

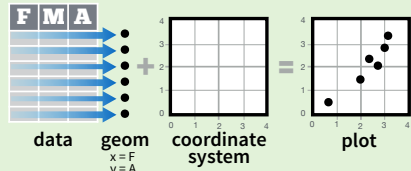
Data Visualization with ggplot2

Cheat Sheet

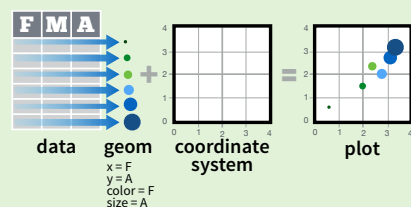


Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same few components: a **data** set, a set of **geoms**—visual marks that represent data points, and a **coordinate system**.



To display data values, map variables in the data set to aesthetic properties of the geom like **size**, **color**, and **x** and **y** locations.



Build a graph with **qplot()** or **ggplot()**

aesthetic mappings **data** **geom**

qplot(x = cty, y = hwy, color = cyl, data = mpg, geom = "point")

Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.

ggplot(data = mpg, aes(x = cty, y = hwy))

Begins a plot that you finish by adding layers to. No defaults, but provides more control than qplot().

data

```
ggplot(mpg, aes(hwy, cty)) +  
  geom_point(aes(color = cyl)) +  
  geom_smooth(method = "lm") +  
  coord_cartesian() +  
  scale_color_gradient() +  
  theme_bw()
```

add layers,
elements with +

layer = geom +
default stat +
layer specific
mappings

additional
elements

Add a new layer to a plot with a **geom_*()** or **stat_*()** function. Each provides a geom, a set of aesthetic mappings, and a default stat and position adjustment.

last_plot()

Returns the last plot

ggsave("plot.png", width = 5, height = 5)

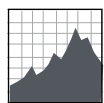
Saves last plot as 5' x 5' file named "plot.png" in working directory. Matches file type to file extension.

Geoms - Use a geom to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

One Variable

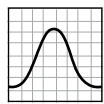
Continuous

a <- ggplot(mpg, aes(hwy))



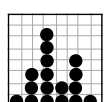
a + geom_area(stat = "bin")

x, y, alpha, color, fill, linetype, size
b + geom_area(aes(y = ..density..), stat = "bin")



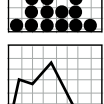
a + geom_density(kernel = "gaussian")

x, y, alpha, color, fill, linetype, size, weight
b + geom_density(aes(y = ..count..))



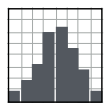
a + geom_dotplot()

x, y, alpha, color, fill



a + geom_freqpoly()

x, y, alpha, color, linetype, size
b + geom_freqpoly(aes(y = ..density..))

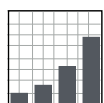


a + geom_histogram(binwidth = 5)

x, y, alpha, color, fill, linetype, size, weight
b + geom_histogram(aes(y = ..density..))

Discrete

b <- ggplot(mpg, aes(fl))

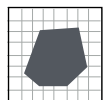


b + geom_bar()

x, alpha, color, fill, linetype, size, weight

Graphical Primitives

c <- ggplot(map, aes(long, lat))



c + geom_polygon(aes(group = group))

x, y, alpha, color, fill, linetype, size

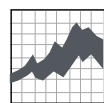
d <- ggplot(economics, aes(date, unemploy))



d + geom_path(lineend="butt",

linejoin="round", linemitre=1)

x, y, alpha, color, linetype, size

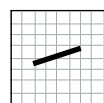


d + geom_ribbon(aes(ymin=unemploy - 900,

ymin=unemploy + 900))

x, ymax, ymin, alpha, color, fill, linetype, size

e <- ggplot(seals, aes(x = long, y = lat))

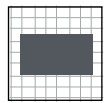


e + geom_segment(aes(

xend = long + delta_long,

yend = lat + delta_lat))

x, xend, y, yend, alpha, color, linetype, size



e + geom_rect(aes(xmin = long, ymin = lat,

xmax = long + delta_long,

ymax = lat + delta_lat))

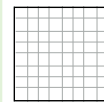
xmax, xmin, ymax, ymin, alpha, color, fill,

linetype, size

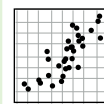
Two Variables

Continuous X, Continuous Y

f <- ggplot(mpg, aes(cty, hwy))

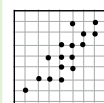


f + geom_blank()



