kind,collapse="->"))
    points(t.x,xx,type="l",col="red") # lty=1+which(choice==kind))
    slider(obj.name="nts",obj.value=xx)
  }
  reset<-function(...){
    slider(obj.name="nts",obj.value=x)
    slider(obj.name="kind",obj.value="3")
    slider(obj.name="history.kind",obj.value="")
    refresh()
  }
  f1<-function(...){slider(obj.name="kind",obj.value="3RS3R");refresh()}
  f2<-function(...){slider(obj.name="kind",obj.value="3RSS"); refresh()}
  f3<-function(...){slider(obj.name="kind",obj.value="3RSR"); refresh()}
  f4<-function(...){slider(obj.name="kind",obj.value="3R");   refresh()}
  f5<-function(...){slider(obj.name="kind",obj.value="3");    refresh()}
  f6<-function(...){slider(obj.name="kind",obj.value="S");    refresh()}
  refresh()
  slider(but.functions=c(f1,f2,f3,f4,f5,f6),
         but.names=kind,reset.function=reset)
```

```
  cat("select type of smoothing a la Tukey and look the result!\n")
 }
```

6.3.1 Test

For testing we use some random numbers.

51 ⟨*test of* `slider.smooth.plot.ts` 51⟩ ≡

```
 ⟨define slider.smooth.plot.ts 50⟩
 slider.smooth.plot.ts(rnorm(100),main="\nrandom",col="blue")
```

6.3.2 Help Page

52 ⟨*define help of* `slider.smooth.plot.ts` 52⟩ ≡

```
 \name{slider.smooth.plot.ts}
 \title{interactive Tukey smoothing}
 \alias{slider.smooth.plot.ts}

 \description{
   \code{slider.smooth.plot.ts} computes smooth curves
   of a time series plot by Tukey's smoothers.
   The kind of smoothing is controlled by a Tcl/Tk widget.
 }
 \usage{
   slider.smooth.plot.ts(x, ...)
 }
 \arguments{
   \item{x}{ time series }
   \item{\dots}{ additional graphical parameters }
 }
 \details{
   \code{slider.smooth.plot.ts} draws the time series \code{x}.
   The user selects a filter of the set
   \code{c("3RS3R", "3RSS", "3RSR", "3R", "3", "S")}
   step by step and the resulting curve is added to the plot.
   The selection is performed by pressing a button of the control
   widget of \code{slider.smooth.plot.ts}.
   The button \code{reset} restarts the smoothing process.
 }
 \value{
   a message about the usage
 }
 \references{  Tukey, J. W. (1977). Exploratory Data Analysis, Reading
      Massachusetts: Addison-Wesley.
 }
 \author{ Hans Peter Wolf }
  \seealso{ \code{\link{plot}}, \code{\link{smooth}} }
 \examples{
 \dontrun{
 ## This example cannot be run by examples() but should be work in an inter-
active R session
   slider.smooth.plot.ts(rnorm(100))
```

```
}
}
\keyword{ iplot }
```

7 Regression

7.1 Smoothing by lowess – `slider.lowess.plot`

The result of the lowess smoother heavily depends on the setting of the parameter `f`. This parameter controls the smoother span and has to be fixed by the user. The function `slider.lowess.plot` allows the user to select the span and to observe the corresponding line. Furthermore, the number of iterations are set interactively.

53 ⟨*define* `slider.lowess.plot` 53⟩ ≡ ⊂ 9, 54, 60

```
slider.lowess.plot<-function(x,y=NULL,...)
{
  # slider function to draw lowess smoother, pwolf 080525
  ⟨check if x is a matrix or x and y are vectors 15⟩
  args<-list(...)
  refresh<-function(...){
    f<-slider(no=1)
    iter<-slider(no=2)
    xy<-lowess(x,y,f=f,iter=iter)
    # plot(x,y,bty="n")
    do.call("plot",c(alist(x,y,bty="n"),args))
    lines(xy)
    title(paste("\n\nlowess: f =",signif(f,4),", iterations =",iter))
    lines(xy)
  }
  slider(refresh,
         c("smoother span","iterations"),
         c(.01,1),c(1,7),c(.01,1),c(2/3,3)
  )
  refresh()
  cat("use slider to select smoother span!\n")
}
```

7.1.1 Test

54 ⟨*check of* `slider.lowess.plot` 54⟩ ≡

```
⟨define slider.lowess.plot 53⟩
slider.lowess.plot(cars,col="red")
```

7.1.2 Help Page

55 ⟨*define help of* `slider.lowess.plot` 55⟩ ≡

