A GUI-Builder Approach to Grid Graphics

December 18, 2001

⟨*⟩≡

Grid contains a lot of support for locating, sizing, and arranging graphical components on a device and with respect to each other. However, most of this support relies on *either* the parent object dictating both location and size (layouts) *or* the child dictating both location and size.

Some sorts of arrangements are more conveniently handled by having the parent dictate the location, but letting the child dictate the size. This is the situation for GUI-builders (software which forms arrangements of GUI components or widgets). The approach taken by (many ?) GUI-builders is to allow the user to create a parent *frame* and then *pack* widgets into this frame. The frame locates and arranges the children with the help of hints such as "place this widget at the bottom of the frame", and the children dictate what size they would like to be.

This document describes a first attempt at such an interface for arranging Grid graphical objects.

The `"frame"` grob

You can create a `"frame"` graphical object using the function `grid.frame()`. This function never produces any output, but it is still important that you specify `draw=TRUE` if you want to "pack" the frame interactively. Conversely, if you want to pack the frame first and then view it, it is important that you specify `draw=FALSE` (the default).

It is *very* important that you assign the result to something. The `grid.pack()` function requires a reference to the `"frame"` object that is being packed.

⟨*frame*⟩≡

```
gf <- grid.frame()
```

The `grid.pack` function

Having created a frame, you can then pack other graphical objects into it using the `grid.pack()` function. This function has a complex interface which allows for a variety of methods of packing graphical objects. The required arguments are:

`frame` is a `"frame"` object created by `grid.frame`.

`grob` is the grob to pack into the frame.

The remaining arguments specify where the grob is located in the frame and possibly how much space the grob should occupy. The frame is effectively just a layout; you can add grobs to existing rows and columns or you can append the grob in a new row and/or column. If the grob is added to an existing row (column) then the height (width) of that row (column) becomes the maximum of the new height (width) and the previous height (width). If the row (column) is new then it just gets the specified height (width).

`col` is the column to put the grob in. This can be 1 greater than the existing number of columns (in which case a new column is added).

`row` is like `col` but for rows.

`col.after` specifies that the grob should be put in a new column inserted between `col.after` and `col.after + 1`.

`col.before` specifies that the grob should be put in a new column inserted between `col.before` and `col.before + 1`.

`row.after` **and** `row.before` do what you would expect.

`side` specifies which side to append the new grob to. The valid values are `"left"`, `"right"`, `"bottom"`, and `"top"`.

`width` is the width of the row that the grob is being packed into. If this is not given then the grob supplies the width.

`height` is like `width` but for rows.

It is possible to modify this default behaviour. For example, it is possible to add a grob to a row and force that row to have the specified height by setting `force.height=TRUE` (and similarly for column widths). It is also possible to pack a graphical object into several rows or columns at once (although you cannot simultaneously affect the heights or widths of those rows and columns).

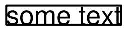
`"grobwidth"` and `"grobheight"` units

A `"frame"` object allows a grob to specify its size by making use of `"grobwidth"` and `"grobheight"` units. These units may, of course, be used outside of frames too so their use is described here.

Consider a simple example where I want to draw a rectangle around a piece of text. I can get the size of the piece of text from the `"text"` grob as follows:

⟨*simpleGrobWidthHeight*⟩≡

```
my.text <- grid.text("some text")
grid.rect(width=unit(1, "grobwidth", my.text),
          height=unit(1, "grobheight", my.text))
```



You could do the same thing with simple "strwidth" and "strheight" units, but "grobwidth" and "grobheight" give you a lot more power. The biggest gain is that you can get the size of other objects besides pieces of text (more on that soon), but there are more subtle advantages too. Going back to the simple example above, we have more than just the string label of the "text" function stored in our unit; we have information about the entire drawing context specific to that unit. Look at what happens if I modify that context:

⟨*subtleGrobWidthHeight*⟩≡
```
grid.edit(my.text, gp=gpar(fontsize=20))
```

Similarly, I can change features of the text itself:

⟨*subtleGrobWidthHeight*⟩+≡
```
grid.edit(my.text, label="some different text")
```

The width.details and height.details generic functions

The calculation of "grobwidth" and "grobheight" units is a bit complicated, but fortunately most of it is automated. The simple part is that a grob provides a normal "unit" object to express its width or height. The complication comes because that "unit" object has to be evaluated in the correct context. This typically just means that the grob's graphical parameter settings have to be enforced, and these operations are automated just as they are for drawing grobs (as long as the graphical parameters are in a slot called gp).