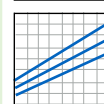
f + geom_jitter()

x, y, alpha, color, fill, shape, size



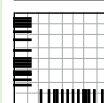
f + geom_point()

x, y, alpha, color, fill, shape, size



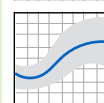
f + geom_quantile()

x, y, alpha, color, linetype, size, weight



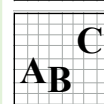
f + geom_rug(sides = "bl")

alpha, color, linetype, size



f + geom_smooth(model = lm)

x, y, alpha, color, fill, linetype, size, weight



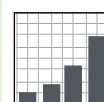
f + geom_text(aes(label = cty))

x, y, label, alpha, angle, color, family, fontface,

hjust, lineheight, size, vjust

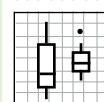
Discrete X, Continuous Y

g <- ggplot(mpg, aes(class, hwy))



g + geom_bar(stat = "identity")

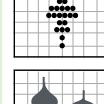
x, y, alpha, color, fill, linetype, size, weight



g + geom_boxplot()

lower, middle, upper, x, ymax, ymin, alpha,

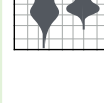
color, fill, linetype, shape, size, weight



g + geom_dotplot(binaxis = "y",

stackdir = "center")

x, y, alpha, color, fill

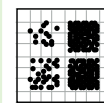


g + geom_violin(scale = "area")

x, y, alpha, color, fill, linetype, size, weight

Discrete X, Discrete Y

h <- ggplot(diamonds, aes(cut, color))



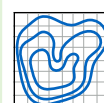
h + geom_jitter()

x, y, alpha, color, fill, shape, size

Three Variables

seals\$z <- with(seals, sqrt(delta_long^2 + delta_lat^2))

m <- ggplot(seals, aes(long, lat))

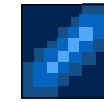


m + geom_contour(aes(z = z))

x, y, z, alpha, colour, linetype, size, weight

Continuous Bivariate Distribution

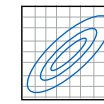
i <- ggplot(movies, aes(year, rating))



i + geom_bin2d(binwidth = c(5, 0.5))

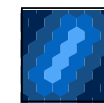
xmax, xmin, ymax, ymin, alpha, color, fill,

linetype, size, weight



i + geom_density2d()

x, y, alpha, colour, linetype, size

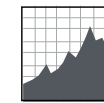


i + geom_hex()

x, y, alpha, colour, fill size

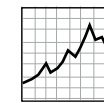
Continuous Function

j <- ggplot(economics, aes(date, unemploy))



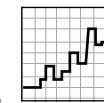
j + geom_area()

x, y, alpha, color, fill, linetype, size



j + geom_line()

x, y, alpha, color, linetype, size



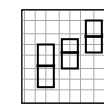
j + geom_step(direction = "hv")

x, y, alpha, color, linetype, size

Visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)

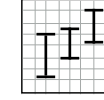
k <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))



k + geom_crossbar(fatten = 2)

x, y, ymax, ymin, alpha, color, fill, linetype,

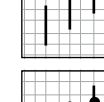
size



k + geom_errorbar()

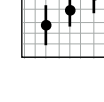
x, ymax, ymin, alpha, color, linetype, size,

width (also **geom_errorbarh**())



k + geom_linerange()

x, ymin, ymax, alpha, color, linetype, size



k + geom_pointrange()

x, y, ymin, ymax, alpha, color, fill, linetype,

shape, size

Maps

data <- data.frame(murder = USArrests\$Murder,

state = tolower(rownames(USArrests)))

map <- map_data("state")

l <- ggplot(data, aes(fill = murder))



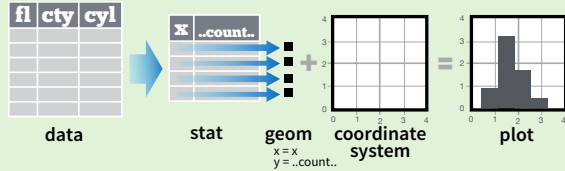
l + geom_map(aes(map_id = state), map = map) +

expand_limits(x = map\$long, y = map\$lat)

map_id, alpha, color, fill, linetype, size

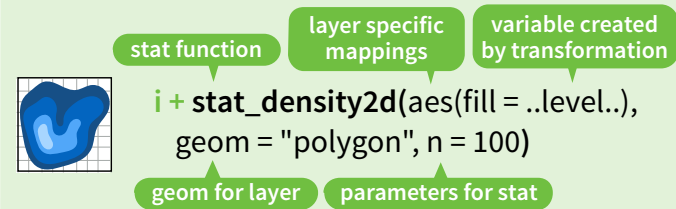
Stats - An alternative way to build a layer

Some plots visualize a **transformation** of the original data set. Use a **stat** to choose a common transformation to visualize, e.g. `a + geom_bar(stat = "bin")`



Each stat creates additional variables to map aesthetics to. These variables use a common **..name..** syntax.

stat functions and geom functions both combine a stat with a geom to make a layer, i.e. `stat_bin(geom="bar")` does the same as `geom_bar(stat="bin")`



1D distributions

- `a + stat_bin(binwidth = 1, origin = 10)`
x, y | ..count.., ..ncount.., ..density.., ..ndensity..
- `a + stat_bindot(binwidth = 1, binaxis = "x")`
x, y, | ..count.., ..ncount..
- `a + stat_density(adjust = 1, kernel = "gaussian")`
x, y, | ..count.., ..density.., ..scaled..

