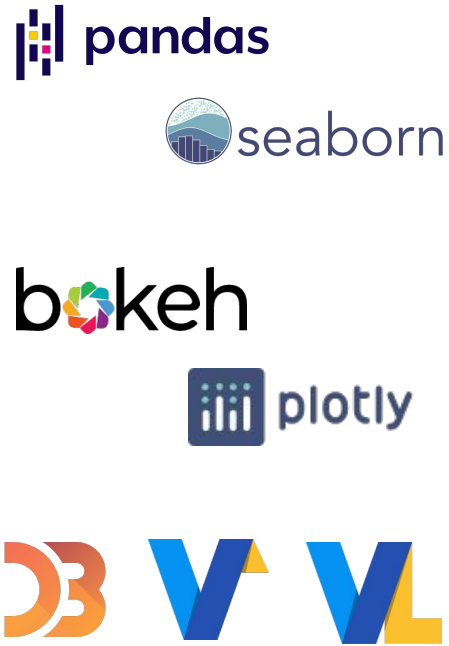
Interactive Data Visualization

Workshop with Altair

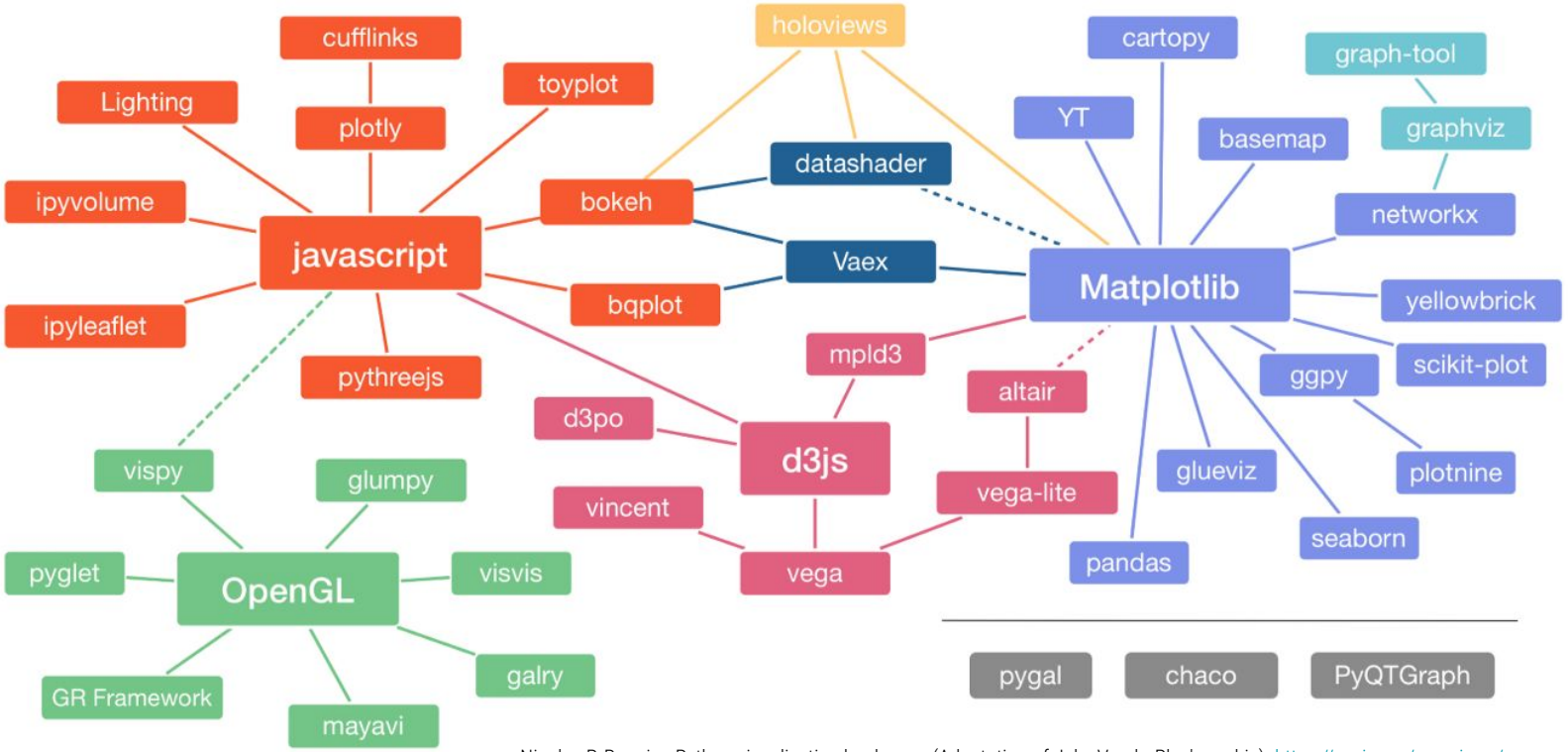
Natkamon Tovanich

Data Visualization Tools

- **Matplotlib-based**, e.g. Pandas, Seaborn
  - Matplotlib API is imperative and often overly verbose.
  - Keep matplotlib as a versatile, well-test backend, and provide a new domain-specific API.
- **JavaScript-based**, e.g. Bokeh and Plotly
  - Build a new API that produces a plot serialization (often JSON) that can be displayed in the browser (often in Jupyter notebooks).
  - Predefined charts and interactions with limited configuration options.
- **D3.js-based**, e.g. Vega, Vega-lite, Altair
  - Specify how the chart looks and feels and interaction with the chart.
  - Based on the grammar of of graphics and declarative visualization.
