Q-Step: Data visualisation in R

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09 November 2017

Download materials from Q-Step ELE page (log-in required)

http://vle.exeter.ac.uk/course/view.php?id=6042

or from Github

https://github.com/YiLiu6240/exeter-qstep-data-visualisation-workshop

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This is the Exeter Q-step workshop guide to data visualisation in R. We will be covering the basics of plotting in base R and using the package `"ggplot2"`.

For the purpose of this workshop, we will use the `titanic` dataset to demonstrate how data visualisation works in R.

It is recommended to use RStudio for this workshop.

Preparation

Use the code below to initialise the working environment.

```r
# If you need to install these packages
install.packages(c("tidyverse", "titanic"),
                 repos = "https://cran.rstudio.com")
```

```r
library("tidyverse")
library("titanic")
```

The data set we are going to use is the training split of the titanic data.

```r
# We create a tibble dataframe called `df` from `titanic_train`
df <- titanic_train %>% as_tibble()
df %>% glimpse()
```

```
## Observations: 891
## Variables: 12
## $ PassengerId <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,...
## $ Survived    <int> 0, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0,...
## $ Pclass      <int> 3, 1, 3, 1, 3, 3, 1, 3, 3, 2, 3, 1, 3, 3, 3, 2, 3,...
## $ Name        <chr> "Braund, Mr. Owen Harris", "Cumings, Mrs. John Bra...
## $ Sex         <chr> "male", "female", "female", "female", "male", "mal...
## $ Age         <dbl> 22, 38, 26, 35, 35, NA, 54, 2, 27, 14, 4, 58, 20, ...
## $ SibSp       <int> 1, 1, 0, 1, 0, 0, 0, 3, 0, 1, 1, 0, 0, 1, 0, 0, 4,...
## $ Parch       <int> 0, 0, 0, 0, 0, 0, 0, 1, 2, 0, 1, 0, 0, 5, 0, 0, 1,...
## $ Ticket      <chr> "A/5 21171", "PC 17599", "STON/O2. 3101282", "1138...
## $ Fare        <dbl> 7.250, 71.283, 7.925, 53.100, 8.050, 8.458, 51.862...
## $ Cabin       <chr> "", "C85", "", "C123", "", "", "E46", "", "", "", ...
## $ Embarked    <chr> "S", "C", "S", "S", "S", "Q", "S", "S", "S", "C", ...
```

The first 10 rows of the dataset:

```
df %>% head(10) %>% knitr::kable()
```

PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch
1	0	3	Braund, Mr. Owen Harris	male	22	1	0
2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Thayer)	female	38	1	0
3	1	3	Heikkinen, Miss. Laina	female	26	0	0
4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35	1	0
5	0	3	Allen, Mr. William Henry	male	35	0	0
6	0	3	Moran, Mr. James	male	NA	0	0
7	0	1	McCarthy, Mr. Timothy J	male	54	0	0
8	0	3	Palsson, Master. Gosta Leonard	male	2	3	1
9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27	0	2
10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14	1	0

Meanings of categorical variables

- **`Survived`**: whether the passenger survived; 0: Did not survive, 1: Survived
- **`pclass`**: ticket class; 1st, 2nd, 3rd
- **`SibSp`**: Number of siblings / spouses aboard
- **`Parch`**: Numebr of parents / children aboard
- **`Embarked`**: Port of Embarkation; C: Cherbourg, Q: Queenstown, S: Southhampton

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We would also need to use a factor type for the categorical variables that are not numerical in nature:

```
df <- titanic_train %>% as_tibble() %>%
  mutate_at(vars(PassengerId, Survived, Pclass), as.factor)
df %>% glimpse()
```

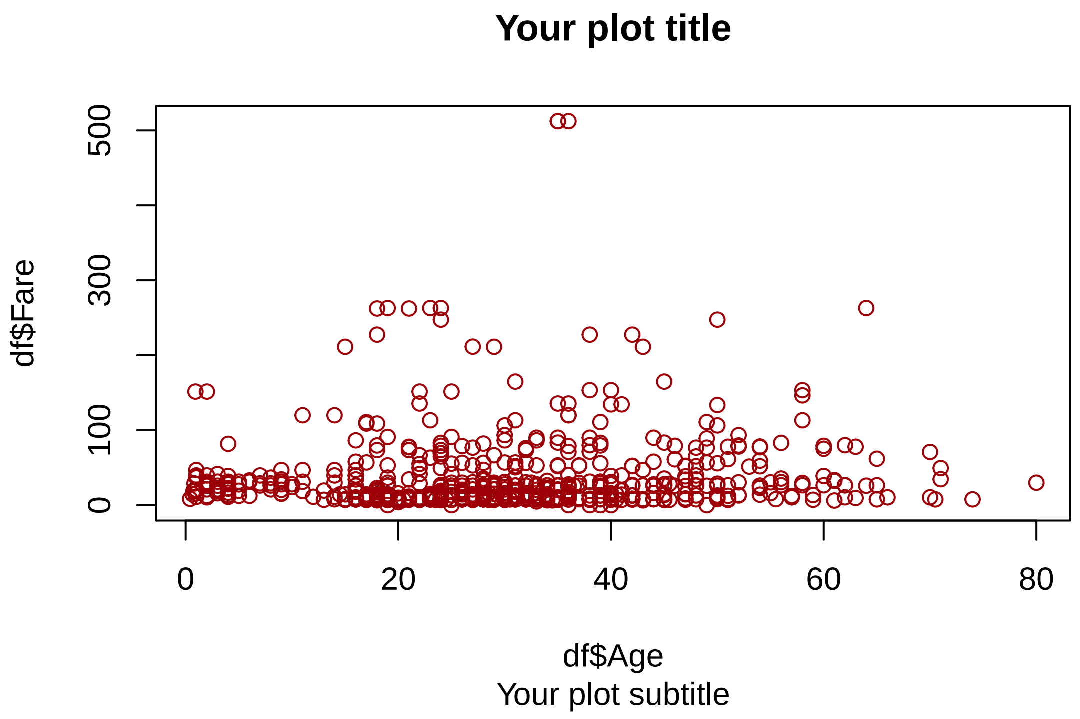
```
## Observations: 891
## Variables: 12
## $ PassengerId <fctr> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15...
## $ Survived    <fctr> 0, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0...
## $ Pclass      <fctr> 3, 1, 3, 1, 3, 3, 1, 3, 3, 2, 3, 1, 3, 3, 3, 2, 3...
## $ Name        <chr> "Braund, Mr. Owen Harris", "Cumings, Mrs. John Bra...
## $ Sex         <chr> "male", "female", "female", "female", "male", "mal...
## $ Age         <dbl> 22, 38, 26, 35, 35, NA, 54, 2, 27, 14, 4, 58, 20, ...
## $ SibSp       <int> 1, 1, 0, 1, 0, 0, 0, 3, 0, 1, 1, 0, 0, 1, 0, 0, 4,...
## $ Parch       <int> 0, 0, 0, 0, 0, 0, 0, 1, 2, 0, 1, 0, 0, 5, 0, 0, 1,...
## $ Ticket      <chr> "A/5 21171", "PC 17599", "STON/O2. 3101282", "1138...
## $ Fare        <dbl> 7.250, 71.283, 7.925, 53.100, 8.050, 8.458, 51.862...
## $ Cabin       <chr> "", "C85", "", "C123", "", "", "E46", "", "", "", ...
## $ Embarked    <chr> "S", "C", "S", "S", "S", "Q", "S", "S", "S", "C", ...
```

