R for Public Health

Wednesday, November 13, 2013

ggplot2: Cheatsheet for Scatterplots

The graphics package ggplot2 is powerful, aesthetically pleasing, and (after a short learning curve to understand the syntax) easy to use. I have made some pretty cool plots with it, but on the whole I find myself making a lot of the same ones, since doing something over and over again is generally how research goes. Since I constantly forget the options that I need to customize my plots, this next series of posts will serve as cheatsheets for scatterplots, barplots, and density plots. We start with scatterplots.

Quick Intro to ggplot2

The way ggplot2 works is by layering components of your plot on top of each other. You start with the basic of the data you want your plot to include (x and y variables), and then layer on top the kind of plotting colors/symbols you want, the look of the x- and y-axes, the background color, etc. You can also easily add regression lines and summary statistics.

For great reference guides, use the ggplot2 documentation or the R Graphs Cookbook.

In this post, we focus only on scatterplots with a continuous x and continuous y. We are going to use the mtcars data that is available through R.

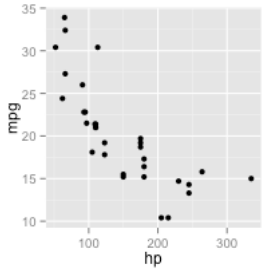
```
library(ggplot2)
library(gridExtra)
mtc <- mtcars
```

Here's the basic syntax of a scatterplot. We give it a dataframe, mtc, and then in the **aes()** statement, we give it an x-variable and a y-variable to plot. I save it as a ggplot object called p1, because we are going to use this as the base and then layer everything else on top:

```
# Basic scatterplot
p1 <- ggplot(mtc, aes(x = hp, y = mpg))
```

Now for the plot to print, we need to specify the next layer, which is how the symbols should look - do we want points or lines, what color, how big. Let's start with points:

```
# Print plot with default points
p1 + geom_point()
```



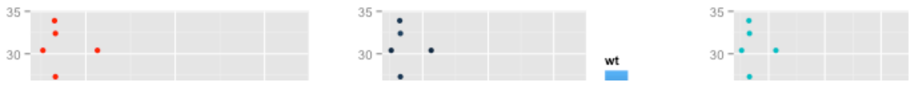
That's the bare bones of it. Now we have fun with adding layers. For each of the examples, I'm going to use the *grid.arrange()* function in the **gridExtra** package to create multiple graphs in one panel to save space.

>> Change color of points

We start with options for colors just by adding how we want to color our points in the geom_point() layer:

```
p2 <- p1 + geom_point(color="red")            #set one color for all points
p3 <- p1 + geom_point(aes(color = wt))        #set color scale by a
continuous variable
p4 <- p1 + geom_point(aes(color=factor(am)))  #set color scale by a factor
variable

grid.arrange(p2, p3, p4, nrow=1)
```



Data and Code Download

All data and code for this blog can be downloaded here:

Data and Code Download Site

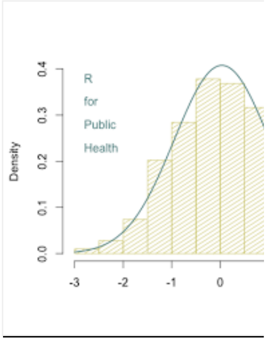
NB: It's been pointed out to me that s images don't show up on IE, so you'l switch to Chrome or Firefox if you are IE. Thanks!

Why R for public health?

I created this blog to help public hea researchers that are used to Stata or begin using R. I find that public healt unique and this blog is meant to add specific data management and analy needs of the world of public health.

R is a very powerful tool for program can have a steep learning curve. In r experience, people find it easier to d long way with another programming language, rather than try R, because takes longer to learn. I think all statis packages are useful and have their p the public health world. However, I a strong proponent of R and I hope thi can help you move toward using it w makes sense for you.

Please email me with posts you wou see or R questions, and I'll try my bes answer them. Thanks for following!