- **Visualization for large data**, e.g. OpenGL, DataShader, Holoviews



Data Visualization Tools



Nicolas P. Rougier. Python visualization landscape (Adaptation of Jake VanderPlas' graphic). https://pyviz.org/overviews/

Data Visualization Tools

Imperative

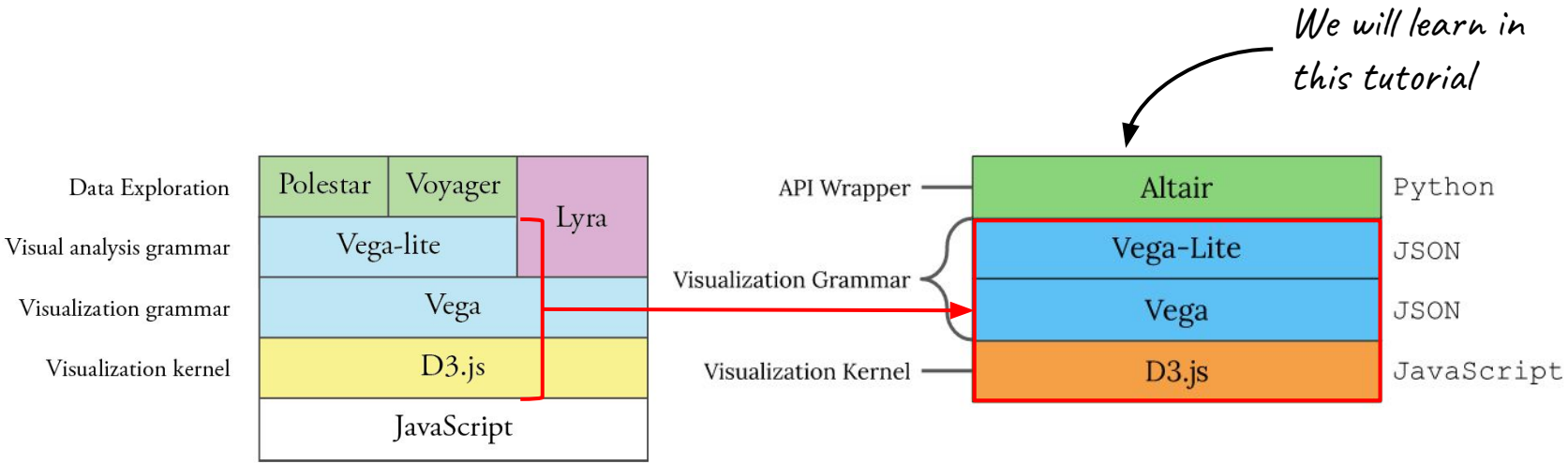
- Specify *How* something should be done.
- Must manually specify plotting steps.
- Specification & execution intertwined.

Declarative

- Specify *What* should be done
- Details determine automatically
- Separate specification from execution.

Declarative visualization lets you think about **data** and **relationships**, rather than incidental details

The D3 - Vega Stack

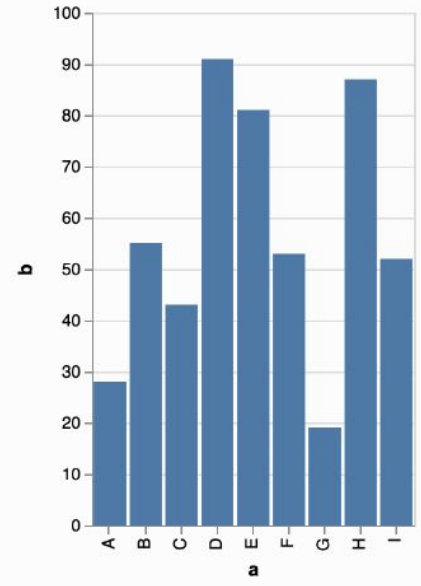


Eitan Lees, *Understanding The Altair Stack*, 2020.
Éric Marty, *The D3/Vega "stack"*, 2016.

