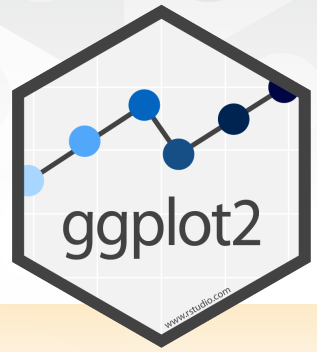


Data Visualization with ggplot2 : : CHEAT SHEET

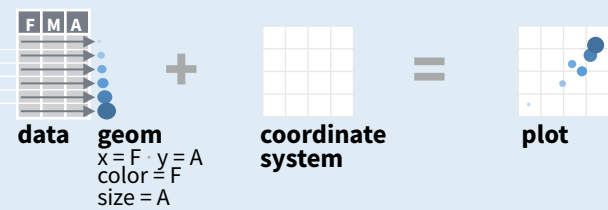


Basics

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>
```

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

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

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

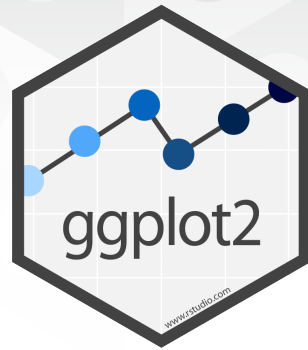
visualizing error

- 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

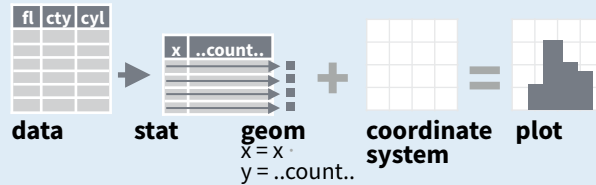




Stats

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

- `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..`
- `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")`
- `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..`
- `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..`
- `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..`
- `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

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")) prepackaged scale to use

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 & 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))`  
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
  - `p + scale_radius(range = c(1,6))`
  - `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_classic()`
- `r + theme_light()`
- `r + theme_linedraw()`
- `r + theme_minimal()`
Minimal themes
- `r + theme_void()`
Empty theme
- `r + theme_gray()`
Grey background (default theme)
- `r + theme_dark()`
dark for contrast

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)))
```
- |            |            |            |            |            |
|------------|------------|------------|------------|------------|
| $\alpha^c$ | $\alpha^d$ | $\alpha^e$ | $\alpha^p$ | $\alpha^r$ |
|------------|------------|------------|------------|------------|
- ```
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))`