posit

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.

```
library(ggplot2)
```

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>
```

Data, a Geom Function, and Aes Mappings are required. Stat, Position, and the Coordinate, Facet, Scale, and Theme functions are not required and will supply sensible defaults.

- `ggplot(data = mpg, aes(x = cty, y = hwy))`: Begins a plot that you finish by adding layers to. Add one geom function per layer.

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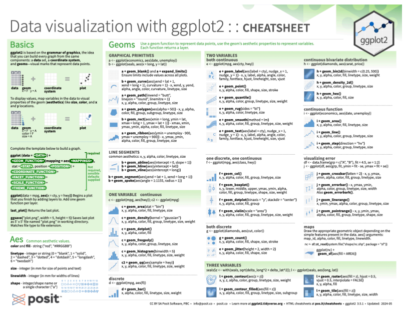
Data visualization with ggplot2 : : CHEATSHEET

Translations (PDF)

- Chinese
- Dutch
- French
- German
- Japanese
- Portuguese
- Spanish
- Turkish
- Vietnamese

- `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.

Aes

Common aesthetic values.

- `color` and `fill`: String (`"red"`, `"#RRGGBB"`).
- `linetype`: Integer or string (0 = `"blank"`, 1 = `"solid"`, 2 = `"dashed"`, 3 = `"dotted"`, 4 = `"dotdash"`, 5 = `"longdash"`, 6 = `"twodash"`).
- `size`: Integer (in mm for size of points and text).
- `linewidth`: Integer (in mm for widths of lines).
- `shape`: Integer/shape name or a single character (`"a"`).
  - `shape` integer/name pairs: 0 = `"square open"`, 1 = `"circle open"`, 2 = `"triangle open"`, 3 = `"plus"`, 4 = `"cross"`, 5 = `"diamond open"`, 6 = `"triangle down open"`, 7 = `"square cross"`, 8 = `"asterisk"`, 9 = `"diamond plus"`, 10 = `"circle plus"`, 11 = `"star"`, 12 = `"square plus"`, 13 = `"circle cross"`, 14 = `"square triangle"`, 15 = `"square"`, 16 = `"circle"`, 17 = `"triangle"`, 18 = `"diamond"`, 19 = `"circle small"`, 20 = `"bullet"`, 21 = `"circle filled"`, 22 = `"square filled"`, 23 = `"diamond filled"`, 24 = `"triangle filled"`, 25 = `"triangle down filled"`

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()` and `a + expand_limits()`: Ensure limits include values across all plots.
- `b + geom_curve(aes(yend = lat + 1, xend = long + 1), curvature = 1)`: Draw a curved line from `(x, y)` to `(xend, yend)`. `aes()` arguments: `x`, `xend`, `y`, `yend`, `alpha`, `angle`, `color`, `curvature`, `linetype`, `size`.
- `a + geom_path(lineend = "butt", linejoin = "round", linemitre = 1)`: Connect observations in the order they appear. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `size`.
- `a + geom_polygon(aes(alpha = 50))`: Connect points into polygons. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `subgroup`, `linetype`, `size`.
- `b + geom_rect(aes(xmin = long, ymin = lat, xmax = long + 1, ymax = lat + 1))`: Draw a rectangle by connecting four corners (`xmin`, `xmax`, `ymin`, `ymax`). `aes()` arguments: `xmax`, `xmin`, `ymax`, `ymin`, `alpha`, `color`, `fill`, `linetype`, `size`.
- `a + geom_ribbon(aes(ymin = unemploy - 900, ymax = unemploy + 900)`: For each `x`, plot an interval from `ymin` to `ymax`. `aes()` arguments: `x`, `ymax`, `ymin`, `alpha`, `color`, `fill`, `group`, `linetype`, `size`.

Line Segments

Common aesthetics: `x`, `y`, `alpha`, `color`, `linetype`, `size`, `linewidth`.

- `b + geom_abline(aes(intercept = 0, slope = 1))`: Draw a diagonal reference line with a given `slope` and `intercept`.
- `b + geom_hline(aes(yintercept = lat))`: Draw a horizontal reference line with a given `yintercept`.
- `b + geom_vline(aes(xintercept = long))`: Draw a vertical reference line with a given `xintercept`.
- `b + geom_segment(aes(yend = lat + 1, xend = long + 1))`: Draw a straight line from `(x, y)` to `(xend, yend)`.

- `b + geom_spoke(aes(angle = 1:1155, radius = 1))`: Draw line segments using polar coordinates (`angle` and `radius`).

One Variable - Continuous

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

- `c + geom_area(stat = "bin")`: Draw an area plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `linewidth`.
- `c + geom_density(kernel = "gaussian")`: Compute and draw kernel density estimates. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`, `weight`.
- `c + geom_dotplot()`: Draw a dot plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`.
- `c + geom_freqpoly()`: Draw a frequency polygon. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `linewidth`.
- `c + geom_histogram(binwidth = 5)`: Draw a histogram. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `linewidth`, `weight`.