```
\name{slider.lowess.plot}
```

```
\title{interactive lowess smoothing}
\alias{slider.lowess.plot}
\description{
  \code{slider.lowess.plot} computes an xy-plot of the data and
  adds LOWESS lines. The smoother
  span and the number of iterations are selected by sliders.
}
\usage{
  slider.lowess.plot(x, y, ...)
}
\arguments{
  \item{x}{ data set to be used for plotting or vector of x values }
  \item{y}{ vector of y values in case \code{x} is not a matrix }
  \item{\dots}{ additional (graphics) parameter settings }
}
\details{
  \code{slider.lowess.plot} computes a scatterplot of the data.
  Then a LOWESS smoother line is added to the plot.
  For more details about the lowess parameters \code{f} and \code{iter}
  take a look at the help page of \code{lowess}.
  The parameters are set by moving sliders of the
  control widget. The first slider defines the smoother span \code{f}
  and the second one the number of iterations.
}
\value{
  a message about the usage
}
\references{ for references see help file of \code{lowess} }
\author{ Hans Peter Wolf }
 \seealso{ \code{\link{lowess}}, \code{slider} }
\examples{
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  slider.lowess.plot(cars)
}
}
\keyword{ iplot }
```

7.2 Sensitivity of Regression Line – `slider.bootstrap.lm.plot`

To understand the senitivity of a regression curve the function `slider.bootstrap.lm.plot` shows the user a lot of bootstrap regression lines computed on samples of the data points. The number of repetitions, the random seed and the polynomial degree is controlled by sliders.

56 ⟨*define* `slider.bootstrap.lm.plot` 56⟩ ≡ ⊂ 10, 57, 60

```
slider.bootstrap.lm.plot<-function(x,y=NULL,...)
{
 ⟨check if x is a matrix or x and y are vectors 15⟩
 args<-list(...)
 n<-length(x)
 ind<-order(x); x.orig<-x<-x[ind]; y.orig<-y<-y[ind]
```

```
  xx<-seq(min(x),max(x),length=100)
  # plot(x,y,...)
  do.call("plot",c(alist(x,y,bty="n"),args))
  abline(lm(y~x),lwd=5)
  refresh<-function(...){
    # plot(x,y,...);
    do.call("plot",c(alist(x,y,bty="n"),args))
    abline(coefyx<-lm(y~x)$coef, lwd=3)
    polytype<-slider(no=1)
    form<-paste(paste(sep="","I(x^",1:polytype,")"),collapse="+")
    form<-as.formula(paste("y ~",form)); coef<-lm(form)$coef
    yy<-outer(xx,0:polytype,"^")%*%coef; lines(xx,yy,lwd=2)
    B<-slider(no=2); zz<-slider(no=3); set.seed(zz)
    result<-matrix(0,1+polytype,B)
    for(i in 1:B){
      index<-sample(1:n,n,replace=TRUE)
      x<-x.orig[index]; y<-y.orig[index]
      coef<-lm(form)$coef
      yy<-outer(xx,0:polytype,"^")%*%coef
      lines(xx,yy,lwd=2,col=i,lty=2)
      result[,i]<-coef
    }
    abline(coefyx, lwd=5)
    result<-t(result);
    colnames(result)<-c("intercept",paste(sep="","beta: x^",1:polytype))
    print(summary(result))
  }
  slider(refresh,c("polynomial degree","number repetitions","random seed"),
         c(1,1,1),c(5,50,100),c(1,1,1),c(1,10,1))
  refresh()
  "ok"
 }
```

7.2.1 Test

57 ⟨*test of* `slider..bootstrap.lm.plot` 57⟩ ≡

```
⟨define slider.bootstrap.lm.plot 56⟩
daten<-iris[,2:3]
slider.bootstrap.lm.plot(daten)
```

7.2.2 Help Page

58 ⟨*define help of* `slider.bootstrap.lm.plot` 58⟩ ≡

```
\name{slider.bootstrap.lm.plot}
\title{interactive bootstapping for lm}
\alias{slider.bootstrap.lm.plot}

\description{
  \code{slider.bootstrap.lm.plot} computes a scatterplot and
  adds regression curves of samples of the data points.
  The number of samples and the degree of the model are
```

