

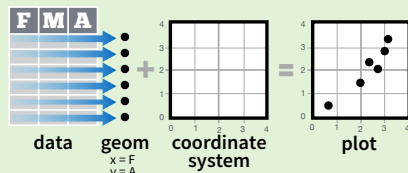
Data Visualization with ggplot2

Cheat Sheet

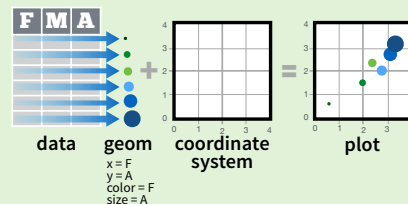


Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same 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.

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

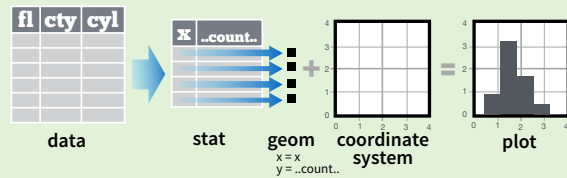
seals\$z <- with(seals, sqrt(delta_long^2 + delta_lat^2))
l <- ggplot(seals, aes(long, lat))

l + geom_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

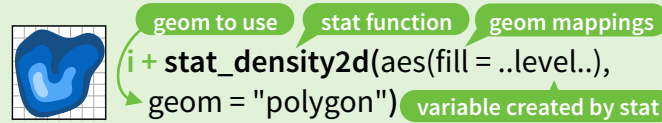
Stats - An alternative way to build a layer

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.



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

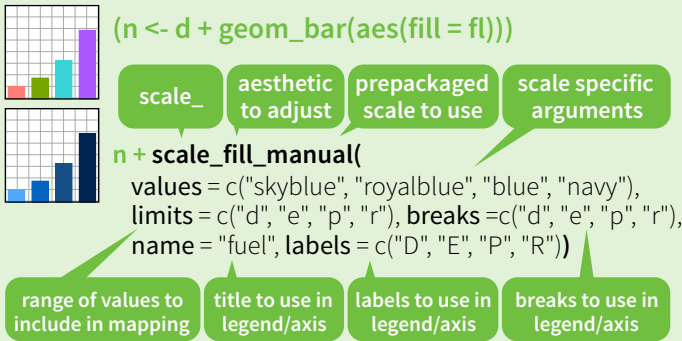
- `e + stat_ecdf(n = 40)` x, y | ..x.., ..y..
- `e + stat_quantile(quantiles = c(0.1, 0.9), formula = y ~ log(x), method = "rq")` x, y | ..quantile..
- `e + stat_smooth(method = "lm", formula = y ~ x, se=T, level=0.95)` x, y | ..se.., ..x.., ..y.., ..ymin.., ..ymax..

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.



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))` Maps to radius of circle, or area
- `p + scale_size_area(max_size = 6)`

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)`
- `t + facet_grid(fl ~ ., labeller = label_bquote(alpha ^ .(fl)))`
- `t + facet_grid(. ~ fl, labeller = label_parsed)`

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")`
- `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))`