Base R plotting

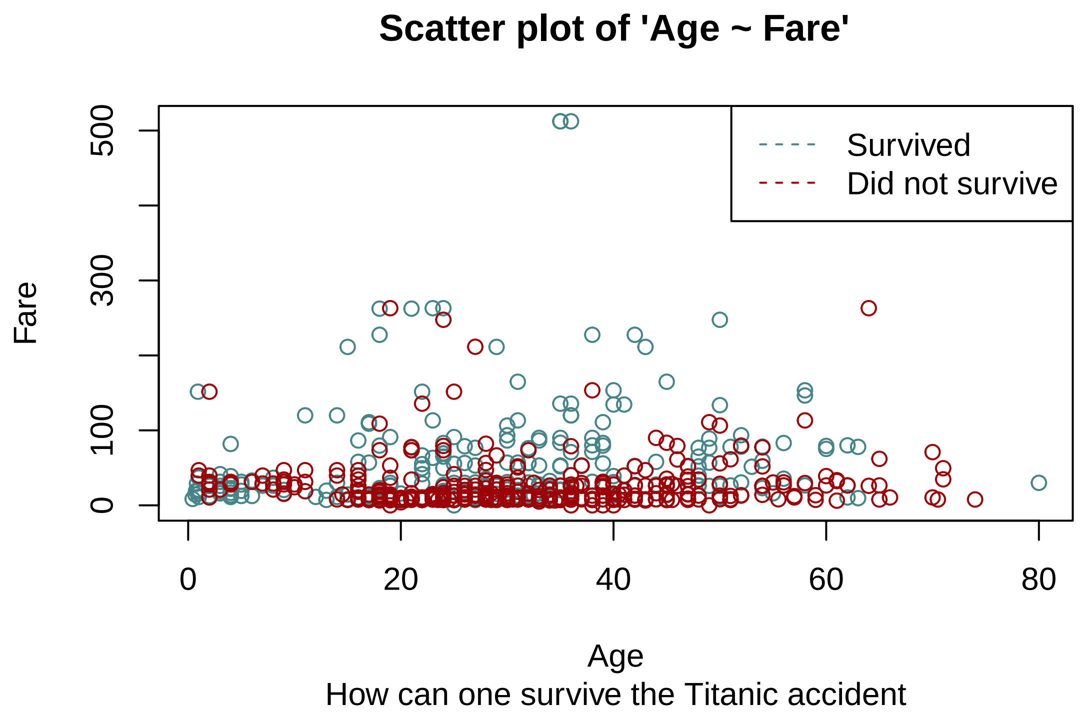
The plotting system in base R

Base R plotting is done primarily by the `plot` function:

```r
plot(x = df$Age, y = df$Fare,
     main = "Your plot title", sub = "Your plot subtitle",
     type = "p", col = "#9d0006")
```



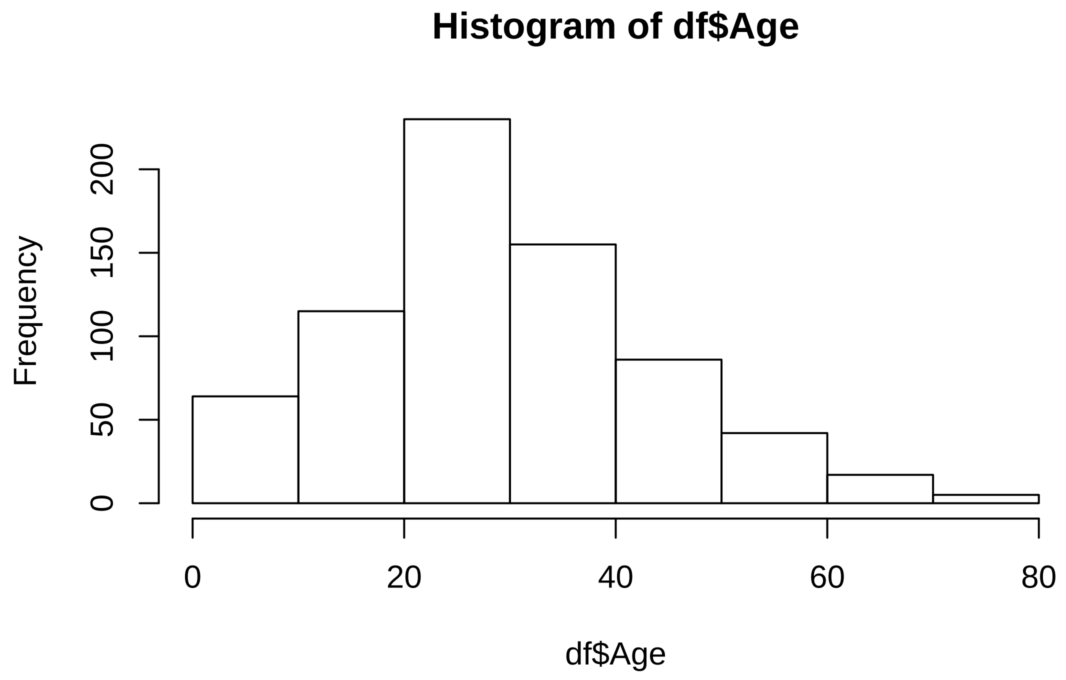
```r
plot(x = df$Age[df$Survived == 1], y = df$Fare[df$Survived == 1],
     main = "Scatter plot of 'Age ~ Fare'",
     sub = "How can one survive the Titanic accident",
     xlab = "Age", ylab = "Fare",
     type = "p", col = "#458588")
points(x = df$Age[df$Survived == 0], y = df$Fare[df$Survived == 0],
       type = "p", col = "#9d0006")
legend(x = "topright",
       legend = c("Survived", "Did not survive"),
       lty = 2,
       col = c("#458588", "#9d0006"))
```



Other specialised plots

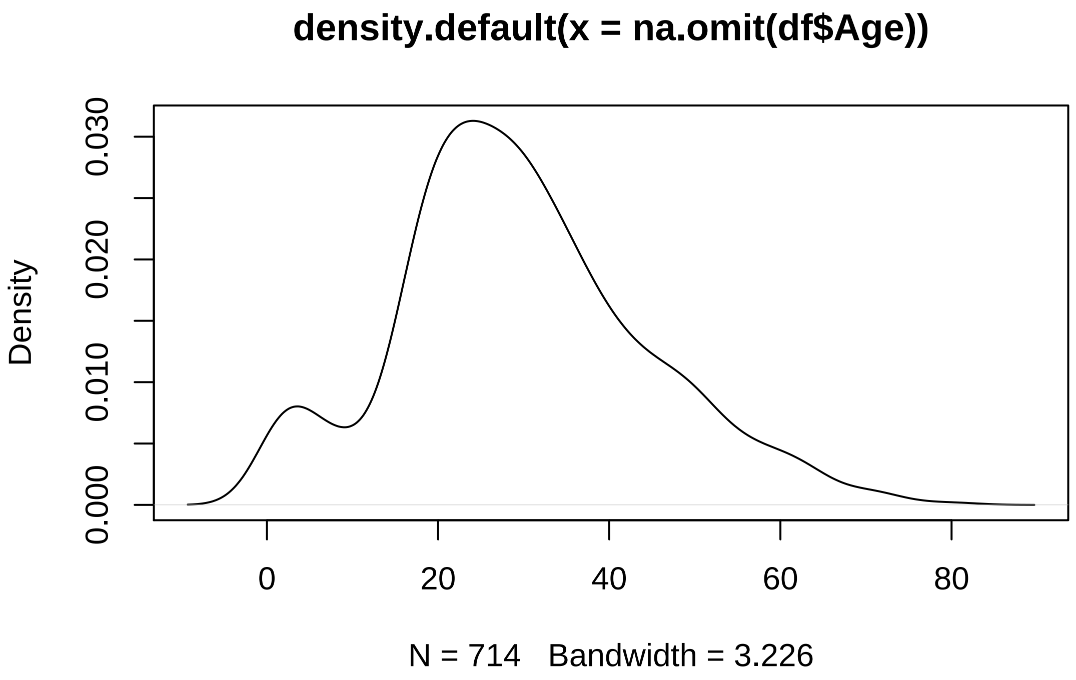
Histograms

```
hist(df$Age)
```



Density plots

```
density_age <- density(na.omit(df$Age))
plot(density_age)
```



Alternatively, you can chain the procedure using a `%>%` pipe:

```
df$Age %>% na.omit() %>%
  density() %>% plot()
```