- `c2 + geom_qq(aes(sample = hwy))`: Draw a quantile-quantile plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `size`, `weight`.

One Variable - Discrete

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

- `d + geom_bar()`: Draw a bar chart. `aes()` arguments: `x`, `alpha`, `color`, `fill`, `linetype`, `linewidth`, `weight`.

Two Variables - Both Continuous

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

- `e + geom_label(aes(label = cty), nudge_x = 1, nudge_y = 1)`: Add text with a rectangle background. `aes()` arguments: - `x`, `y`, `label`, `alpha`, `angle`, `color`, `family`, `fontface`, `hjust`, `lineheight`, `size`, `vjust`.
- `e + geom_point()`: Draw a scatter plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `shape`, `size`, `stroke`.
- `e + geom_quantile()`: Fit and draw quantile regression for the plot data. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `linewidth`, `weight`.
- `e + geom_rug(sides = "bl")`: Draw a rug plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `linetype`, `linewidth`.
- `e + geom_smooth(method = lm)`: Plot smoothed conditional means. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`, `weight`.
- `e + geom_text(aes(label = cty), nudge_x = 1, nudge_y = 1)`: Add text to a plot. `aes()` arguments: `x`, `y`, `label`, `alpha`, `angle`, `color`, `family`, `fontface`, `hjust`, `lineheight`, `size`, `vjust`.

Two Variables - One Discrete, One Continuous

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

- `f + geom_col()`: Draw a bar plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`.
- `f + geom_boxplot()`: Draw a box plot. `aes()` arguments: `x`, `y`, `lower`, `middle`, `upper`, `ymax`, `ymin`, `alpha`, `color`, `fill`, `group`, `linetype`, `shape`, `linewidth`, `weight`.
- `f + geom_dotplot(binaxis ="y", stackdir = "center")`: Draw a dot plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`.

- `f + geom_violin(scale = "area")`: Draw a violin plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`, `weight`.

Two Variables - Both Discrete

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

- `g + geom_count()`: Plot a count of points in an area to address over plotting. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `shape`, `size`, `stroke`.
- `e + geom_jitter(height = 2, width = 2)`: Jitter points in a plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `shape`, `size`.

Two Variables - Continuous Bivariate Distribution

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

- `h + geom_bin2d(binwidth = c(0.25, 500))`: Draw a heatmap of 2D rectangular bin counts. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `size`, `weight`.
- `h + geom_density_2d()`: Plot contours from 2D kernel density estimation. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `linewidth`.
- `h + geom_hex()`: Draw a heatmap of 2D hexagonal bin counts. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linewidth`.

Two Variables - Continuous Function

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

- `i + geom_area()`: Draw an area plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `linewidth`.

- `i + geom_line()`: Connect data points, ordered by the x axis variable. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `linewidth`.
- `i + geom_step(direction = "hv"`: Draw a stairstep plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `group`, `linetype`, `linewidth`.

Two Variables - 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)`: Draw a crossbar. `aes()` arguments: `x`, `y`, `ymax`, `ymin`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`.
- `j + geom_errorbar()`: Draw an errorbar. Also `geom_errorbarh()`. `aes()` arguments: `x`, `ymax`, `ymin`, `alpha`, `color`, `group`, `linetype`, `linewidth`, `width`.
- `j + geom_linerange()`: Draw a line range. `aes()` arguments: `x`, `ymin`, `ymax`, `alpha`, `color`, `group`, `linetype`, `linewidth`.
- `j + geom_pointrange()`: Draw a point range. `aes()` arguments: `x`, `y`, `ymin`, `ymax`, `alpha`, `color`, `fill`, `group`, `linetype`, `shape`, `linewidth`.

Two Variables - Maps

Draw the appropriate geometric object depending on the simple features present in the data. `aes()` arguments: `map_id`, `alpha`, `color`, `fill`, `linetype`, `linewidth`.

