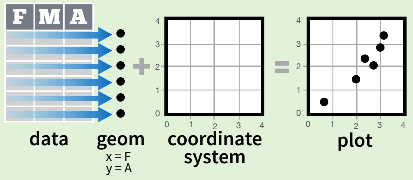
Data Visualization with ggplot2

Cheat Sheet

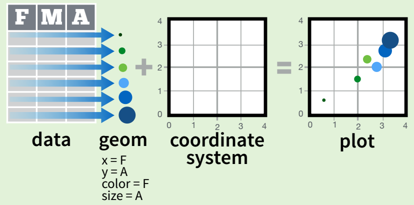
RStudio

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 **ggplot()** or **qplot()**

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.

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.

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.

Graphical Primitives

a <- ggplot(seals, aes(x = long, y = lat))
b <- ggplot(economics, aes(date, unemploy))

a + **geom_blank()**
(Useful for expanding limits)

a + **geom_curve(**aes(yend = lat + delta_lat, xend = long + delta_long, curvature = z)**)**
x, xend, y, yend, alpha, angle, color, curvature, linetype, size

b + **geom_path(**lineend="butt", linejoin="round', linemitre=1**)**
x, y, alpha, color, group, linetype, size

b + **geom_polygon(**aes(group = group)**)**
x, y, alpha, color, fill, group, linetype, size

a + **geom_rect(**aes(xmin = long, ymin = lat, xmax= long + delta_long, ymax = lat + delta_lat)**)**
xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

b + **geom_ribbon(**aes(ymin=unemploy - 900, ymax=unemploy + 900)**)**
x, ymax, ymin, alpha, color, fill, group, linetype, size

a + **geom_segment(**aes(yend=lat + delta_lat, xend = long + delta_long)**)**
x, xend, y, yend, alpha, color, linetype, size

a + **geom_spoke(**aes(yend = lat + delta_lat, xend = long + delta_long)**)**
x, y, angle, radius, alpha, color, linetype, size

One Variable

Continuous

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

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

c + **geom_density(**kernel = "gaussian"**)**
x, y, alpha, color, fill, group, linetype, size, weight

c + **geom_dotplot()**
x, y, alpha, color, fill

c + **geom_freqpoly()**
x, y, alpha, color, group, linetype, size
a + geom_freqpoly(aes(y = ..density..))

c + **geom_histogram(**binwidth = 5**)**
x, y, alpha, color, fill, linetype, size, weight
a + geom_histogram(aes(y = ..density..))

Discrete

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

d + **geom_bar()**
x, alpha, color, fill, linetype, size, weight

Two Variables

Continuous X, Continuous Y

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

e + **geom_label(**aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE**)**
x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

e + **geom_jitter(**height = 2, width = 2**)**
x, y, alpha, color, fill, shape, size

e + **geom_point()**
x, y, alpha, color, fill, shape, size, stroke

e + **geom_quantile()**
x, y, alpha, color, group, linetype, size, weight

e + **geom_rug(**sides = "bl"**)**
x, y, alpha, color, linetype, size

e + **geom_smooth(**method = lm**)**
x, y, alpha, color, fill, group, linetype, size, weight

e + **geom_text(**aes(label = cty), nudge_x = 1, nudge_y = 1, check_overlap = TRUE**)**
x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

Discrete X, Continuous Y

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

f + **geom_bar(stat = "identity")**
x, y, alpha, color, fill, linetype, size, weight

f + **geom_boxplot()**
x, y, lower, middle, upper, ymax, ymin, alpha, color, fill, group, linetype, shape, size, weight

f + **geom_dotplot(**binaxis = "y", stackdir = "center"**)**
x, y, alpha, color, fill, group

f + **geom_violin(**scale = "area"**)**
x, y, alpha, color, fill, group, linetype, size, weight

Discrete X, Discrete Y

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

g + **geom_count()**
x, y, alpha, color, fill, shape, size, stroke

Continuous Bivariate Distribution

h <- ggplot(diamonds, aes(carat, price))

h + **geom_bin2d(**binwidth = c(0.25, 500)**)**
x, y, alpha, color, fill, linetype, size, weight

h + **geom_density2d()**
x, y, alpha, colour, group, linetype, size

h + **geom_hex()**
x, y, alpha, colour, fill, size

Continuous Function

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

i + **geom_area()**
x, y, alpha, color, fill, linetype, size

i + **geom_line()**
x, y, alpha, color, group, linetype, size

i + **geom_step(**direction = "hv"**)**
x, y, alpha, color, group, linetype, size

Visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
j <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))

j + **geom_crossbar(**fatten = 2**)**
x, y, ymax, ymin, alpha, color, fill, group, linetype, size

j + **geom_errorbar()**
x, ymax, ymin, alpha, color, group, linetype, size, width (also **geom_errorbarh()**)

j + **geom_linerange()**
x, ymin, ymax, alpha, color, group, linetype, size

j + **geom_pointrange()**
x, y, ymin, ymax, alpha, color, fill, group, linetype, shape, size

Maps

data <- data.frame(murder = USArrests$Murder,
  state = tolower(rownames(USArrests)))
map <- map_data("state")
k <- ggplot(data, aes(fill = murder))

k + **geom_map(**aes(map_id = state), map = map**)** +
expand_limits(x = map$long, y = map$lat**)**
map_id, alpha, color, fill, linetype, size

Three Variables

seals$z <- with(seals, sqrt(delta_long^2 + delta_lat^2))
l <- ggplot(seals, aes(long, lat))

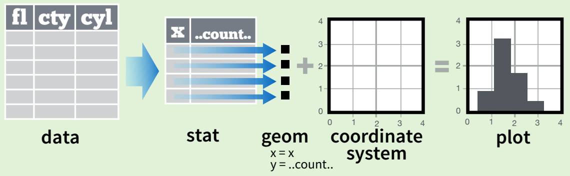
l + **geom_contour(**aes(z = z)**)**
x, y, z, alpha, colour, group, linetype, size, weight

l + **geom_raster(**aes(fill = z), hjust=0.5, vjust=0.5, interpolate=FALSE**)**
x, y, alpha, fill

l + **geom_tile(**aes(fill = z)**)**
x, y, alpha, color, fill, linetype, size, width

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 = "count")



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

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

stat function | layer mappings

i + **stat_density2d**(aes(fill = ..level..), geom = "polygon", n = 100)

variable created by transformation

geom for layer | parameters for stat

c + **stat_bin**(binwidth = 1, origin = 10) — 1D distributions
x, y | ..count.., ..ncount.., ..density.., ..ndensity..
c + **stat_count**(width = 1)
x, y, | ..count.., ..prop..
c + **stat_density**(adjust = 1, kernel = "gaussian")
x, y, | ..count.., ..density.., ..scaled..

e + **stat_bin_2d**(bins = 30, drop = TRUE) — 2D distributions
x, y, fill | ..count.., ..density..
e + **stat_bin_hex**(bins = 30)
x, y, fill | ..count.., ..density..
e + **stat_density_2d**(contour = TRUE, n = 100)
x, y, color, size | ..level..
e + **stat_ellipse**(level = 0.95, segments = 51, type = "t")

l + **stat_contour**(aes(z = z)) — 3 Variables
x, y, z, order | ..level..
l + **stat_summary_hex**(aes(z = z), bins = 30, fun = mean)
x, y, z, fill | ..value..
l + **stat_summary_2d**(aes(z = z), bins = 30, fun = mean)
x, y, z, fill | ..value..

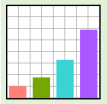
f + **stat_boxplot**(coef = 1.5) — Comparisons
x, y | ..lower.., ..middle.., ..upper.., ..width.. , ..ymin.., ..ymax..
f + **stat_ydensity**(adjust = 1, kernel = "gaussian", scale = "area")
x, y | ..density.., ..scaled.., ..count.., ..n.., ..violinwidth.., ..width..

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

ggplot() + **stat_function**(aes(x = -3:3), fun = dnorm, n = 101, args = list(sd=0.5)) — General Purpose
x | ..x.., ..y..
e + **stat_identity**(na.rm = TRUE)
ggplot() + **stat_qq**(aes(sample=1:100), distribution = qt, dparams = list(df=5))
sample, x, y | ..sample.., ..theoretical..
e + **stat_sum()**
x, y, size | ..n.., ..prop..
e + **stat_summary**(fun.data = "mean_cl_boot")
h + **stat_summary_bin**(fun.y = "mean", geom = "bar")
e + **stat_unique()**

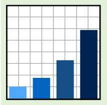
Scales

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



n <- b + **geom_bar**(aes(fill = fl))
n

scale_ | aesthetic to adjust | prepackaged scale to use | scale specific arguments



n + **scale_fill_manual(**
values = c("skyblue", "royalblue", "blue", "navy"),
limits = c("d", "e", "p", "r"), breaks =c("d", "e", "p", "r"),
name = "fuel", labels = c("D", "E", "P", "R"))

range of values to include in mapping | title to use in legend/axis | labels to use in legend/axis | breaks to use in legend/axis

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

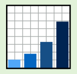
Use with x or y aesthetics (x shown here)

scale_x_date(date_labels = "%m/%d"), 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

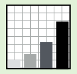
Color and fill scales

Discrete

n <- d + **geom_bar(**
aes(fill = fl))



