Data Visualization

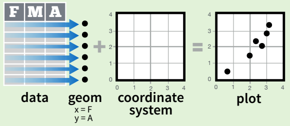
with ggplot2

Cheat Sheet

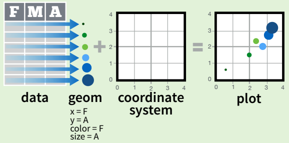
RStudio

Basics

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



To display values, map variables in the data to visual properties of the geom (**aesthetics**) like **size**, **color**, and **x** and **y** locations.



Complete the template below to build a graph.

```
ggplot(data = <DATA>) +
  <GEOM_FUNCTION>(
     mapping = aes(<MAPPINGS>),
     stat = <STAT>,
     position = <POSITION>
  ) +
  <COORDINATE_FUNCTION> +
  <FACET_FUNCTION> +
  <SCALE_FUNCTION> +
  <THEME_FUNCTION>
```

Required

Not required, sensible defaults supplied

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

Begins a plot that you finish by adding layers to. Add one geom function per layer.

aesthetic mappings   data   geom

qplot(x = cty, y = hwy, 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 function to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

Graphical Primitives

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

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

b + **geom_curve(**aes(yend = lat + 1, xend=long+1,curvature=z)**)** - x, xend, y, yend, alpha, angle, color, curvature, linetype, size

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

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

b + **geom_rect(**aes(xmin = long, ymin=lat, xmax= long + 1, ymax = lat + 1)**)** - xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

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

Line Segments

common aesthetics: x, y, alpha, color, linetype, size

b + **geom_abline(**aes(intercept=0, slope=1)**)**
b + **geom_hline(**aes(yintercept = lat)**)**
b + **geom_vline(**aes(xintercept = long)**)**

b + **geom_segment(**aes(yend=lat+1, xend=long+1)**)**
b + **geom_spoke(**aes(angle = 1:1155, radius = 1)**)**

One Variable

Continuous

c <- ggplot(mpg, aes(hwy)); c2 <- ggplot(mpg)

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

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

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

c2 + **geom_qq(**aes(sample = hwy)**)**
x, y, alpha, color, fill, linetype, size, weight

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_col()**
x, y, alpha, color, fill, group, linetype, size

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))

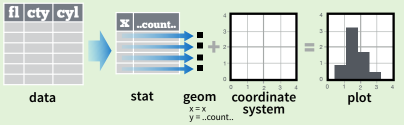
l + **geom_contour(**aes(z = z)**)**
x, y, z, alpha, colour, group, linetype, size, weight

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

A stat builds new variables to plot (e.g., count, prop).



Visualize a stat by changing the default stat of a geom function, **geom_bar(stat="count")** or by using a stat function, **stat_count(geom="bar")**, which calls a default geom to make a layer (equivalent to a geom function).

Use **..name..** syntax to map stat variables to aesthetics.

geom to use · stat function · geom mappings

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

variable created by stat

1D distributions

c + **stat_bin**(binwidth = 1, origin = 10)
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..

2D distributions

e + **stat_bin_2d**(bins = 30, drop = T)
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")

3 Variables

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

Comparisons

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

Functions

e + **stat_ecdf**(n = 40) x, y | ..x.., ..y..
e + **stat_quantile**(quantiles = c(0.1, 0.9),
formula = y ~ log(x), method = "rq") x, y | ..quantile..
e + **stat_smooth**(method = "lm", formula = y ~ x,
se=T, level=0.95) x, y | ..se.., ..x.., ..y.., ..ymin.., ..ymax..

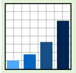
General Purpose

ggplot() + **stat_function**(aes(x = -3:3), n = 99,
fun = dnorm, args = list(sd=0.5)) x | ..x.., ..y..
e + **stat_identity**(na.rm = TRUE)
ggplot() + **stat_qq**(aes(sample=1:100), dist = qt,
dparam=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 map data values to the visual values of an aesthetic. To change a mapping, add a new scale.