Altair

Python wrappers for Vega-Lite!

Works with Pandas, Jupyter, etc.



Save as SVG Save as PNG View Source O

Vega-Lite JSON Specification

```
{
  "$schema": "https://vega.github.io/schema/vega-lite/v3.json",
  "description": "A simple bar chart with embedded data.",
  "data": {
    "values": [
      {"a": "A","b": 28}, {"a": "B","b": 55}, {"a": "C","b": 43},
      {"a": "D","b": 91}, {"a": "E","b": 81}, {"a": "F","b": 53},
      {"a": "G","b": 19}, {"a": "H","b": 87}, {"a": "I","b": 52}
    ]
  },
  "mark": "bar",
  "encoding": {
    "x": {"field": "a", "type": "ordinal"},
    "y": {"field": "b", "type": "quantitative"}
  }
}
```

Display a menu

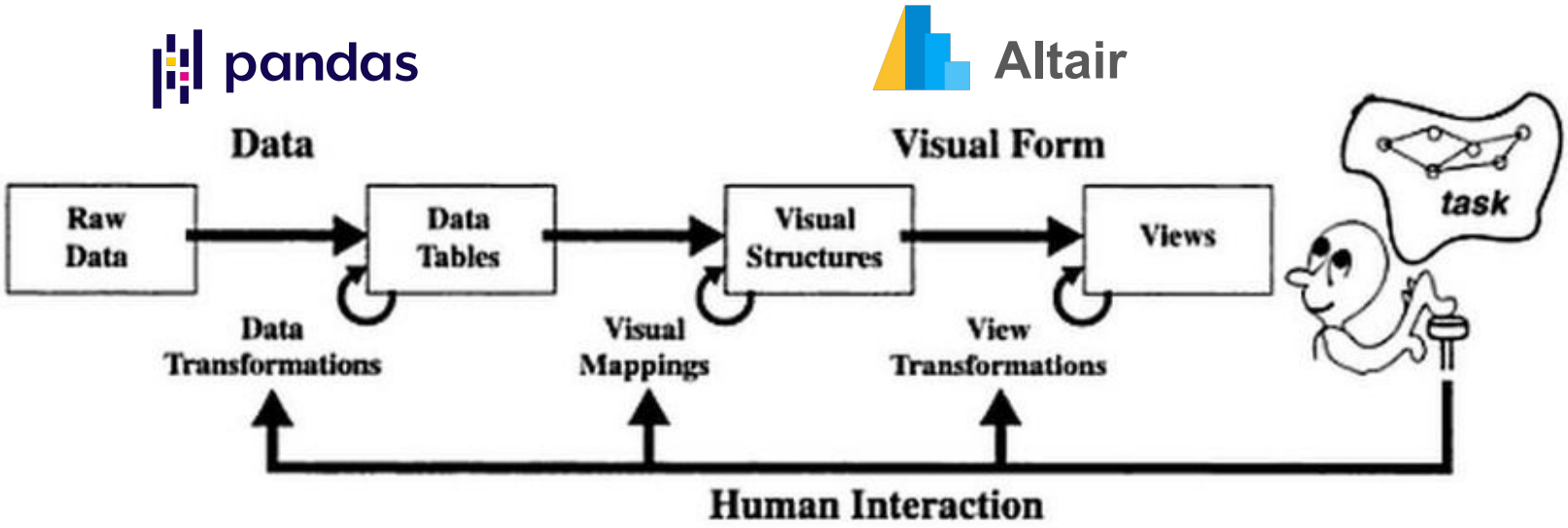
```
import altair as alt
import pandas as pd

source = pd.DataFrame({
    'a': ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I'],
    'b': [28, 55, 43, 91, 81, 53, 19, 87, 52]
})

alt.Chart(source).mark_bar().encode(
    x='a',
    y='b'
)
```

Slide from Wesley Willett, University of Calgary

Data Visualization Pipeline



Card, Mackinlay. *Readings in Information Visualization: Using Vision to Think.* Morgan Kaufmann, 1999.