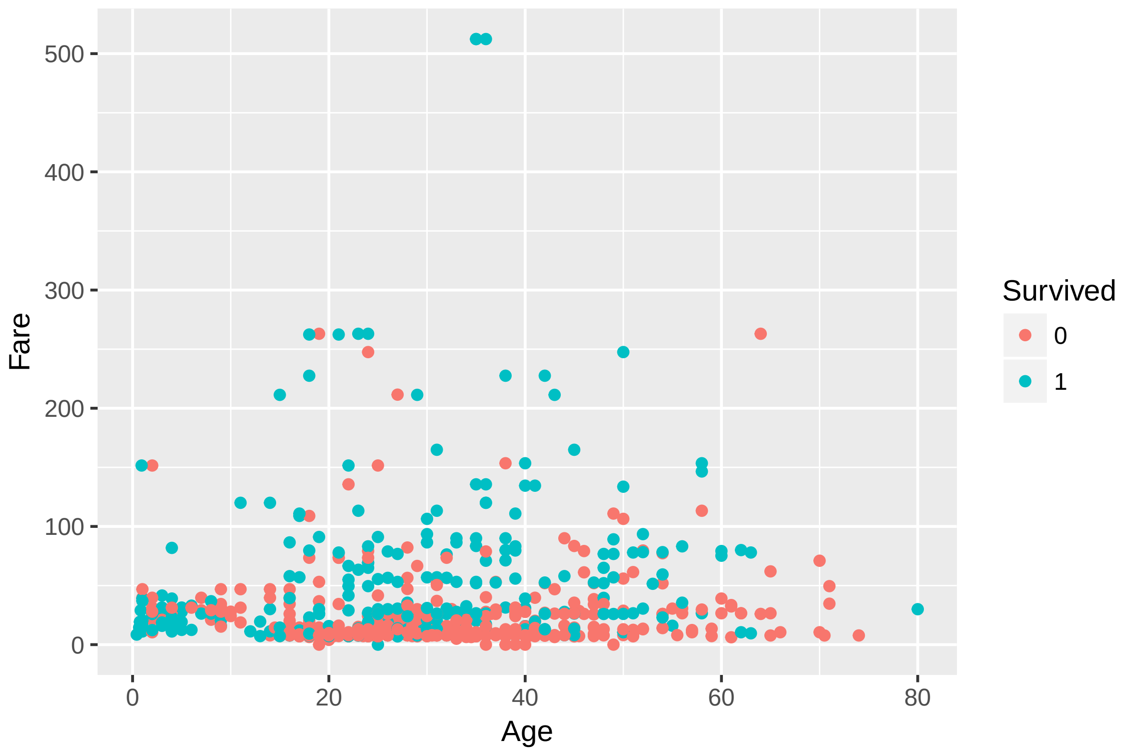
Saving the plot

```
png("base-r-density-plot.png",
    width = 7.2, height = 4.8, units = "in", res = 300)
df$Age %>% na.omit() %>%
  density() %>% plot()
dev.off()
```

ggplot2: Basics

An example

```
ggplot(data = df,
       mapping = aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived))
```



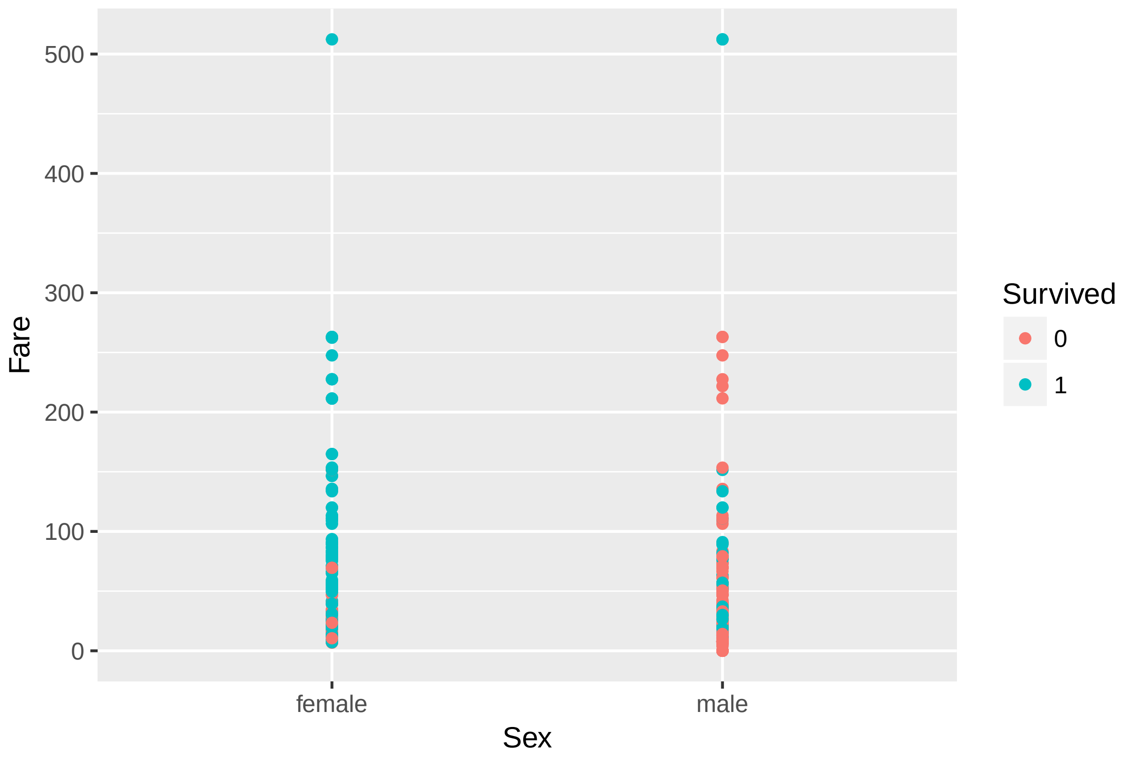
Alternatively you can write the above code as

```r
df %>% ggplot(aes(Age, Fare)) +
  geom_point(aes(color = Survived))
```

Aesthetics and the layering system

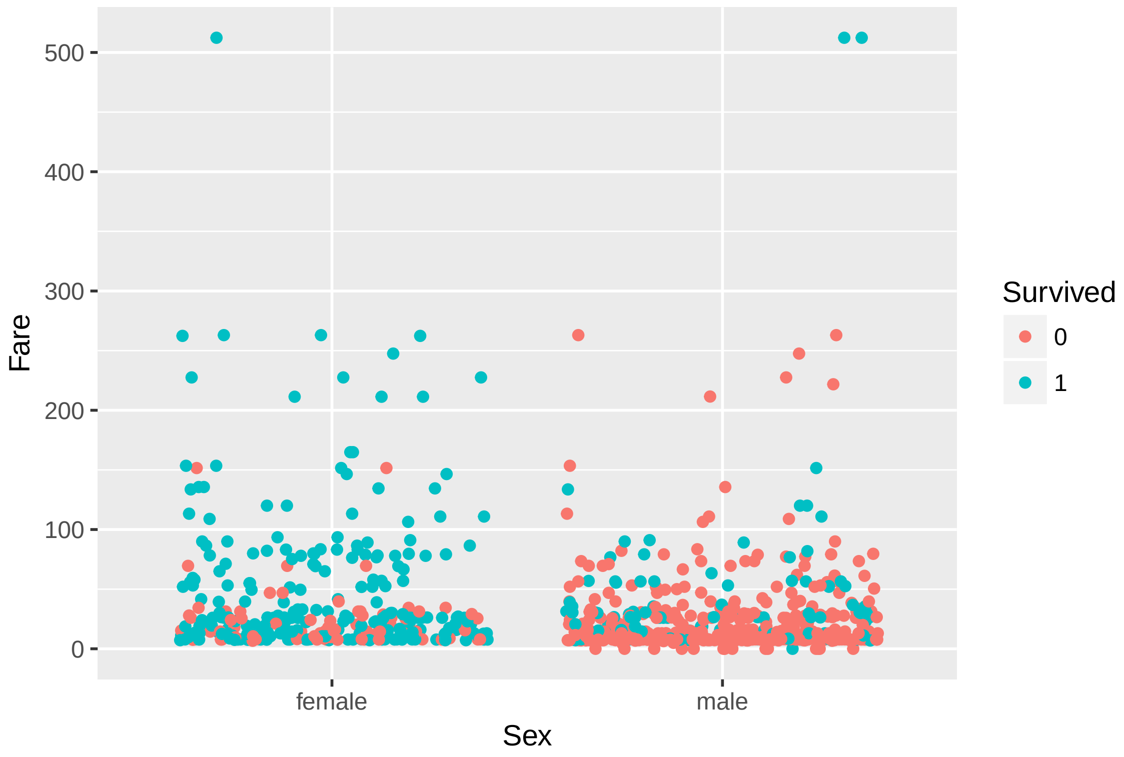
What if we want a scatter plot of "Sex ~ Fare"?

```r
df %>% ggplot(aes(x = Sex, y = Fare)) +
  geom_point(aes(color = Survived))
```