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



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 most aesthetics

scale_*_continuous() - map cont' values to visual ones
scale_*_discrete() - map discrete values to visual ones
scale_*_identity() - use data values **as** visual ones
scale_*_manual(values = c()) - map discrete values to manually chosen visual ones
scale_*_date(date_labels = "%m/%d"), date_breaks = "2 weeks") - treat data values as dates.
scale_*_datetime() - treat data x values as date times.
Use same arguments as scale_x_date().
See ?strptime for label formats.

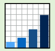
X and Y location scales

Use with x or y aesthetics (x shown here)

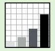
scale_x_log10() - Plot x on log10 scale
scale_x_reverse() - Reverse direction of x axis
scale_x_sqrt() - Plot x on square root scale

Color and fill scales (Discrete)

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



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



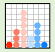
n + **scale_fill_grey**(start = 0.2, end = 0.8, na.value = "red")

Color and fill scales (Continuous)

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

o + **scale_fill_distiller**(palette = "Blues")

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

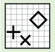


o + **scale_fill_gradient2**(low="red", high="blue", mid = "white", midpoint = 25)

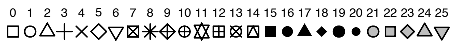
o + **scale_fill_gradientn**(colours=topo.colors(6))
Also: rainbow(), heat.colors(), terrain.colors(), cm.colors(), RColorBrewer::brewer.pal()

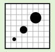
Shape and size scales

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



p + **scale_shape() + scale_size()**
p + **scale_shape_manual**(values = c(3:7))



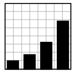


p + **scale_radius**(range = c(1,6))
p + **scale_size_area**(max_size = 6)

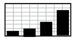
Maps to radius of circle, or area

Coordinate Systems

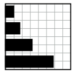
r <- d + geom_bar()



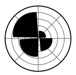
r + **coord_cartesian**(xlim = c(0, 5))
xlim, ylim
The default cartesian coordinate system



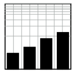
r + **coord_fixed**(ratio = 1/2)
ratio, xlim, ylim
Cartesian coordinates with fixed aspect ratio between x and y units



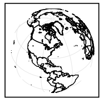
r + **coord_flip()**
xlim, ylim
Flipped Cartesian coordinates



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.

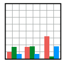


π + **coord_quickmap()**
π + **coord_map**(projection = "ortho", orientation=c(41, -74, 0))
projection, orientation, xlim, ylim
Map projections from the mapproj package (mercator (default), azequalarea, lagrange, etc.)

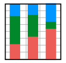
Position Adjustments

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

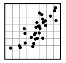
s <- ggplot(mpg, aes(fl, fill = drv))



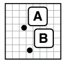
s + geom_bar(**position = "dodge"**)
Arrange elements side by side



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



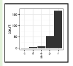
e + geom_label(**position = "nudge"**)
Nudge labels away from points

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

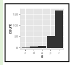
Each position adjustment can be recast as a function with manual **width** and **height** arguments

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

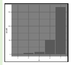
Themes



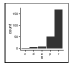
r + **theme_bw()**
White background with grid lines



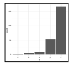
r + **theme_gray()**
Grey background (default theme)



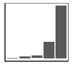
r + **theme_dark()**
dark for contrast



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



r + **theme_minimal()**
Minimal themes



r + **theme_void()**
Empty theme

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

Labels

t + **labs(** **x** = "New x axis label", **y** = "New y axis label",
title ="Add a title above the plot",
subtitle = "Add a subtitle below title",
caption = "Add a caption below plot",
<AES> = "New <AES> legend title")

Use scale functions to update legend labels

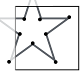
t + **annotate(**geom = "text", x = 8, y = 9, label = "A")

geom to place · manual values for geom's aesthetics

Legends

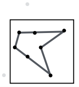
n + **theme(**legend.position = "bottom")
Place legend at "bottom", "top", "left", or "right"
n + **guides(**fill = "none")
Set legend type for each aesthetic: colorbar, legend, or none (no legend)
n + **scale_fill_discrete(**name = "Title", labels = c("A", "B", "C", "D", "E"))
Set legend title and labels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

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))

Learn more at **docs.ggplot2.org** and **www.ggplot2-exts.org** • ggplot2 2.1.0 • Updated: 11/16