Elements of Data Visualization

Elements of Data Visualization

Data

Marks

Encondings

Scales & Guides

Interaction

```
from vega_datasets import data
source = data.gapminder()
```

	year	country	cluster	pop	life_expect	fertility
0	1955	Afghanistan	0	8891209	30.3320	7.7000
1	1960	Afghanistan	0	9829450	31.9970	7.7000
2	1965	Afghanistan	0	10997885	34.0200	7.7000
3	1970	Afghanistan	0	12430623	36.0880	7.7000
4	1975	Afghanistan	0	14132019	38.4380	7.7000
5	1980	Afghanistan	0	15112149	39.8540	7.8000
6	1985	Afghanistan	0	13796928	40.8220	7.9000
7	1990	Afghanistan	0	14669339	41.6740	8.0000
8	1995	Afghanistan	0	20881480	41.7630	8.0000
9	2000	Afghanistan	0	23898198	42.1290	7.4792

Ordinal Nominal Nominal Quantitative

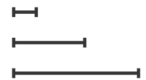
Attribute Types

→ Categorical

→ Ordered

→ *Ordinal*

→ *Quantitative*



Elements of Data Visualization

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Interaction

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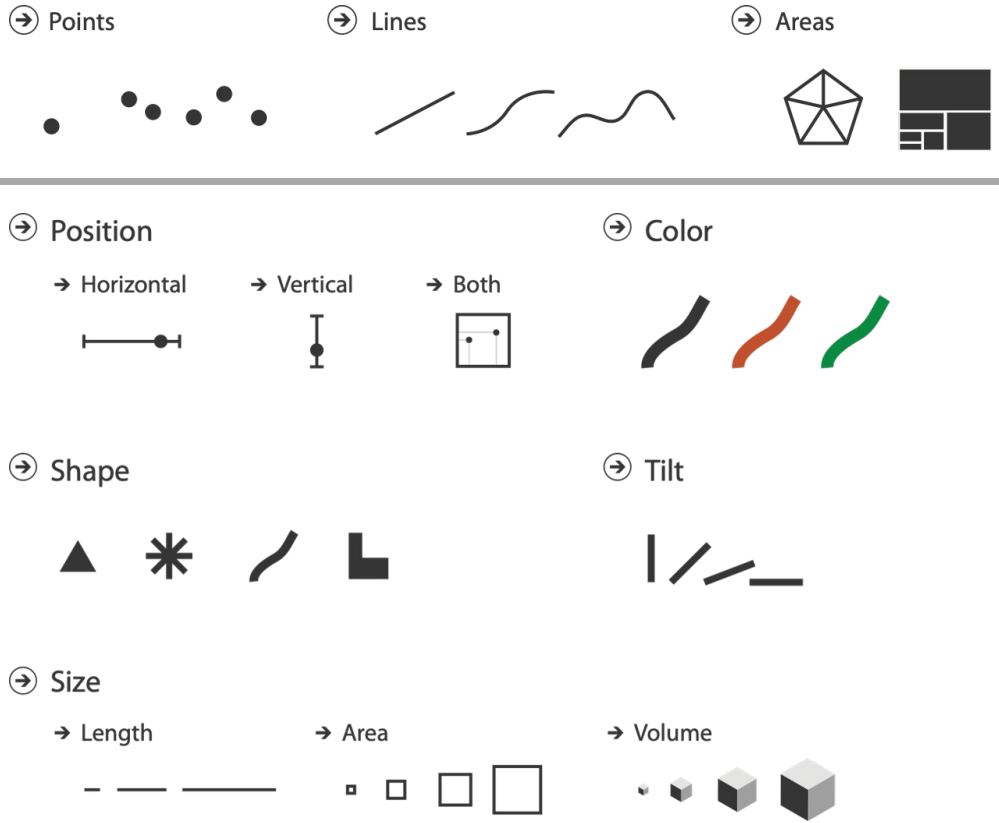