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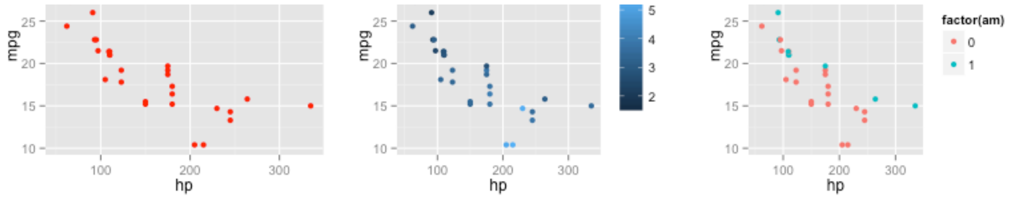
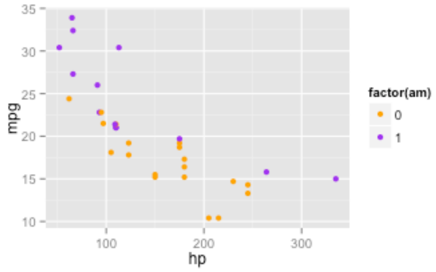


We can also change the default colors that are given by ggplot2 like this:

```
#Change default colors in color scale
p1 + geom_point(aes(color=factor(am))) + scale_color_manual(values =
c("orange", "purple"))
```

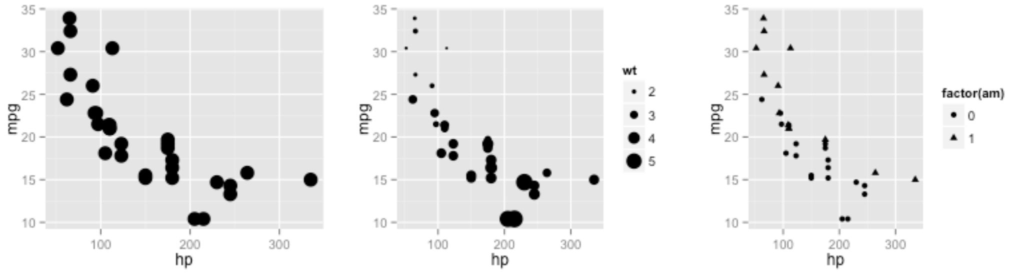


>> Change shape or size of points

We're sticking with the basic p1 plot, but now changing the shape and size of the points:

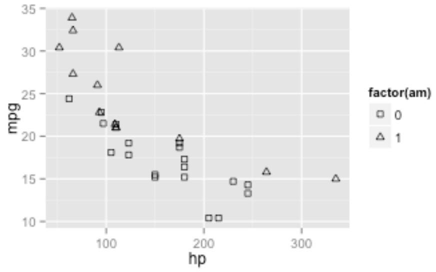
```
p2 <- p1 + geom_point(size = 5)                   #increase all points to
size 5
p3 <- p1 + geom_point(aes(size = wt))             #set point size by
continuous variable
p4 <- p1 + geom_point(aes(shape = factor(am)))    #set point shape by factor
variable

grid.arrange(p2, p3, p4, nrow=1)
```



Again, if we want to change the default shapes we can:

```
p1 + geom_point(aes(shape = factor(am))) + scale_shape_manual(values=c(0,2))
```



- More options for color and shape manual changes are here
- All shape and line types can be found here: **http://www.cookbook-r.com/Graphs/Shapes_and_line_types**

>> Add lines to scatterplot

```
p2 <- p1 + geom_point(color="blue") + geom_line()
#connect points with line
p3 <- p1 + geom_point(color="red") + geom_smooth(method = "lm", se = TRUE)
#add regression line
p4 <- p1 + geom_point() + geom_vline(xintercept = 100, color="red")
#add vertical line
```

Labels

aggregate (2) animation (1) apply (6)
categorical (2) cbind (3) character (3)
clustered (1) continuous (2) CSV (1) cut (1)
(7) date (1) density (1) DHS (1) distributio
message (2) Export (2) factor (1) functi
ggplot (4) ggplot2 (4) graph (4) his
ifelse (2) Import (1) knitr (1) label (1) late
logical (1) loop (1) matrix (6) names (2)
numeric (4) plot (7) power (1) F
regression (5) reshape (1) sample size
scatterplot (4) standard errors (1) stargaze
(4) subset (5) summary (5) table (3)
time (1) vector (5) xtable (1)

About Me

Slawa Rokicki

I am a doctoral student i
Policy at Harvard Univer
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reproductive health.