```
  controlled by sliders.
}
\usage{
  slider.bootstrap.lm.plot(x, y, ...)
}
\arguments{
  \item{x}{ two column matrix or vector of x values if y is used }
  \item{y}{ y values if x is not a matrix }
  \item{\dots}{ additional graphics parameters }
}
\details{
  \code{slider.bootstrap.lm.plot} draws a scatterplot of the data points
  and fits a linear model to the data set. Regression curves
  of samples of the data are then added to the plot. Within a Tcl/Tk
  control widget the degree of the model, the repetitions and the start
  of the random seed are set. After modification of a parameter
  the plot is updated.
}
\value{
  a message about the usage
}
\references{ ~~ }
\author{ Hans Peter Wolf }
 \seealso{ \code{\link{plot}} }
\examples{
\dontrun{
## This example cannot be run by examples() but should be work in an inter-
active R session
  daten<-iris[,2:3]
  slider.bootstrap.lm.plot(daten)
}
}
\keyword{ iplot }
```

8 Appendix

8.1 Definition of `slider`

We will finish the paper by listing the definition of the function `slider()`. The definition is copied from package relax.

59 ⟨*define* slider 59⟩ ≡

```
slider<-function (sl.functions, sl.names, sl.mins, sl.maxs, sl.deltas,
    sl.defaults, but.functions, but.names, no, set.no.value,
    obj.name, obj.value, reset.function, title)
{
    if (!exists("slider.env"))
        slider.env <<- new.env(parent = .GlobalEnv)
    if (!missing(no))
        return(as.numeric(tclvalue(get(paste("slider", no, sep = ""),
            env = slider.env))))
    if (!missing(set.no.value)) {
        try(eval(parse(text = paste("tclvalue(slider", set.no.value[1],
            ")<-", set.no.value[2], sep = "")), env = slider.env))
        return(set.no.value[2])
    }
```

```
if (!missing(obj.name)) {
    if (!missing(obj.value))
        assign(obj.name, obj.value, env = slider.env)
    else obj.value <- get(obj.name, env = slider.env)
    return(obj.value)
}
if (missing(title))
    title <- "slider control widget"
if (missing(sl.names)) {
    sl.defaults <- sl.names <- NULL
}
if (missing(sl.functions))
    sl.functions <- function(...) {
    }
# require(tcltk) # now in the depends section of the package
nt <- tktoplevel()
tkwm.title(nt, title)
tkwm.geometry(nt, "+0+15")
assign("tktop.slider", nt, env = slider.env)
"relax"
for (i in seq(sl.names)) {
    "relax"
    eval(parse(text = paste("assign('slider", i, "',tclVar(sl.defaults[i]),env=slider.env)",
        sep = "")))
    tkpack(fr <- tkframe(nt))
    lab <- tklabel(fr, text = sl.names[i], width = "25")
    sc <- tkscale(fr, from = sl.mins[i], to = sl.maxs[i],
        showvalue = TRUE, resolution = sl.deltas[i], orient = "horiz")
    tkpack(lab, sc, side = "right")
    assign("sc", sc, env = slider.env)
    eval(parse(text = paste("tkconfigure(sc,variable=slider",
        i, ")", sep = "")), env = slider.env)
    sl.fun <- if (length(sl.functions) > 1)
        sl.functions[[i]]
    else sl.functions
    if (!is.function(sl.fun))
        sl.fun <- eval(parse(text = paste("function(...){",
            sl.fun, "}")))
    tkbind(sc, "<ButtonRelease>", sl.fun)
}
assign("slider.values.old", sl.defaults, env = slider.env)
tkpack(f.but <- tkframe(nt), fill = "x")
tkpack(tkbutton(f.but, text = "Exit", command = function() tkdestroy(nt)),
    side = "right")
if (!missing(reset.function)) {
    if (!is.function(reset.function))
        reset.function <- eval(parse(text = paste("function(...){",
            reset.function, "}")))
    tkpack(tkbutton(f.but, text = "Reset", command = function() {
        for (i in seq(sl.names)) eval(parse(text = paste("tclvalue(slider",
            i, ")<-", sl.defaults[i], sep = "")), env = slider.env)
        reset.function()
    }), side = "right")
}
if (missing(but.names))
    but.names <- NULL
for (i in seq(but.names)) {
    but.fun <- if (length(but.functions) > 1)
        but.functions[[i]]
    else but.functions
    if (!is.function(but.fun))
        but.fun <- eval(parse(text = c("function(...){",
            but.fun, "}")))
    tkpack(tkbutton(f.but, text = but.names[i], command = but.fun),
        side = "left")
```

```
    }
    invisible(nt)
}
```