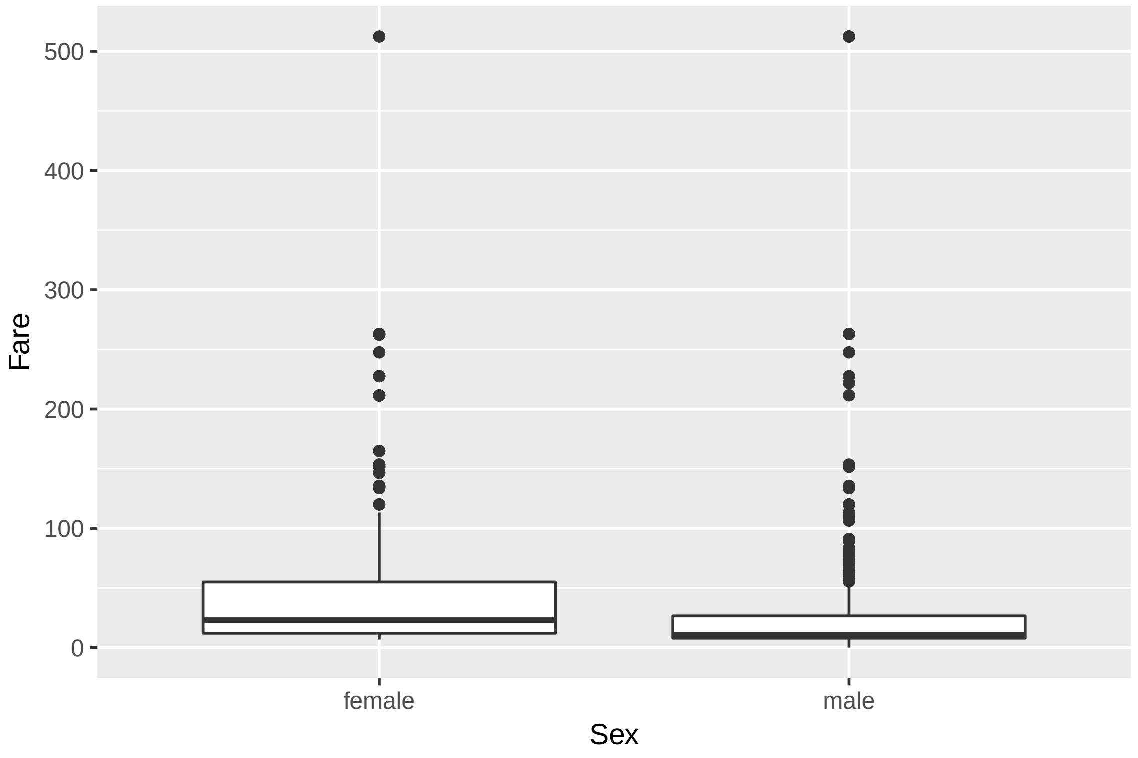
We need to change the main geom (geometric object) to `geom_jitter` when variables on both axes are categorical.

```r
df %>% ggplot(aes(x = Sex, y = Fare)) +
  geom_jitter(aes(color = Survived))
```



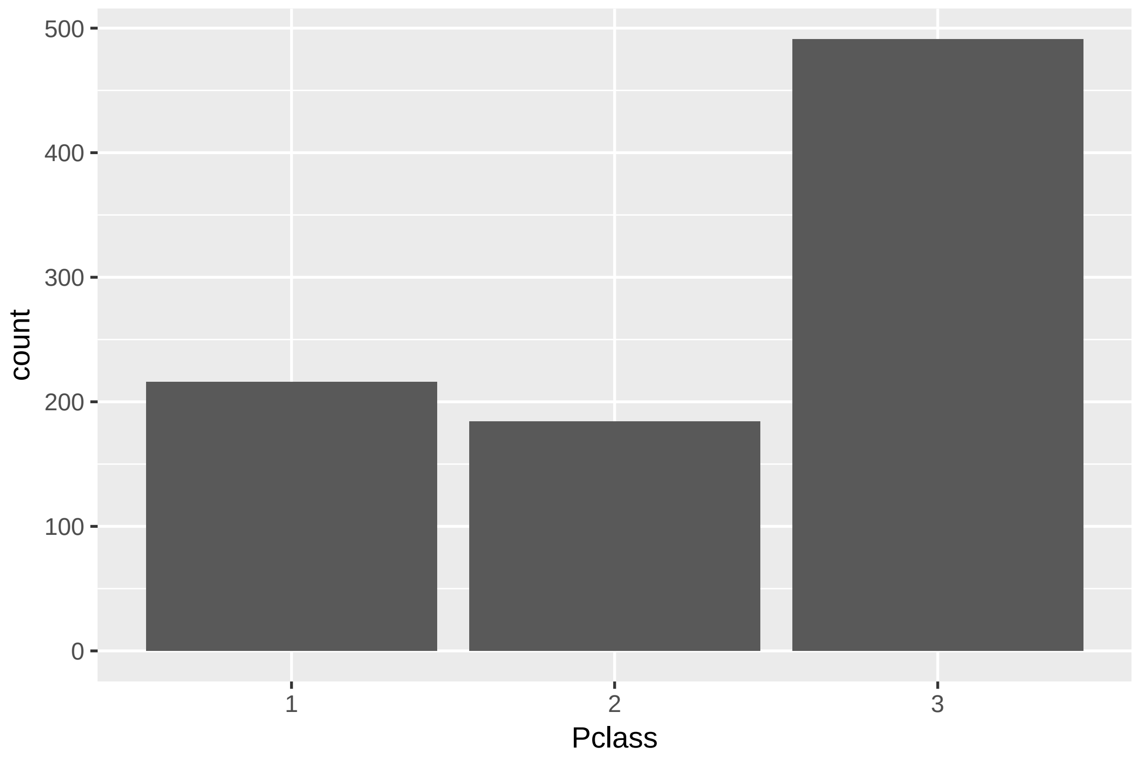
Alternatively we can do a boxplot:

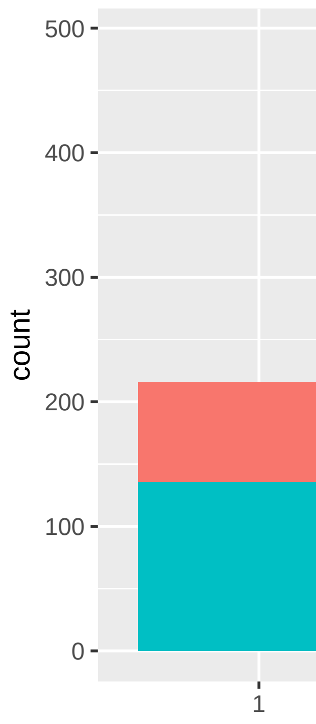
```r
df %>% ggplot(aes(x = Sex, y = Fare)) +
  geom_boxplot()
```