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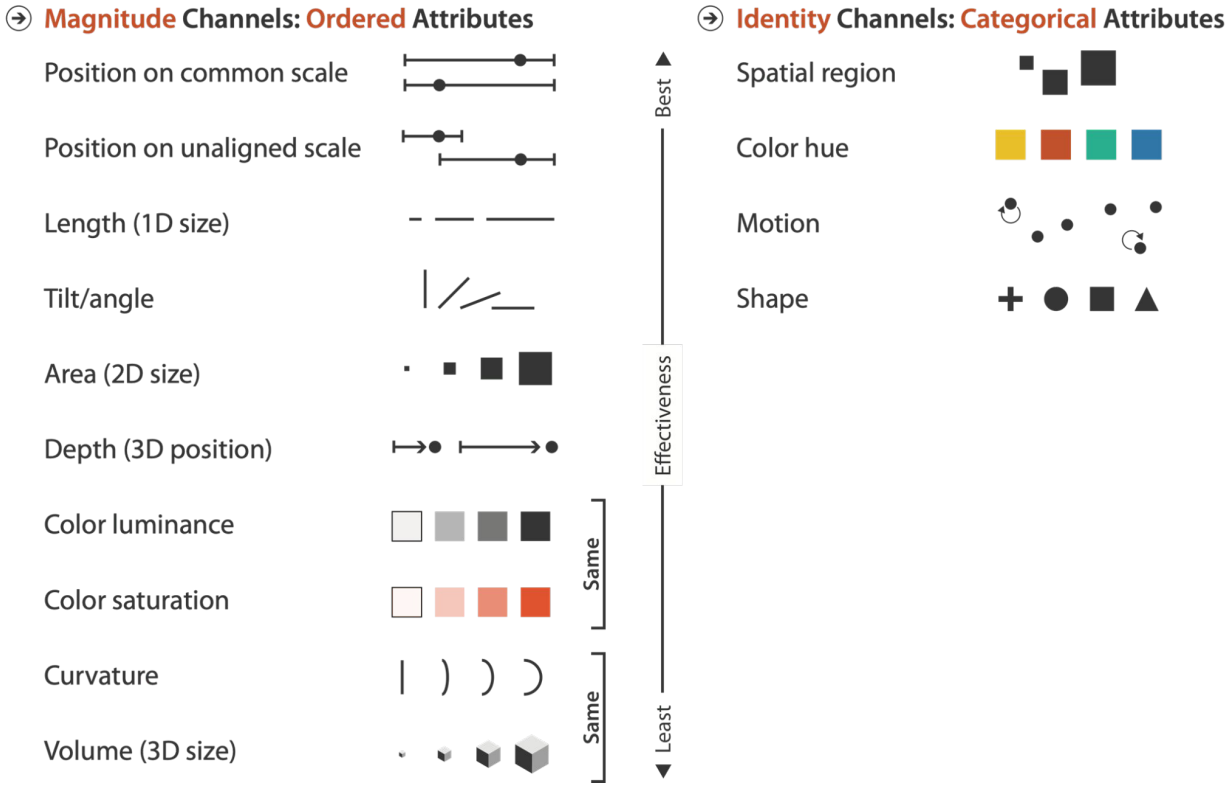

How to create a chart in Altair

How to Create a Chart

Data

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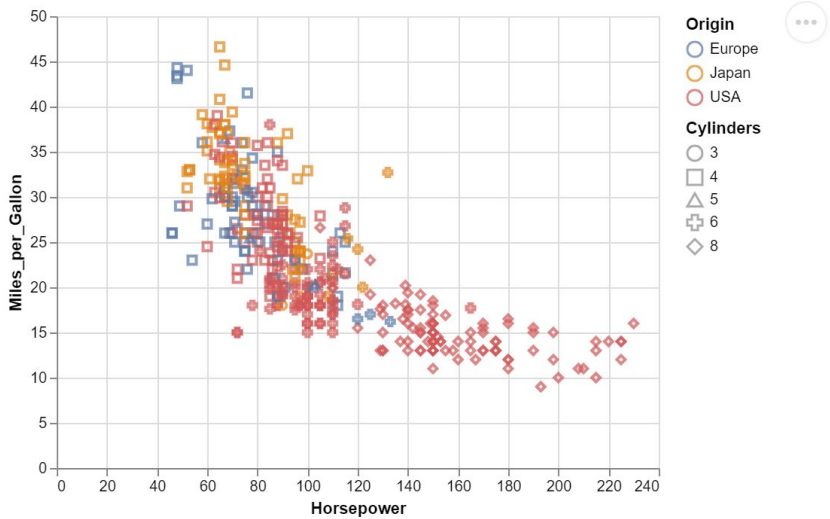
Encondings

Scales & Guides

Interaction

Dataset

```
[2]  alt.Chart(cars).mark_point().encode(
         x='Horsepower:Q',
         y='Miles_per_Gallon:Q',
         color='Origin:N',
         shape='Cylinders:N'
     )
```