View my complete profile

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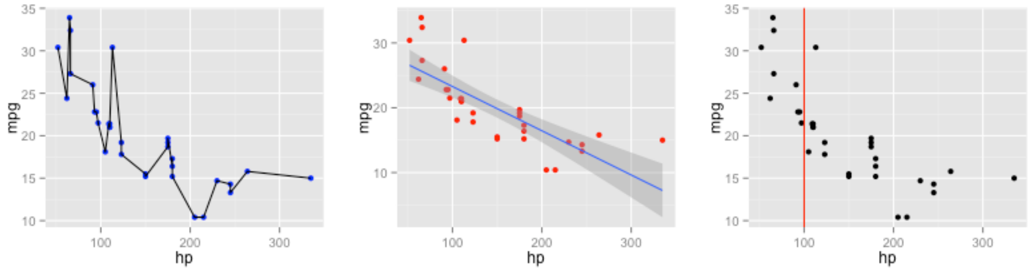
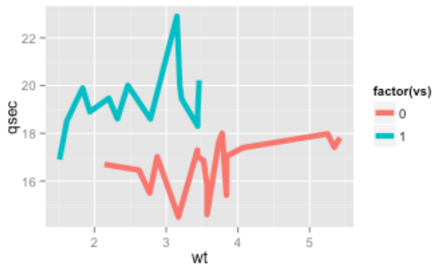
```
grid.arrange(p2, p3, p4, nrow=1)
```



You can also take out the points, and just create a line plot, and change size and color as before:

```
ggplot(mtc, aes(x = wt, y = qsec)) + geom_line(size=2,
aes(color=factor(vs)))
```

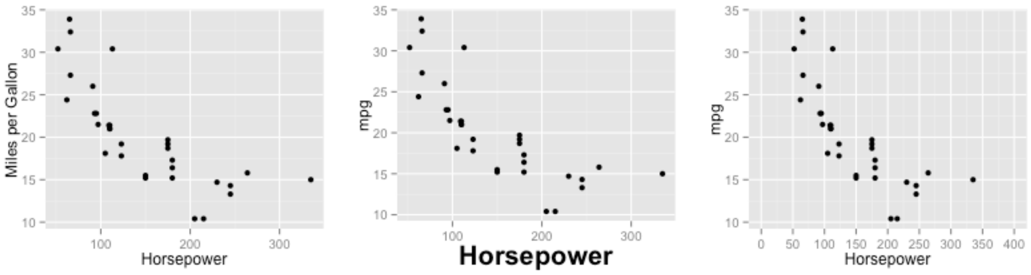


- More help on scatterplots can be found here: http://www.cookbook-r.com/Graphs/Scatterplots_(ggplot2)

>> Change axis labels

There are a few ways to do this. If you only want to quickly add labels you can use the *labs()* layer. If you want to change the font size and style of the label, then you need to use the *theme()* layer. More on this at the end of this post. If you want to change around the limits of the axis, and exactly where the breaks are, you use the *scale_x_continuous* (and *scale_y_continuous* for the y-axis).

```
p2 <- ggplot(mtc, aes(x = hp, y = mpg)) + geom_point()

p3 <- p2 + labs(x="Horsepower",
                y = "Miles per Gallon")
#label all axes at once

p4 <- p2 + theme(axis.title.x = element_text(face="bold", size=20)) +
          labs(x="Horsepower")
#label and change font size

p5 <- p2 + scale_x_continuous("Horsepower",
                              limits=c(0,400),
                              breaks=seq(0, 400, 50))
#adjust axis limits and breaks

grid.arrange(p3, p4, p5, nrow=1)
```