Counts and values

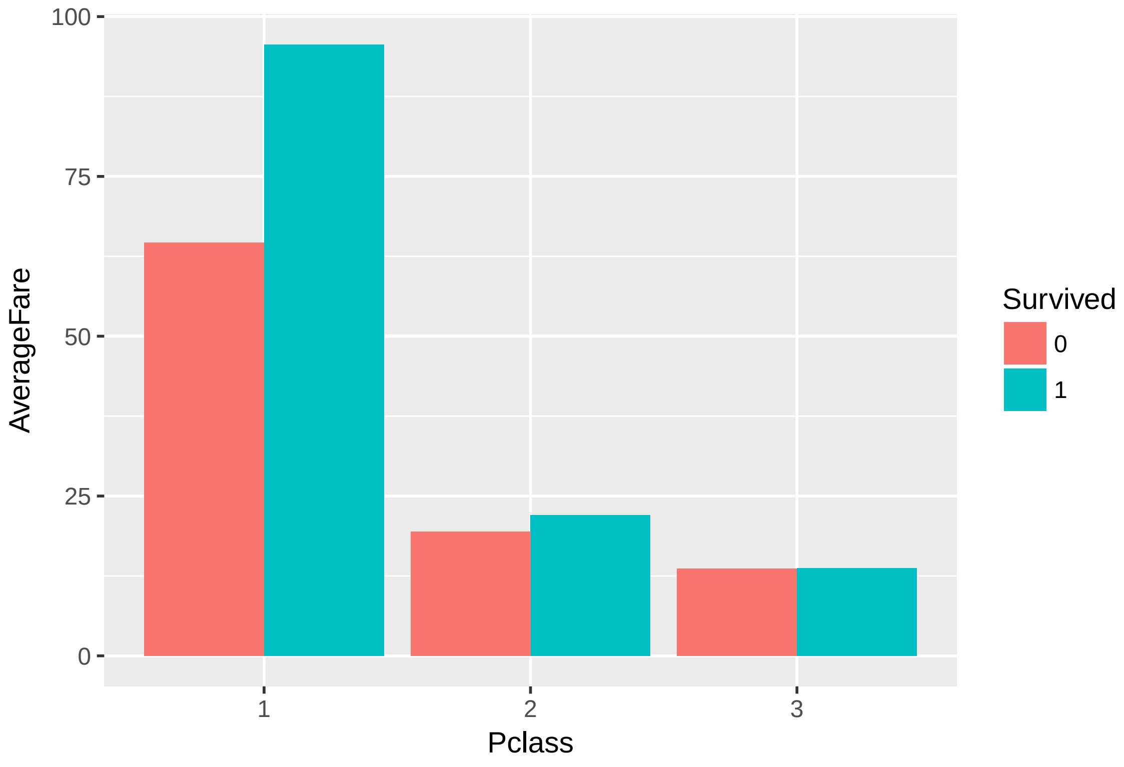
```r
df %>% ggplot(aes(x = Pclass)) +
  geom_bar(stat = "count")
df %>% ggplot(aes(x = Pclass)) +
  geom_bar(aes(fill = Survived),
           stat = "count", position = "stack")
```





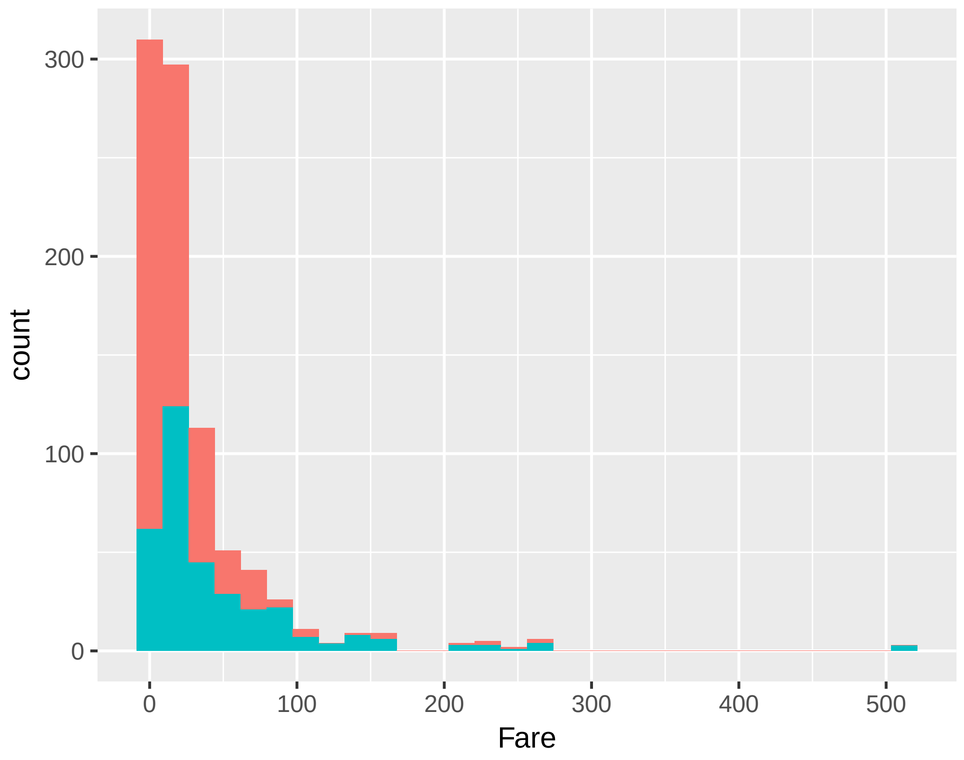
When you need to supply your own `y` in a barchart:

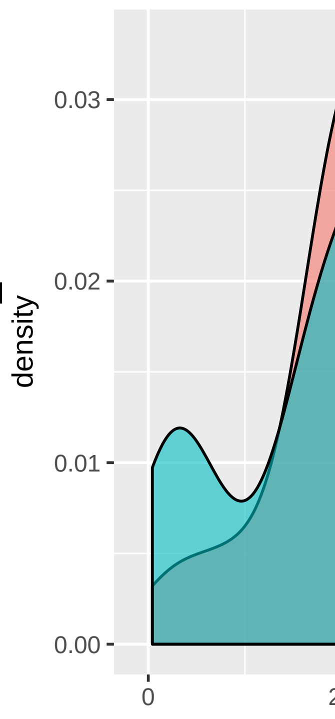
```
df %>% group_by(Survived, Pclass) %>%
  summarise(AverageFare = mean(Fare, na.rm = TRUE)) %>%
  ggplot(aes(x = Pclass, y = AverageFare)) +
  # `geom_bar(stat = "identity", ...)` is equivalent to `geom_col(..)`
  geom_col(aes(fill = Survived), position = "dodge")
```



Continuous numerical variables

```
df %>% ggplot(aes(x = Fare)) +
  geom_histogram(aes(fill = Survived), position = "stack")
df %>% ggplot(aes(x = Age)) +
  geom_density(aes(fill = Survived), alpha = 0.6)
```