All that needs to be written (usually) are the functions that provide the "unit" objects. These functions need to be width.details and height.details methods.

The default methods return unit(1, "null") so your grob will be of this size unless you write your own methods.

The classic example methods are those for "text" grobs; these return unit(1, "mystrwidth", <text grob label>) and unit(1, "mystrheight", <text grob label>) respectively.

The other very important examples of these methods are those for "frame" grobs. These return the sum of the widths (heights) of the columns (rows) of the layout that has been built up by packing grobs into the frame. This means that when a "frame" grob is packed within another "frame" grob the parent automatically leaves enough room for the child.

Another useful pair of examples are those for "rect" grobs. These methods make use of the absolute.size function. When a grob is asked to specify its size, it makes sense to respond with the grob's width and height if the grob has an "absolute" size (e.g., "inches", "cm", "lines", etc; "i.e., the grob knows exactly how big itself is). On the other hand, it does not make sense to respond with the grob's width and height if the grob has a "relative" size (e.g., "npc" or "native"; i.e., the grob needs to know about it's parent's size before it can figure out its own). The absolute.size function leaves absolute units alone, but converts relative units to "null" units (i.e., the child says to the parent, "you decide how big I should be"), so you can return something like absolute.size(<grob>$width) in order to always give a sensible answer.

In some cases there will be a need for additional methods to be written. The width.pre.details and width.post.details generic functions (and their "height" counterparts) are provided for this purpose. Methods may be written to allow you to alter gpar settings in different ways. Note, however, that it is **very** important that the post method reverses all operations performed in the pre method (i.e., resets gpars).

Examples

The original motivating example for this GUI-builder approach was to be able to produce a quite general-purpose legend grob.

A legend consists of data symbols and associated textual descriptions. In order to be quite general, it would be nice to allow, for example, multiple lines of text per data symbol. Rather than having to look at the text supplied for the legend in order to determine the arrangement of the legend, it would be nice to be able to simply specify the composition of the legend and let it figure out the arrangement for us. The code below defines just such a legend grob, using the new `"frame"` grob and `grid.pack()` function. Some points to note are:

- The use of `border`s to create space around the legend components.
- The size of the data symbol component is specified, but the size of the text components are taken from the `"text"` grobs.
- The heights of the rows in the legend will be the maximum of `vgap` + `unit(1, "lines")` and `vgap` + `unit(1, "grobheight", <text grob>)`.

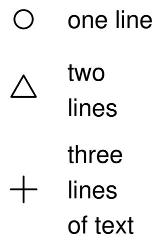
⟨*frame*⟩+≡

```
grid.legend <- function(pch, labels, frame=TRUE,
                        hgap=unit(1, "lines"), vgap=unit(1, "lines"),
                        default.units="lines", draw=TRUE,
                        vp=NULL) {
  nkeys <- length(labels)
  gf <- grid.frame(vp=vp, draw=FALSE)
  for (i in 1:nkeys) {
    if (i == 1) {
        symbol.border <- unit.c(vgap, hgap, vgap, hgap)
        text.border <- unit.c(vgap, unit(0, "npc"), vgap,
            hgap)
    }
    else {
        symbol.border <- unit.c(vgap, hgap, unit(0, "npc"),
            hgap)
        text.border <- unit.c(vgap, unit(0, "npc"), unit(0,
            "npc"), hgap)
    }
    grid.pack(gf, grid.points(0.5, 0.5, pch=pch[i], draw=FALSE),
        col=1, row=i, border=symbol.border, width=unit(1,
            "lines"), height=unit(1, "lines"), force.width=TRUE,
        draw=FALSE)
    grid.pack(gf, grid.text(labels[i], x=0, y=0.5, just=c("left",
        "centre"), draw=FALSE), col=2, row=i, border=text.border,
        draw=FALSE)
  }
  if (draw)
    grid.draw(gf)
  gf
}
```

The next piece of code shows the `grid.legend()` function being used procedurally; the output is shown below the code.