How to Create a Chart

Data

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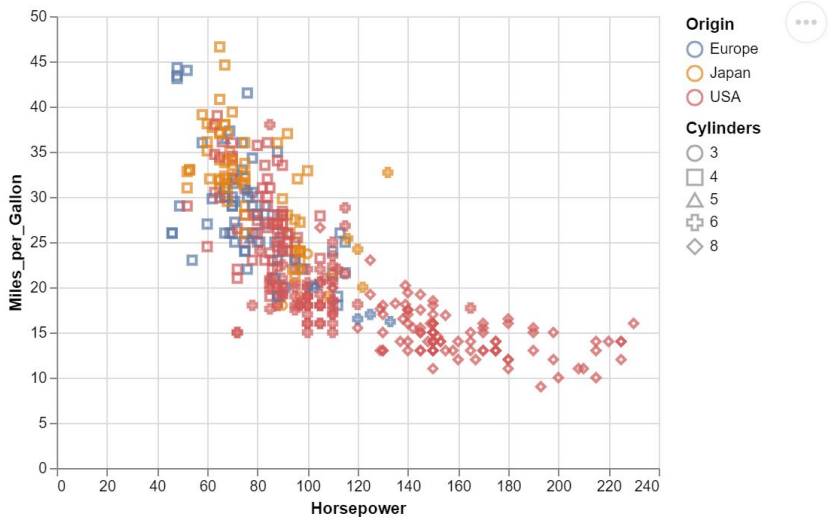
Scales & Guides

Interaction

Dataset **Mark**

```
[2]  alt.Chart(cars).mark_point().encode(
         x='Horsepower:Q',
         y='Miles_per_Gallon:Q',
         color='Origin:N',
         shape='Cylinders:N'
     )
```



How to Create a Chart

Data

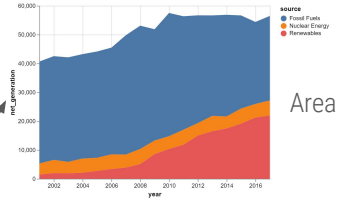
Marks

Encondings

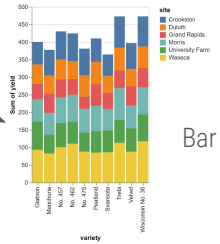
Scales & Guides

Interaction

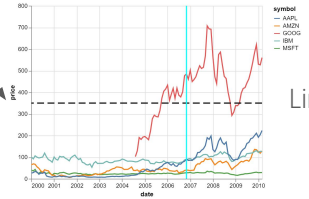
Mark Name	Method	Description	Example
arc	`mark_arc()`	A pie chart.	Pie Chart
area	`mark_area()`	A filled area plot.	Simple Stacked Area Chart
bar	`mark_bar()`	A bar plot.	Simple Bar Chart
circle	`mark_circle()`	A scatter plot with filled circles.	One Dot Per Zipcode
geoshape	`mark_geoshape()`	A geographic shape	Choropleth Map
image	`mark_image()`	A scatter plot with image markers.	Image Mark
line	`mark_line()`	A line plot.	Simple Line Chart
point	`mark_point()`	A scatter plot with configurable point shapes.	Multi-panel Scatter Plot with Linked Brushing
rect	`mark_rect()`	A filled rectangle, used for heatmaps	Simple Heatmap
rule	`mark_rule()`	A vertical or horizontal line spanning the axis.	Candlestick Chart
square	`mark_square()`	A scatter plot with filled squares.	N/A
text	`mark_text()`	A scatter plot with points represented by text.	Bar Chart with Labels
tick	`mark_tick()`	A vertical or horizontal tick mark.	Simple Strip Plot
trail	`mark_trail()`	A line with variable widths.	Line Chart with Varying Size



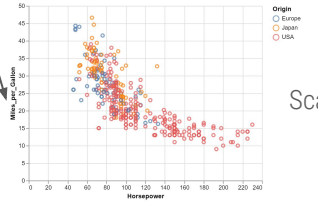
Area chart



Bar chart



Line chart



Scatterplot

How to Create a Chart

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Scales & Guides

Interaction

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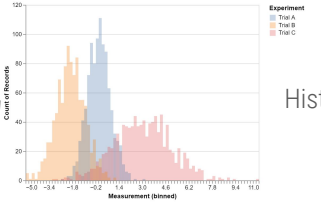
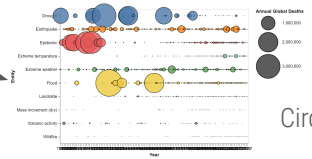
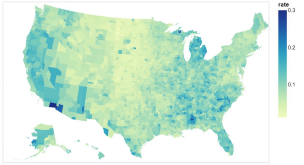