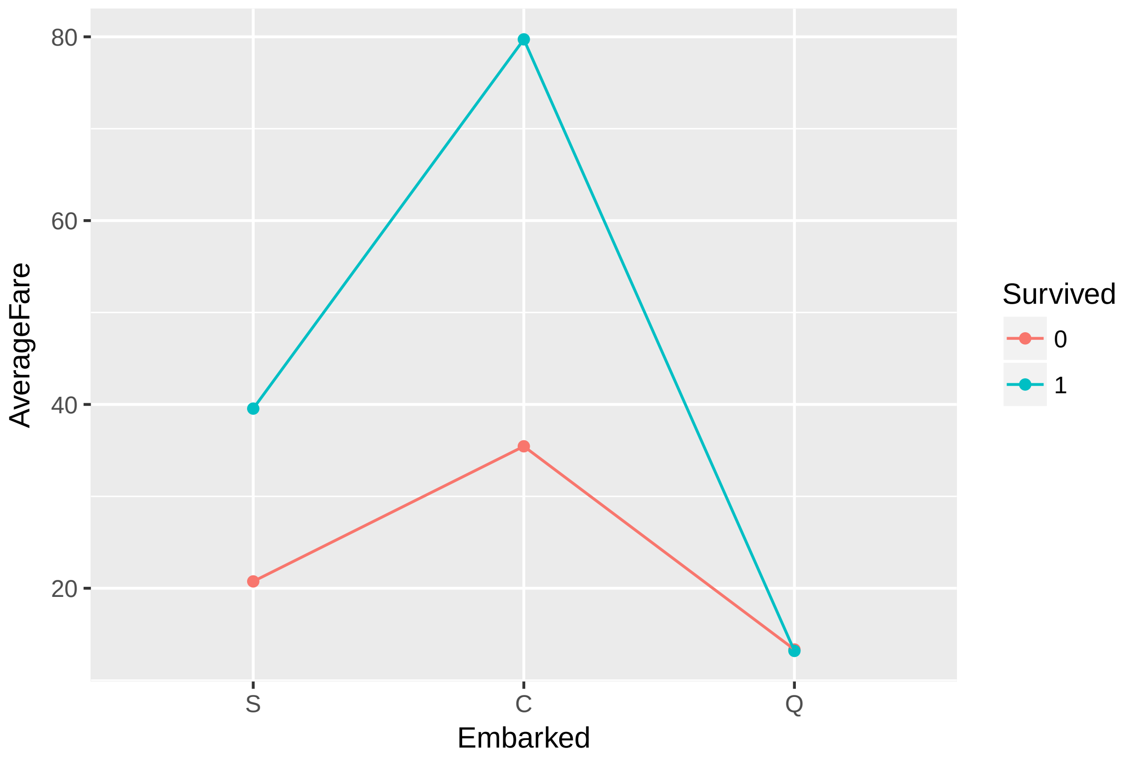




Line charts

For line charts that represent connections, we ususally need to specify a "group" aesthetics.

```
df %>%
  filter(Embarked != "") %>%
  mutate(Embarked = Embarked %>% factor(levels = c("S", "C", "Q"))) %>%
  group_by(Embarked, Survived) %>%
  summarise(AverageFare = mean(Fare, na.rm = TRUE)) %>%
  ggplot(aes(x = Embarked, y = AverageFare,
             colour = Survived, group = Survived)) +
  geom_point() + geom_line()
```



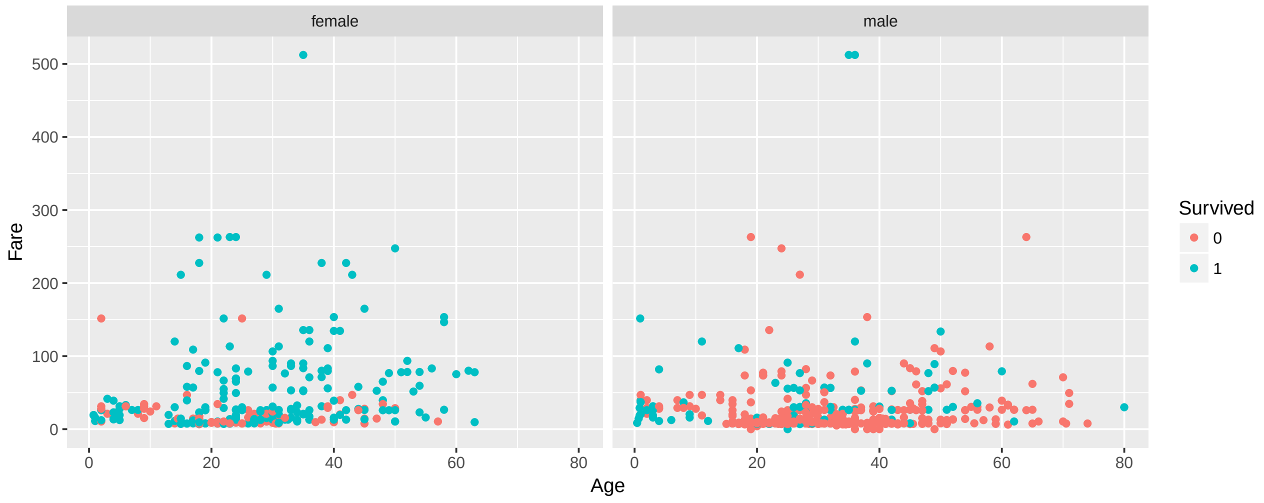
Exercise:

Practice with the ggplot2 geoms and aesthetics with the titanic data, using the examples above.

ggplot2: Beyond basics

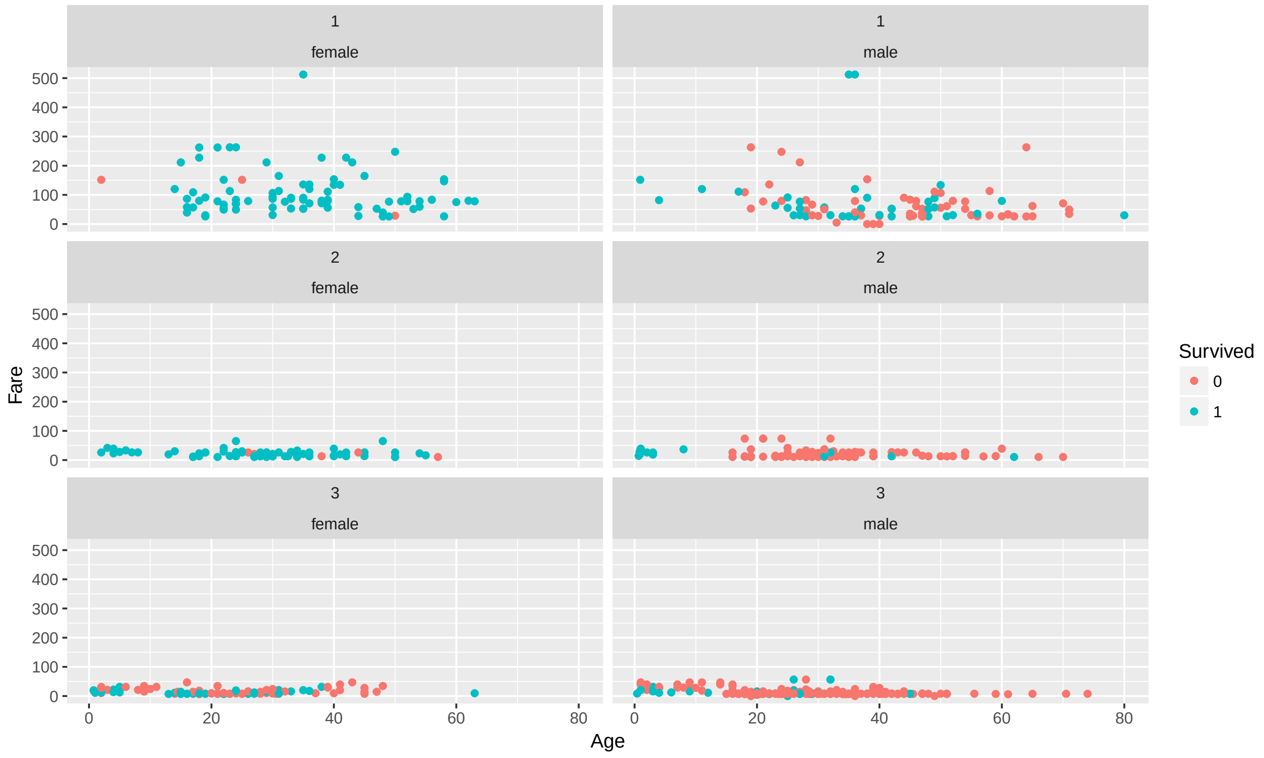
Facetting: `facet_wrap` and `facet_grid`

```
df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_wrap(~ Sex)
```



`facet_wrap` allows for flexible column layout:

```
df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_wrap(Pclass ~ Sex, ncol = 2)
```



`facet_grid` is more ideal for facetting with 2 factors:

```
df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_grid(Pclass ~ Sex, scales = "free_y")
```