2D distributions

- `f + stat_bin2d(bins = 30, drop = TRUE)`
x, y, fill | ..count.., ..density..
- `f + stat_binhex(bins = 30)`
x, y, fill | ..count.., ..density..
- `f + stat_density2d(contour = TRUE, n = 100)`
x, y, color, size | ..level..

3 Variables

- `m + stat_contour(aes(z = z))`
x, y, z, order | ..level..
- `m + stat_spoke(aes(radius = z, angle = z))`
angle, radius, x, xend, y, yend | ..x.., ..xend.., ..y.., ..yend..
- `m + stat_summary_hex(aes(z = z), bins = 30, fun = mean)`
x, y, z, fill | ..value..
- `m + stat_summary2d(aes(z = z), bins = 30, fun = mean)`
x, y, z, fill | ..value..

Comparisons

- `g + stat_boxplot(coef = 1.5)`
x, y | ..lower.., ..middle.., ..upper.., ..outliers..
- `g + stat_ydensity(adjust = 1, kernel = "gaussian", scale = "area")`
x, y | ..density.., ..scaled.., ..count.., ..n.., ..violinwidth.., ..width..

Functions

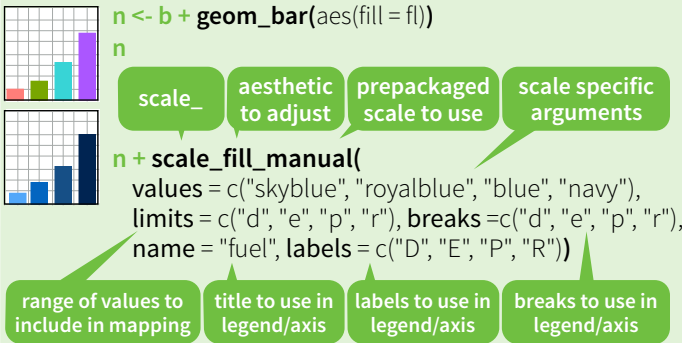
- `f + stat_ecdf(n = 40)`
x, y | ..x.., ..y..
- `f + stat_quantile(quantiles = c(0.25, 0.5, 0.75), formula = y ~ log(x), method = "rq")`
x, y | ..quantile.., ..x.., ..y..
- `f + stat_smooth(method = "auto", formula = y ~ x, se = TRUE, n = 80, fullrange = FALSE, level = 0.95)`
x, y | ..se.., ..x.., ..y.., ..ymin.., ..ymax..

General Purpose

- `ggplot() + stat_function(aes(x = -3:3), fun = dnorm, n = 101, args = list(sd = 0.5))`
x | ..y..
- `f + stat_identity()`
- `ggplot() + stat_qq(aes(sample = 1:100), distribution = qt, dparams = list(df = 5))`
sample, x, y | ..x.., ..y..
- `f + stat_sum()`
x, y, size | ..size..
- `f + stat_summary(fun.data = "mean_cl_boot")`
- `f + stat_unique()`

Scales

Scales control how a plot maps data values to the visual values of an aesthetic. To change the mapping, add a custom scale.



General Purpose scales

Use with any aesthetic:
alpha, color, fill, linetype, shape, size

- `scale_*_continuous()` - map cont' values to visual values
- `scale_*_discrete()` - map discrete values to visual values
- `scale_*_identity()` - use data values as visual values
- `scale_*_manual(values = c())` - map discrete values to manually chosen visual values

X and Y location scales

Use with x or y aesthetics (x shown here)

- `scale_x_date(labels = date_format("%m/%d"), breaks = date_breaks("2 weeks"))` - treat x values as dates. See ?strptime for label formats.
- `scale_x_datetime()` - treat x values as date times. Use same arguments as `scale_x_date()`.
- `scale_x_log10()` - Plot x on log10 scale
- `scale_x_reverse()` - Reverse direction of x axis
- `scale_x_sqrt()` - Plot x on square root scale

Color and fill scales

Discrete

- `n + geom_bar(aes(fill = fl))`
- `n + scale_fill_brewer(palette = "Blues")`
For palette choices:
library(RColorBrewer)
display.brewer.all()
- `n + scale_fill_grey(start = 0.2, end = 0.8, na.value = "red")`