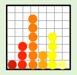
n + **scale_fill_brewer(**
palette = "Blues")
For palette choices:
library(RColorBrewer)
display.brewer.all()



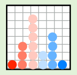
n + **scale_fill_grey(**
start = 0.2, end = 0.8,
na.value = "red")

Continuous

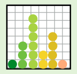
o <- c + **geom_dotplot(**
aes(fill = ..x..))



o + **scale_fill_gradient(**
low = "red",
high = "yellow")

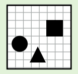


o + **scale_fill_gradient2(**
low = "red", high = "blue",
mid = "white", midpoint = 25)



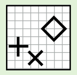
o + **scale_fill_gradientn(**
colours = terrain.colors(6))
Also: rainbow(), heat.colors(), topo.colors(), cm.colors(), RColorBrewer::brewer.pal()

Shape scales



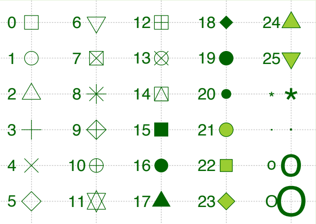
p <- e + **geom_point(**aes(
shape = fl, size = cyl))

p + **scale_shape(**
solid = FALSE)

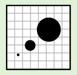


p + **scale_shape_manual(**
values = c(3:7))
Shape values shown in chart on right

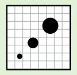
Manual shape values



Size scales



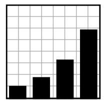
p + **scale_radius(**
range=c(1,6))
p + **scale_size()**



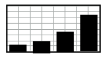
p + **scale_size_area(**
max_scale = 6)
Maps to area of circle (not radius)

Coordinate Systems

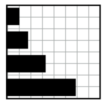
r <- d + geom_bar()



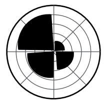
r + **coord_cartesian**(xlim = c(0, 5))
xlim, ylim
The default cartesian coordinate system



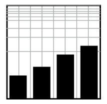
r + **coord_fixed**(ratio = 1/2)
ratio, xlim, ylim
Cartesian coordinates with fixed aspect ratio between x and y units



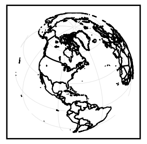
r + **coord_flip()**
xlim, ylim
Flipped Cartesian coordinates



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 xtrans and ytrans to the name of a window function.



π + **coord_map**(projection = "ortho", orientation=c(41, -74, 0))
projection, orientation, xlim, ylim
Map projections from the mapproj package (mercator (default), azequalarea, lagrange, etc.)

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(drv ~ fl, 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

t + **facet_grid(fl ~ ., labeller = label_bquote(**alpha ^ .(fl)**))**

α^c | α^d | α^e | α^p | α^r

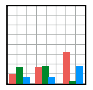
t + **facet_grid(. ~ fl, labeller = label_parsed)**

c | d | e | p | r

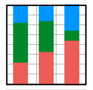
Position Adjustments

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

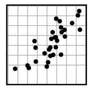
s <- ggplot(mpg, aes(fl, fill = drv))



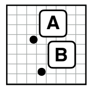
s + **geom_bar(position = "dodge")**
Arrange elements side by side



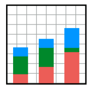
s + **geom_bar(position = "fill")**
Stack elements on top of one another, normalize height



e + **geom_point(position = "jitter")**
Add random noise to X and Y position of each element to avoid overplotting



e + **geom_label(position = "nudge")**
Nudge labels away from points



s + **geom_bar(position = "stack")**
Stack elements on top of one another

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

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

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

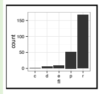
Legends

n + **theme**(legend.position = "bottom")
Place legend at "bottom", "top", "left", or "right"

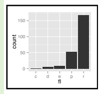
n + **guides**(fill = "none")
Set legend type for each aesthetic: colorbar, legend, or none (no legend)

n + **scale_fill_discrete**(name = "Title", labels = c("A", "B", "C", "D", "E"))
Set legend title and labels with a scale function.

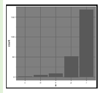
Themes



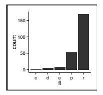
r + **theme_bw()**
White background with grid lines



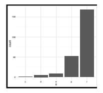
r + **theme_gray()**
Grey background (default theme)



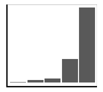
r + **theme_dark()**
dark for contrast



r + **theme_classic()**
r + **theme_light()**
r + **theme_linedraw()**

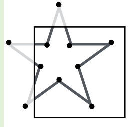


r + **theme_minimal()**
Minimal themes



r + **theme_void()**
Empty theme

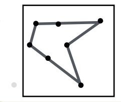
Zooming



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))