```
nc <- sf::st_read(system.file("shape/nc.shp", package = "sf"))
ggplot(nc) +
  geom_sf(aes(fill = AREA))
```

Three Variables

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

- `l + geom_contour(aes(z = z))`: Draw 2D contour plot. `aes()` arguments: `x`, `y`, `z`, `alpha`, `color`, `group`, `linetype`, `linewidth`, `weight`.
- `l + geom_contour_filled(aes(fill = z))`: Draw 2D contour plot with the space between lines filled. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `group`, `linetype`, `linewidth`, `subgroup`.
- `l + geom_raster(aes(fill = z), hjust = 0.5, vjust = 0.5, interpolate = FALSE)`: Draw a raster plot. `aes()` arguments: `x`, `y`, `alpha`, `fill`.
- `l + geom_tile(aes(fill = z))`: Draw a tile plot. `aes()` arguments: `x`, `y`, `alpha`, `color`, `fill`, `linetype`, `linewidth`, `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 `after_stat(name)` syntax to map the stat variable `name` to an aesthetic.

```r
i + stat_density_2d(aes(fill = after_stat(level)), geom = "polygon")
```

In this example, `"polygon"` is the geom to use, `stat_density_2d()` is the stat function, `aes()` contains the geom mappings, and `level` is the variable created by stat.

- `c + stat_bin(binwidth = 1, boundary = 10)`: `x`, `y` | `count`, `ncount`, `density`, `ndensity`
- `c + stat_count(width = 1)`: `x`, `y` | `count`, `density`
- `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`, `linewidth` | `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() + xlim(-5, 5) + stat_function(fun = dnorm, n = 20, geom = "point")`: `x` | `x`, `y`
- `ggplot() + stat_qq(aes(sample = 1:100))`: `x`, `y`, `sample` | `sample`, `theoretical`
- `e + stat_sum()`: `x`, `y`, `size` | `n`, `prop`
- `e + stat_summary(fun.data = "mean_cl_boot")`
- `h + stat_summary_bin(fun = "mean", geom = "bar")`
- `e + stat_identity()`

- e + stat_unique()

Scales

Override defaults with **scales** package.

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))

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")
)
```

In this example, `scale_` specifies a scale function, `fill` is the aesthetic to adjust, and `manual` is the prepackaged scale to use.

`values` contains scale-specific arguments, `limits` specifies the range of values to include in mappings, `breaks` specifies the breaks to use in legend/axis, and `name` and `labels` specify the title and labels to use in the legend/axis.

General Purpose Scales

Use with most aesthetics.

- `scale_*_continuous()`: Map continuous values to visual ones.
- `scale_*_discrete()`: Map discrete values to visual ones.
- `scale_*_binned()`: Map continuous values to discrete bins.

- `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 values as date times. Same as `scale_*_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 the direction of the x axis.
- `scale_x_sqrt()`: Plot `x` on square root scale.

Color and Fill Scales (Discrete)

- `n + scale_fill_brewer(palette = "Blues")`: Use color scales from ColorBrewer. For palette choices `RColorBrewer::display.brewer.all()`.
- `n + scale_fill_grey(start = 0.2, end = 0.8, na.value = "red")`: Use a grey gradient color scale.

Color and Fill Scales (Continuous)

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

- `o + scale_fill_distiller(palette = "Blues")`: Interpolate a palette into a continuous scale.
- `o + scale_fill_gradient(low = "red", high = "yellow")`: Create a two color gradient.
- `o + scale_fill_gradient2(low = "red", high = "blue", mid = "white", midpoint = 25)`: Create a diverging color gradient.