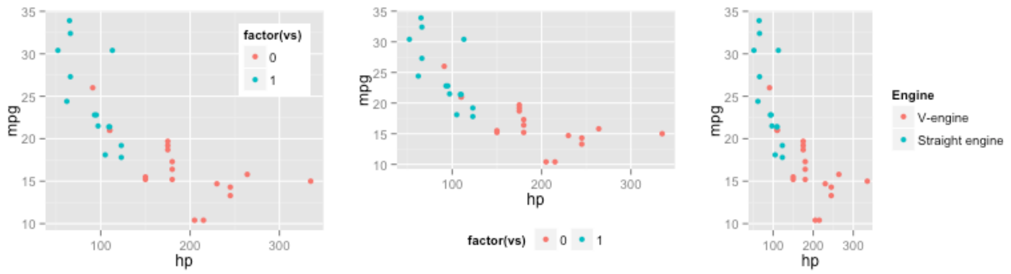
- More axis options can be found here: http://www.cookbook-r.com/Graphs/Axes_(ggplot2)

>> Change legend options

We start off by creating a new ggplot base object, g1, which colors the points by a factor variable. Then we show three basic options to modify the legend.

```
g1<-ggplot(mtc, aes(x = hp, y = mpg)) + geom_point(aes(color=factor(vs)))

g2 <- g1 + theme(legend.position=c(1,1),legend.justification=c(1,1))
#move legend inside
g3 <- g1 + theme(legend.position = "bottom")
#move legend bottom
```

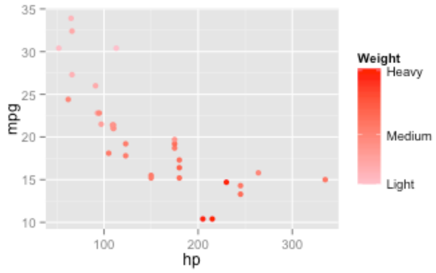
```
g4 <- g1 + scale_color_discrete(name ="Engine",
                                labels=c("V-engine", "Straight engine"))
#change labels

grid.arrange(g2, g3, g4, nrow=1)
```



If we had changed the shape of the points, we would use *scale_shape_discrete()* with the same options. We can also remove the entire legend altogether by using **theme(legend.position="none")**

Next we customize a legend when the scale is continuous:

```
g5<-ggplot(mtc, aes(x = hp, y = mpg)) + geom_point(size=2, aes(color = wt))
g5 + scale_color_continuous(name="Weight",
#name of legend
                            breaks = with(mtc, c(min(wt), mean(wt),
max(wt))), #choose breaks of variable
                            labels = c("Light", "Medium", "Heavy"),
#label
                            low = "pink",
#color of lowest value
                            high = "red")
#color of highest value
```



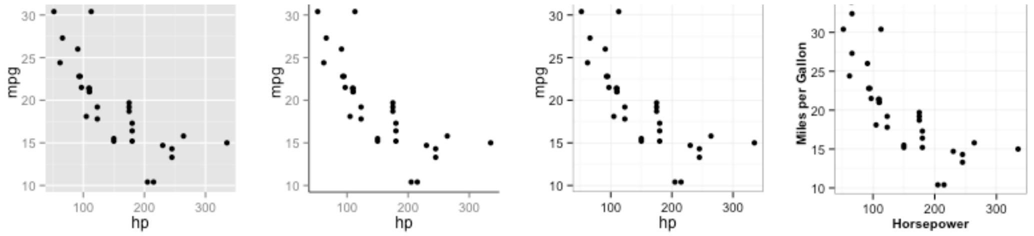
- More legend options can be found here: http://www.cookbook-r.com/Graphs/Legends_(ggplot2)

>> Change background color and style

The look of the plot in terms of the background colors and style is the **theme()**. I personally don't like the look of the default gray so here are some quick ways to change it. I often the theme_bw() layer, which gets rid of the gray.