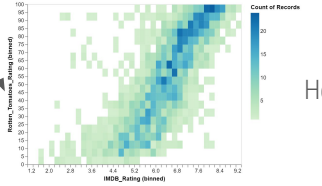
Histogram



Circle plot



Choropleth map



Heatmap

How to Create a Chart

Data

Marks

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Scales & Guides

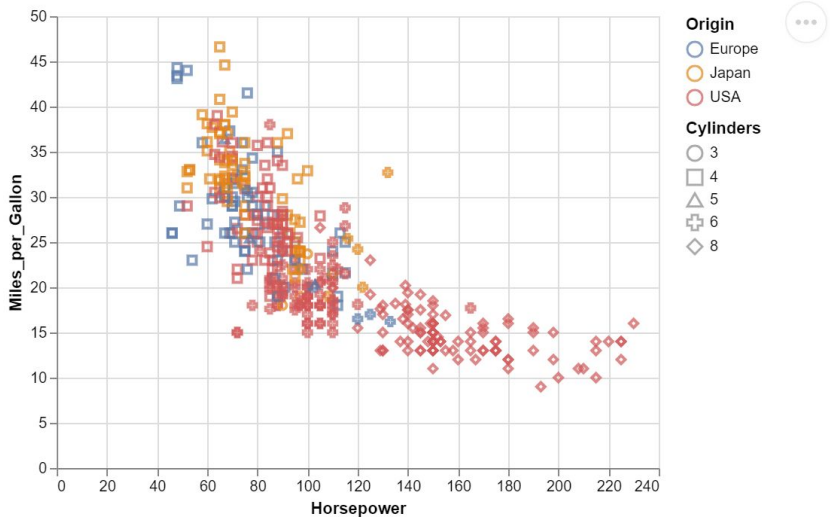
Interaction

Dataset → `alt.Chart(cars)` **Mark** → `mark_point()`

```
[2]  alt.Chart(cars).mark_point().encode(
         x='Horsepower:Q',
         y='Miles_per_Gallon:Q',
         color='Origin:N',
         shape='Cylinders:N'
     )
```

Encodings

Specify data types
- Quantitative (Q)
- Ordinal (O)
- Nominal (N)
- Temporal (T)



How to Create a Chart

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Encondings

Scales & Guides

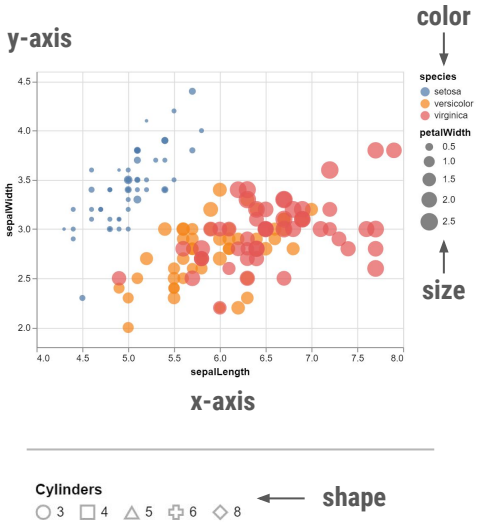
Interaction

Position Channels:

Channel	Altair Class	Description	Example
x	`X`	The x-axis value	Simple Scatter Plot with Tooltips
y	`Y`	The y-axis value	Simple Scatter Plot with Tooltips

Mark Property Channels:

Channel	Altair Class	Description	Example
angle	`Angle`	The angle of the mark	Wind Vector Map
color	`Color`	The color of the mark	Simple Heatmap
fill	`Fill`	The fill for the mark	Ridgeline plot Example
fillopacity	`FillOpacity`	The opacity of the mark's fill	N/A
opacity	`Opacity`	The opacity of the mark	Horizon Graph
radius	`Radius`	The radius or the mark	Radial Chart
shape	`Shape`	The shape of the mark	US Income by State: Wrapped Facet
size	`Size`	The size of the mark	Table Bubble Plot (Github Punch Card)