- `o + scale_fill_gradientn(colors = topo.colors(6))`: Create a n-color gradient. 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()`: Map discrete values to shape and size aesthetics.
- `p + scale_shape_manual(values = c(3:7))`: Map discrete values to specified shape values.
- `p + scale_radius(range = c(1,6))`: Map values to a shape's radius.
- `p + scale_size_area(max_size = 6)`: Like `scale_size()` but maps zero values to zero size.

Shapes used here are the same as the ones listed in the Aes section.

Coordinate Systems

```
u <- d + geom_bar()
```

- `u + coord_cartesian(xlim = c(0, 5))`: `xlim`, `ylim`. The default Cartesian coordinate system.
- `u + coord_fixed(ratio = 1/2)`: `ratio`, `xlim`, `ylim`. Cartesian coordinates with fixed aspect ration between x and y units.
- `ggplot(mpg, aes(y = fl)) + geom_bar()`: Flip Cartesian coordinates by switching x and y aesthetic mappings.
- `u + coord_polar(theta = "x", direction = 1)`: `theta`, `start`, `direction`. Polar coordinates.
- `u + coord_trans(y = "sqrt")`: `x`, `y`, `xlim`, `ylim`. Transformed Cartesian coordinates. Set `xtrans` and `ytrans` to the name of a window function.

- `π + coord_sf()`: `xlim`, `ylim`, `crs`. Ensures all layers use a common Coordinate Reference System.

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 over plotting.
- `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

- `u + theme_bw()`: White background with grid lines.
- `u + theme_gray()`: Grey background with white grid lines (default theme).
- `u + theme_dark()`: Dark grey background and grid lines for contrast.
- `u + theme_classic()`: No grid lines.

- `u + theme_light()`: Light grey axes and grid lines.
- `u + theme_linedraw()`: Uses only black lines.
- `u + theme_minimal()`: Minimal theme.
- `u + theme_void()`: Empty theme.
- `u + theme()`: Customize aspects of the theme such as axis, legend, panel, and facet properties.

```
u + labs(title = "Title") + theme(plot.title.position = "plot")
```

```
u + theme(panel.background = element_rect(fill = "blue"))
```

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 a column 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.
- `t + facet_grid(drv ~ fl, scales = "free")`: Set **scales** to let axis limits vary across facets. Also `"free_x"` for x axis limits adjust to individual facets and `"free_y"` for y axis limits adjust to individual facets.

Set **labeller** to adjust facet label:

- `t + facet_grid(. ~ fl, labeller = label_both)`: Labels each facet as “fl: c”, “fl: d”, etc.

- `t + facet_grid(fl ~ ., labeller = label_bquote(alpha ^ .(fl)))`: Labels each facet as “α^c”, “α^d”, etc.

Labels and Legends

Use `labs()` to label elements of your plot.

```
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",
  alt = "Add alt text to the plot",
  <Aes> = "New <Aes> legend title")
```

- `t + annotate(geom = "text", x = 8, y = 9, label = "A")`: Places a geom with manually selected aesthetics.
- `p + guides(x = guide_axis(n.dodge = 2))`: Avoid crowded or overlapping labels with `guide_axis(n.dodge or angle)`.
- `n + guides(fill = "none")`: Set legend type for each aesthetic: `colorbar`, `legend`, or `none` (no legend).
- `n + theme(legend.position = "bottom")`: Place legend at “bottom”, “top”, “left”, or “right”.
- `n + scale_fill_discrete(name = "Title", labels = c("A", "B", "C", "D", "E"))`: Set legend title and labels with a scale function.

Zooming

- `t + coord_cartesian(xlim = c(0, 100), ylim = c(10,20))`: Zoom without clipping (preferred).

- `t + xlim(0, 100) + ylim(10, 20)` or `t + scale_x_continuous(limits = c(0, 100)) + scale_y_continuous(limits = c(0, 100))`: Zoom with clipping (removes unseen data points).

Learn more at ggplot2.tidyverse.org.

Updated: 2024-05.

```
packageVersion("ggplot2")
```

```
[1] '3.5.1'
```