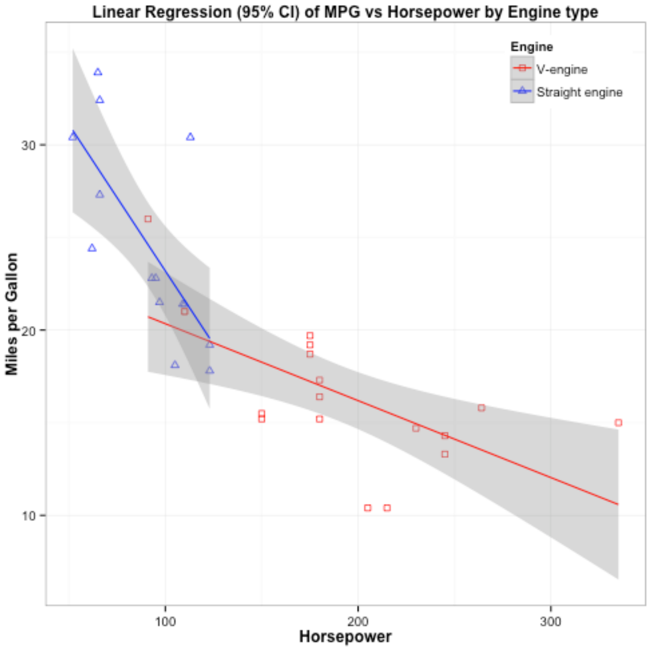
- All of the theme options can be found here.

```
g2<- ggplot(mtc, aes(x = hp, y = mpg)) + geom_point()

#Completely clear all lines except axis lines and make background white
t1<-theme(
  plot.background = element_blank(),
  panel.grid.major = element_blank(),
  panel.grid.minor = element_blank(),
  panel.border = element_blank(),
  panel.background = element_blank(),
  axis.line = element_line(size=.4)
)

#Use theme to change axis label style
t2<-theme(
  axis.title.x = element_text(face="bold", color="black", size=10),
  axis.title.y = element_text(face="bold", color="black", size=10),
  plot.title = element_text(face="bold", color = "black", size=12)
)


g3 <- g2 + t1
g4 <- g2 + theme_bw()
g5 <- g2 + theme_bw() + t2 + labs(x="Horsepower", y = "Miles per Gallon",
title= "MPG vs Horsepower")


grid.arrange(g2, g3, g4, g5, nrow=1)
```



Finally, here's a nice graph using a combination of options:

```
g2<- ggplot(mtc, aes(x = hp, y = mpg)) +
  geom_point(size=2, aes(color=factor(vs), shape=factor(vs))) +
  geom_smooth(aes(color=factor(vs)),method = "lm", se = TRUE) +
  scale_color_manual(name ="Engine",
                     labels=c("V-engine", "Straight engine"),
                     values=c("red","blue")) +
  scale_shape_manual(name ="Engine",
                     labels=c("V-engine", "Straight engine"),
                     values=c(0,2)) +
  theme_bw() +
  theme(
    axis.title.x = element_text(face="bold", color="black", size=12),
    axis.title.y = element_text(face="bold", color="black", size=12),
    plot.title = element_text(face="bold", color = "black", size=12),
    legend.position=c(1,1),
    legend.justification=c(1,1)) +
  labs(x="Horsepower",
       y = "Miles per Gallon",
       title= "Linear Regression (95% CI) of MPG vs Horsepower by Engine
type")

g2
```



>> Reader request: Display Regression Line Equation on Scatterplot

I received a request asking how to overlay the regression equation itself on a plot, so I've decided to update this post with that information.

There are two ways to put text on a ggplot: **annotate** or **geom_text()**. I was finding that the **geom_text()** layer did not look very nice on my screen so I checked up on it and it seems others have this issue as well. I'll show you how the two behave, at least in my version of everything I use on my mac.

We'll go back to the example where I add a regression line to the plot using **geom_smooth()**. To add text, you need to run the regression outside of ggplot, extract the coefficients, and then paste them together into some text that you can layer onto the plot.