$\langle$*frame1*$\rangle\equiv$

```
grid.legend(1:3, c("one line", "two\nlines", "three\nlines\nof text"))
```



The legend example might not seem too difficult to do by hand rather than using frames and packing, but the next example shows how useful it can be.

Suppose you want to arrange a legend next to a plot. This requires leaving enough space for the legend and then filling the remaining space with the plot. This requires figuring out how much space the legend needs, and that is a task that is neither trivial nor easy to cater for in the general case. Ideally, we want to know as little as possible about the legend.

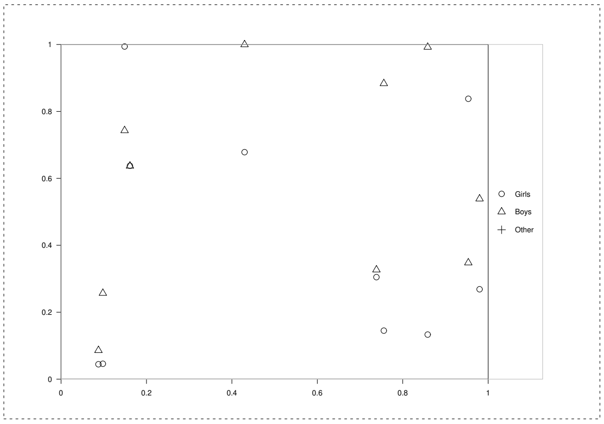
With the GUI-builder approach this becomes extremely simple. The code below shows how the construction of such a scene might be performed; the output from the code is again shown below.

The following points are noteworthy:

- We don't need to know anything about how the legend was constructed; it could be any sort of grob.
- We specify the height of the legend to be `unit(1, "null")` so that it will occupy the full height of the plot. If we did not do this then the plot would be forced to be the height of the legend (because of the way that `"null"` units interact with other units).
- The width of the legend is calculated from the contents of the legend because the legend is a `"frame"` grob.
- The dimensions of the "plot" default to `unit(1, "null")` because `"collection"` grobs have no width or height methods, which means that the plot fills up whatever space remains once the legend has been accomodated.

⟨*frame2*⟩≡

```
top.vp <- viewport(w=0.8, h=0.8)
push.viewport(top.vp)
x <- runif(10)
y1 <- runif(10)
y2 <- runif(10)
pch <- 1:3
labels <- c("Girls", "Boys", "Other")
gf <- grid.frame()
plot <- grid.collection(grid.rect(draw=F),
                        grid.points(x, y1, pch=1, draw=F),
                        grid.points(x, y2, pch=2, draw=F),
                        grid.xaxis(draw=F),
                        grid.yaxis(draw=F),
                        draw=F)
grid.pack(gf, plot)
grid.pack(gf, grid.legend(pch, labels, draw=F),
          height=unit(1,"null"), side="right")
grid.rect(gp=gpar(col="grey"))
pop.viewport()
grid.rect(gp=gpar(lty="dashed"), w=.99, h=.99)
```



Problems

1. This frame-and-packing stuff is easier to use, *but* (in almost all cases) it is less efficient than specifying the arrangement by hand. There is consequently a penalty to pay in terms of memory (inconsequential I think) and in terms of speed (noticeably slower).

   Perhaps one sensible use of these functions is to build an image interactively using the simple arguments, which will be slow, then attempt to speed up the drawing by exploring some of the more advanced arguments.

   One way to speed things up a bit is to specify the layout when the frame is initially created and then use the `grid.place` function to put grobs into existing rows and columns.

   The speed penalty in the cases I have seen are mostly due to the time taken to generate the (sometimes very) complicated unit objects that express the heights and widths of the rows and columns of the frame layout. Future effort will be put into speeding up the creation of unit objects.