How to Create a Chart

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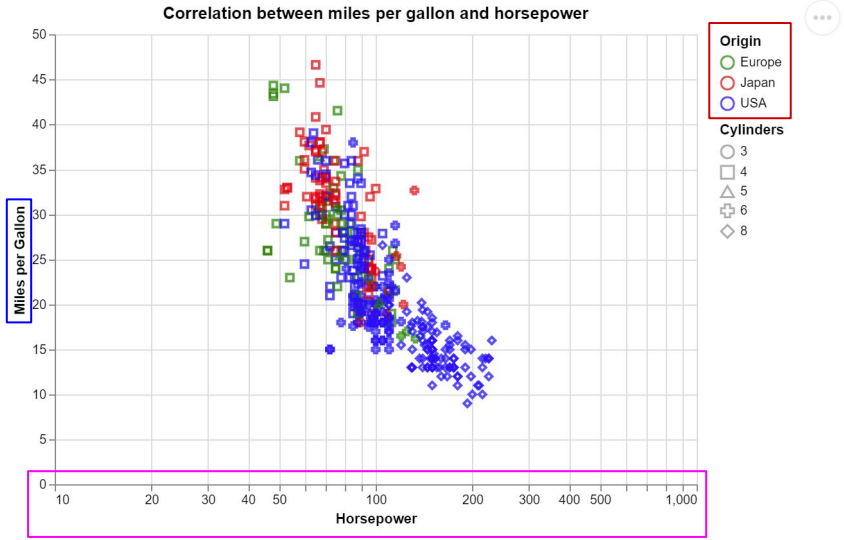
Scales & Guides

Interaction

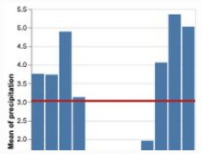
```
[3]  alt.Chart(cars).mark_point().encode(
         x=alt.X('Horsepower:Q', scale=alt.Scale(type='log')),
         y=alt.Y('Miles_per_Gallon:Q', title='Miles per Gallon'),
         color=alt.Color('Origin:N',
                         scale=alt.Scale(domain=['Europe', 'Japan', 'USA'],
                                         range=['green', 'red', 'blue'])),
         shape='Cylinders:N'
     ).properties(title='Correlation between miles per gallon and horsepower',
                  height=350, width=500).interactive()
```



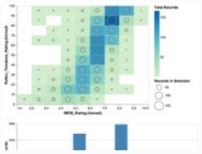
Interactions & Selections in Altair

Interactions and Selections in Altair

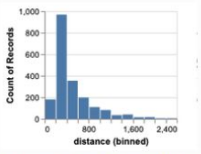
- Pan and zoom
- Selection
- Brushing
- Binding with other views



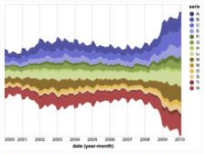
Interactive Average



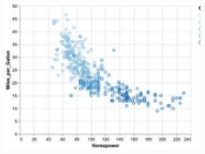
Interactive Chart with Cross-Highlight



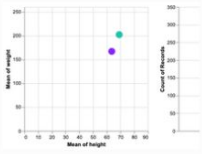
Interactive Crossfilter



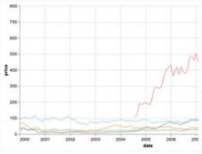
Interactive Legend



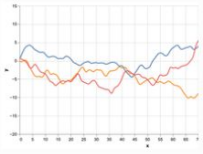
Interactive Rectangular Brush



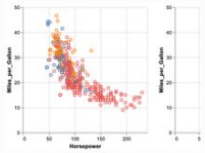
Interactive Scatter Plot and Linked Layered Histogram



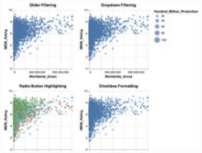
Multi-Line Highlight



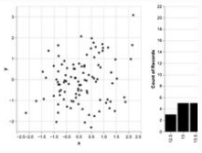
Multi-Line Tooltip



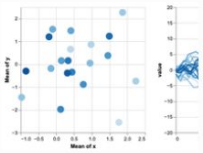
Multi-panel Scatter Plot with Linked Brushing



Multiple Interactions



Scatter Plot and Histogram with Interval Selection



Selection Detail Example

How to Make Charts Interactive

```
source = data.cars()

brush = alt.selection(type='interval')

points = alt.Chart(source).mark_point().encode(
    x='Horsepower:Q',
    y='Miles_per_Gallon:Q',
    color=alt.condition(brush, 'Origin:N', alt.value('lightgray'))
).add_selection(
    brush
)

bars = alt.Chart(source).mark_bar().encode(
    y='Origin:N',
    color='Origin:N',
    x='count(Origin):Q'
).transform_filter(
    brush
)

points & bars
```

1. Create brush selection

2. Add selection to the chart

3. Add the data filter based on the selection