We're plotting MPG against horsepower so we create an object m that stores the linear model, and then extract the coefficients using the **coef()** function. We envelope the **coef()** function with **signif()** in order to round the coefficients to two significant digits. I then paste the regression equation text together, using **sep=“”** in order to eliminate spaces.

```
m <- lm(mtc$mpg ~ mtc$hp)
a <- signif(coef(m)[1], digits = 2)
b <- signif(coef(m)[2], digits = 2)
textlab <- paste("y = ",b,"x + ",a, sep="")
print(textlab)
```

Posted by Slawa Rokicki at 11:56 AM

g+1 +14 Recommend this on Google

Labels: ggplot, ggplot2, plot, R, scatterplot

13 comments:

Duncan November 13, 2013 at 6:52 PM

Thanks! Very clear and helpful.

Reply

Edward Vanden Berghe November 14, 2013 at 1:14 AM

Indeed, very clear and helpful. One question: in your last example, you change both colour and shape to vary with vs. Having colour represent vs, and shape, say, am, is not a problem; but how does one construct a suitable legend?

Reply

Replies

Slawa Rokicki November 14, 2013 at 6:01 AM

Thanks! You would change scale_shape_manual and scale_color_manual accordingly. I took out the regression lines because it would be confusing but here is the plot with color by vs and shape by am with the legend:

```
g2<- ggplot(mtc, aes(x = hp, y = mpg)) +
geom_point(size=3, aes(color=factor(vs), shape=factor(am))) +
scale_color_manual(name ="Engine",
labels=c("V-engine", "Straight"),
values=c("red","blue")) +
scale_shape_manual(name ="Transmission",
labels=c("Automatic", "Manual"),
values=c(0,2)) +
theme_bw() +
theme(
axis.title.x = element_text(face="bold", color="black", size=12),
axis.title.y = element_text(face="bold", color="black", size=12),
plot.title = element_text(face="bold", color = "black", size=12),
legend.position=c(1,1),
legend.justification=c(1,1)) +
labs(x="Horsepower", y = "Miles per Gallon", title= "MPG vs Horsepower by Engine and Transmission")
```

Edward Vanden Berghe November 14, 2013 at 6:51 AM

Works like a charm. Thanks!

Sean S November 15, 2013 at 6:56 AM

Some of the plots are not loading (e.g. 4, 6, 8, 10, ...)

Slawa Rokicki November 15, 2013 at 7:02 AM

Hmm, they look fine to me. Which one specifically doesn't load? Or can you send me a screenshot?
srokicki@fas.harvard.edu

Reply

Daniele Medri November 15, 2013 at 12:31 PM

Thank you!

Reply

Fabz November 17, 2013 at 8:16 AM

Amazing!

Reply

Manoj Aravind March 13, 2014 at 10:33 PM

Hi Rokicki.. I'm also Public Health researcher and admire R very much. Its amazing to learn more of R from your blog. I liked this particular ggplot series on Scatterplot.. I would like to know how we can put the regression equation onto the plot, for example in your plot
p3 <- p1 + geom_point(color="red") + geom_smooth(method = "lm", se = TRUE) #add regression line

Thank you.

Reply

Replies

Slawa Rokicki March 14, 2014 at 12:30 PM

Hi Manoj, Great question! I have updated the Scatterplot blog post to answer it. Check out the last section now and I hope it helps! Thanks for reading.

Reply

Patrick April 7, 2014 at 2:06 PM

Thanks for sharing, that what useful. However, annotate() is a better way than geom_text(), as you can see from the poor, jagged annotations it produces, caused by printing over and over. See http://stackoverflow.com/questions/11618392/ggplot-text-printed-by-geom-text-is-not-clear

Reply

Nick Staresinic May 24, 2014 at 6:02 AM

Thank you very much for taking the initiative to organize this very useful information in a clear and concise way.

I recently finished MITx's excellent 15.071x MOOC in data analytics, and this post plus your

http://www.r-bloggers.com/ggplot2-cheatsheet-for-visualizing-distributions/

complement the visualization unit of that course very well.

Reply

Replies

Slawa Rokicki May 24, 2014 at 11:03 AM

Thanks Nick! I'm really glad it's helpful. That class sounds really interesting. I'll check it out.

Reply

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