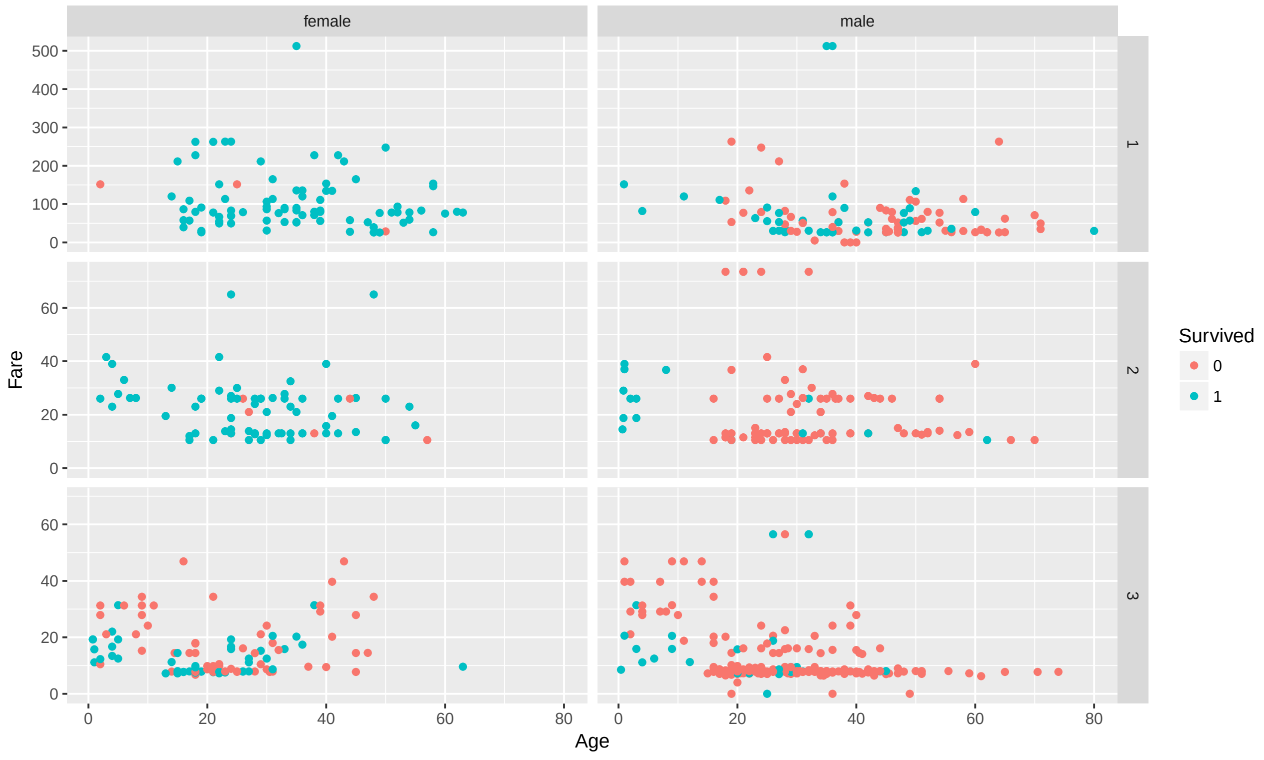
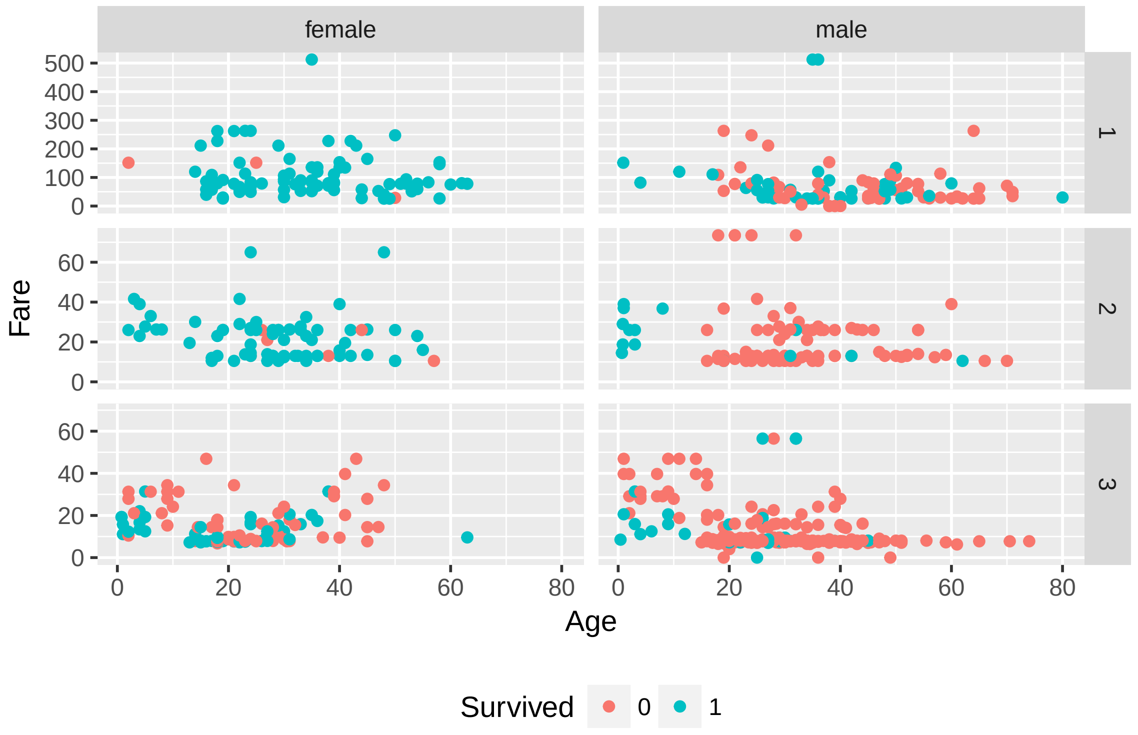


Figure decorations

Configurations regarding the figure as a whole are provided by the `theme()` function. Read all the available options here.

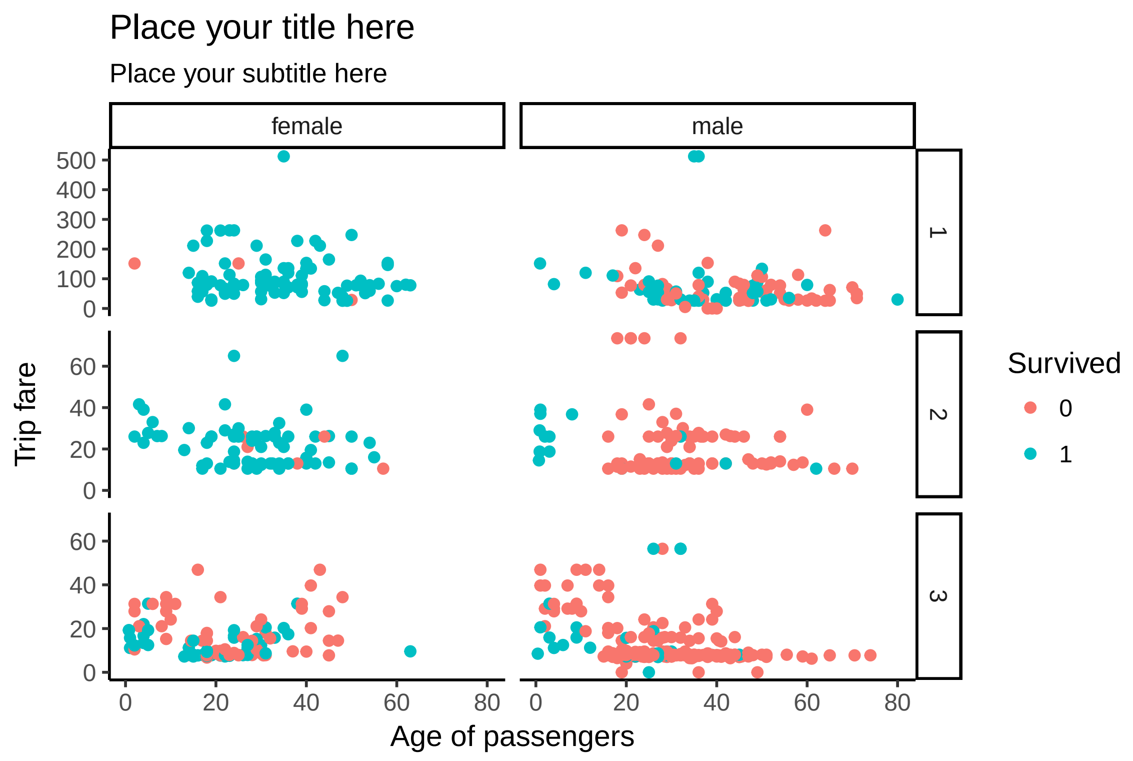
Change the position of the figure legend:

```
df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_grid(Pclass ~ Sex, scales = "free_y") +
  theme(legend.position = "bottom")
```



Add title and other elements:

```
df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_grid(Pclass ~ Sex, scales = "free_y") +
  labs(title = "Place your title here",
       subtitle = "Place your subtitle here",
       x = "Age of passengers",
       y = "Trip fare") +
  theme_classic()
```