Continuous

- `o + geom_dotplot(aes(fill = ..x..))`
- `o + scale_fill_gradient(low = "red", high = "yellow")`
- `o + scale_fill_gradient2(low = "red", high = "blue", mid = "white", midpoint = 25)`
- `o + scale_fill_gradientn(colours = terrain.colors(6))`
Also: rainbow(), heat.colors(), topo.colors(), cm.colors(), RColorBrewer::brewer.pal()

Shape scales

- `p + geom_point(aes(shape = fl))`
- `p + scale_shape(solid = FALSE)`
- `p + scale_shape_manual(values = c(3:7))`
Shape values shown in chart on right

Manual shape values				
0	6	12	18	24
1	7	13	19	25
2	8	14	20	*
3	9	15	21	
4	10	16	22	o
5	11	17	23	o

Size scales

- `q + geom_point(aes(size = cyl))`
- `q + scale_size_area(max = 6)`
Value mapped to area of circle (not radius)

Coordinate Systems

- `r + geom_bar()`
xlim, ylim
The default cartesian coordinate system
- `r + coord_fixed(ratio = 1/2)`
ratio, xlim, ylim
Cartesian coordinates with fixed aspect ratio between x and y units
- `r + coord_flip()`
xlim, ylim
Flipped Cartesian coordinates
- `r + coord_polar(theta = "x", direction = 1)`
theta, start, direction
Polar coordinates
- `r + coord_trans(ytrans = "sqrt")`
xtrans, ytrans, limx, limy
Transformed cartesian coordinates. Set extras and strains to the name of a window function.
- `z + coord_map(projection = "ortho", orientation = c(41, -74, 0))`
projection, orientation, xlim, ylim
Map projections from the mapproj package (mercator (default), azequalarea, lagrange, etc.)

Position Adjustments

Position adjustments determine how to arrange geoms that would otherwise occupy the same space.

- `s + ggplot(mpg, aes(fl, fill = drv))`
- `s + geom_bar(position = "dodge")`
Arrange elements side by side
- `s + geom_bar(position = "fill")`
Stack elements on top of one another, normalize height
- `s + geom_bar(position = "stack")`
Stack elements on top of one another
- `f + geom_point(position = "jitter")`
Add random noise to X and Y position of each element to avoid overplotting

Each position adjustment can be recast as a function with manual **width** and **height** arguments

`s + geom_bar(position = position_dodge(width = 1))`

Themes

- `r + theme_bw()`
White background with grid lines
- `r + theme_classic()`
White background no gridlines
- `r + theme_grey()`
Grey background (default theme)
- `r + theme_minimal()`
Minimal theme

ggthemes - Package with additional ggplot2 themes

Faceting

Facets divide a plot into subplots based on the values of one or more discrete variables.

- `t + ggplot(mpg, aes(cty, hwy)) + geom_point()`
- `t + facet_grid(. ~ fl)`
facet into columns based on fl
- `t + facet_grid(year ~ .)`
facet into rows based on year
- `t + facet_grid(year ~ fl)`
facet into both rows and columns
- `t + facet_wrap(~ fl)`
wrap facets into a rectangular layout

Set **scales** to let axis limits vary across facets

- `t + facet_grid(y ~ x, scales = "free")`
x and y axis limits adjust to individual facets
- **"free_x"** - x axis limits adjust
- **"free_y"** - y axis limits adjust

Set **labeller** to adjust facet labels

- `t + facet_grid(. ~ fl, labeller = label_both)`
- | | | | | |
|------------|------------|------------|------------|------------|
| fl: c | fl: d | fl: e | fl: p | fl: r |
| α^c | α^d | α^e | α^p | α^r |
- `t + facet_grid(. ~ fl, labeller = label_bquote(alpha ^ .(x)))`
- `t + facet_grid(. ~ fl, labeller = label_parsed)`
- | | | | | |
|---|---|---|---|---|
| c | d | e | p | r |
|---|---|---|---|---|

Labels

- `t + ggtitle("New Plot Title")`
Add a main title above the plot
- `t + xlab("New X label")`
Change the label on the X axis
- `t + ylab("New Y label")`
Change the label on the Y axis
- `t + labs(title = "New title", x = "New x", y = "New y")`
All of the above

Use scale functions to update legend labels

Legends

- `t + theme(legend.position = "bottom")`
Place legend at "bottom", "top", "left", or "right"
- `t + guides(color = "none")`
Set legend type for each aesthetic: colorbar, legend, or none (no legend)
- `t + scale_fill_discrete(name = "Title", labels = c("A", "B", "C"))`
Set legend title and labels with a scale function.

Zooming

- Without clipping (preferred)**
`t + coord_cartesian(xlim = c(0, 100), ylim = c(10, 20))`
- With clipping (removes unseen data points)**
`t + xlim(0, 100) + ylim(10, 20)`
`t + scale_x_continuous(limits = c(0, 100)) + scale_y_continuous(limits = c(0, 100))`