Saving the plot

Saving a ggplot object is done by the `ggsave` function.

```r
# Option 1: Assign the ggplot object to a variable
fig <- df %>% ggplot(aes(x = Age, y = Fare)) +
  geom_point(aes(color = Survived)) +
  facet_grid(Pclass ~ Sex, scales = "free_y") +
  labs(title = "Place your title here",
       subtitle = "Place your subtitle here",
       x = "Age of passengers",
       y = "Trip fare") +
  theme_classic()
ggsave(filename = "ggplot-figure.png", plot = fig,
       width = 7.2, height = 4.8, units = "in", dpi = 300)
# Option 2: Evaluate your plot within `()` then chain it
(
  df %>% ggplot(aes(x = Age, y = Fare)) +
    geom_point(aes(color = Survived)) +
    facet_grid(Pclass ~ Sex, scales = "free_y") +
    labs(title = "Place your title here",
         subtitle = "Place your subtitle here",
         x = "Age of passengers",
         y = "Trip fare") +
    theme_classic()
) %>%
  ggsave(filename = "ggplot-figure.png",
         width = 7.2, height = 4.8, units = "in", dpi = 300)
```

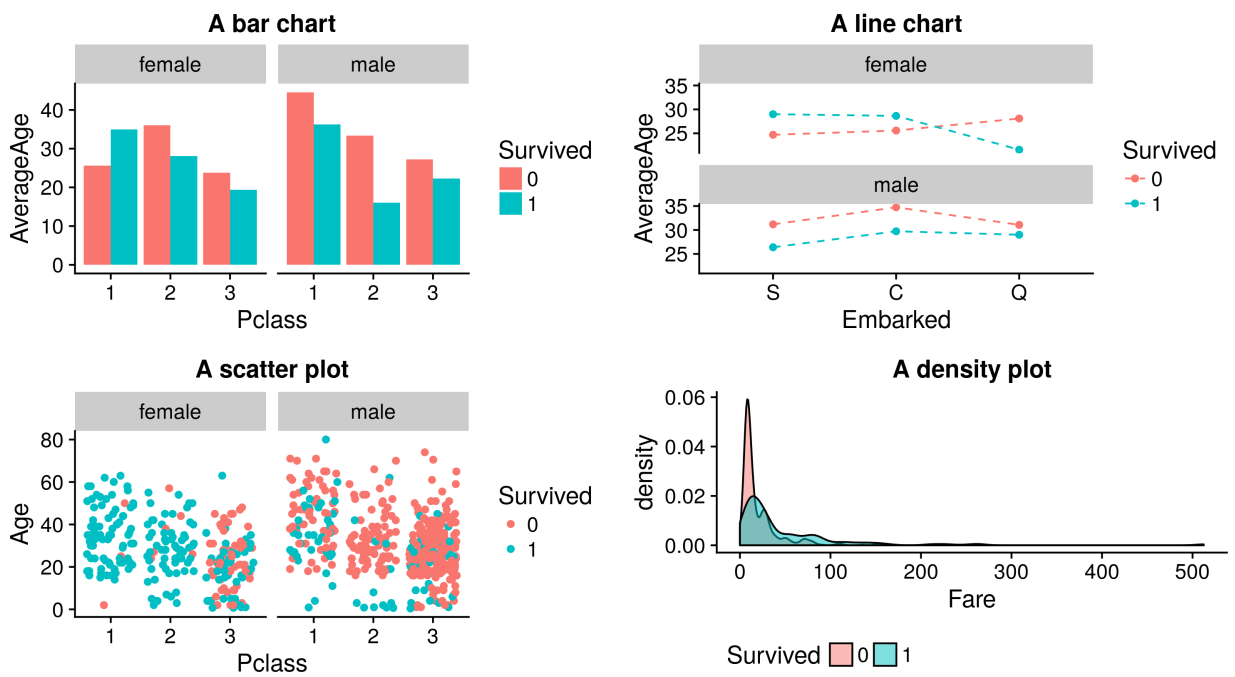


Figure 1:

Wrapping up

Plotting in ggplot2 is done by:

- Calling `ggplot(data)` to initialise the plotting process
- Global aesthetics are specified by a `aes(x = ..., y = ..., ...)` function
- Specific plotting layers are provided by the `geom_` functions
- Fine-tune your plots with other functions

Exercise:

Let us practice what we learn today and see if you could reproduce one of the following figures.

Where to go from here

What can we learn from Titanic data

Exploratory data analysis assisted by visualisation is only the first step in your analysis.

Resources

- Reference manuals and websites:
  - ggplot2 reference: http://ggplot2.tidyverse.org/index.html
  - R graphics cookbook: http://www.cookbook-r.com/Graphs/
  - R for Data Science: http://r4ds.had.co.nz/

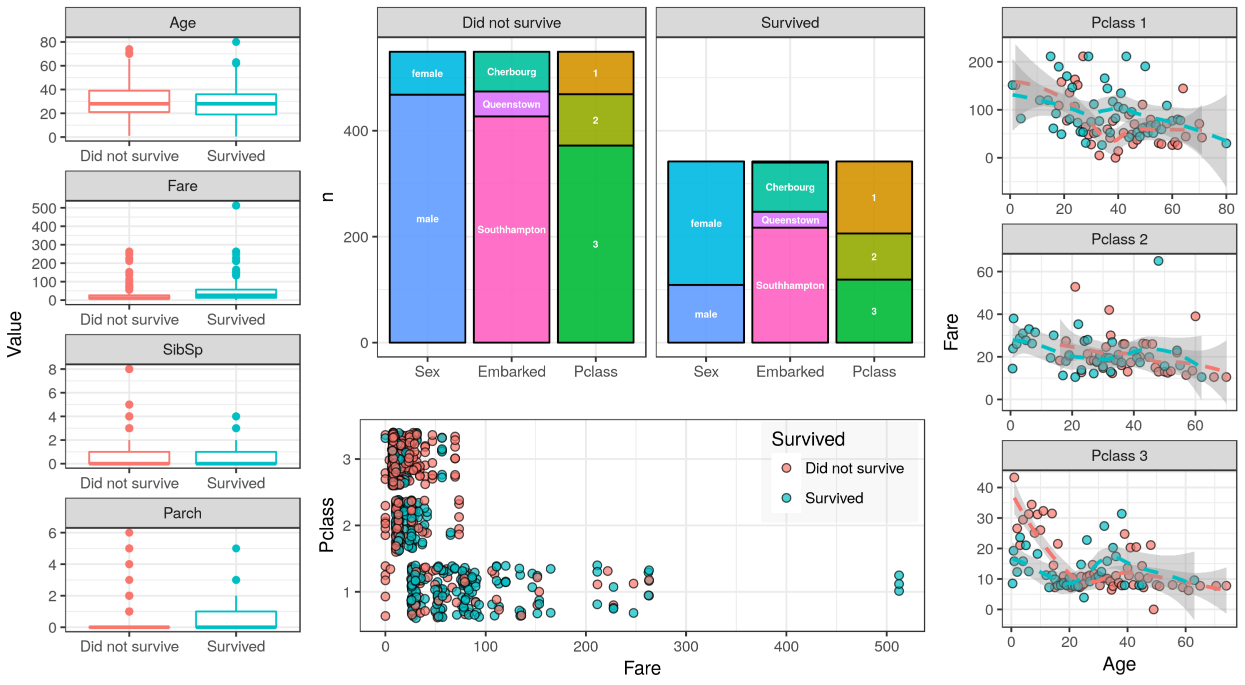


Figure 2:

- Extensions to `ggplot2`:
  - ggthemes: https://github.com/jrnold/ggthemes
  - cowplot: https://cran.r-project.org/web/packages/cowplot/vignettes/introduction.html

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- Interactive plots:
  - plotly: https://plot.ly/r/
  - bokeh: http://hafen.github.io/rbokeh/index.html
- Other types of plots:
  - correlation plots: https://cran.r-project.org/web/packages/corrplot/vignettes/corrplot-intro.html
  - maps: https://github.com/mtennekes/tmap
  - treemaps: https://cran.r-project.org/web/packages/treemap/vignettes/treemap-color_mapping.html