15-388/688 - Practical Data Science: Visualization and Data Exploration

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Outline

Basics of visualization

Data types and visualization types

Software plotting libraries

Announcements

A note on what it means to “run your code locally”: run *and* pass test cases, not just “execute each cell in notebook”

We’re going to put up a Piazza poll asking about students switching 388 to/from 688 (both directions)

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Basics of visualization

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Software plotting libraries

Two types of visualization

Data exploration visualization: figuring out what is true

Data presentation visualization: convincing other people it is true

This lecture will mostly be focused on the first, some later lectures will touch on the second

“Data exploration” is much broader than just visualization (most of the analysis techniques we will cover fit into it)

Importance of visualization

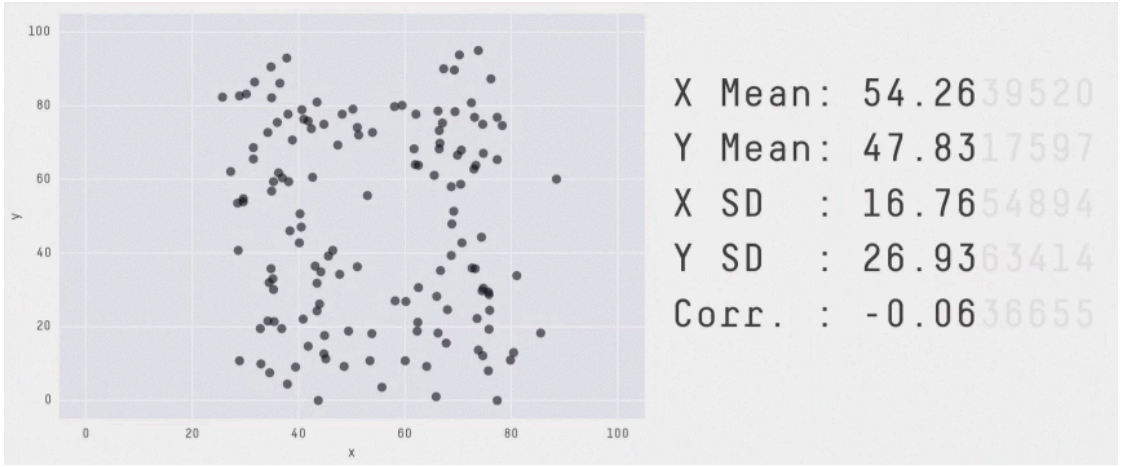
Before you run any analysis, build any machine learning system, etc, always visualize your data

If you can't identify a trend or make a prediction for your dataset, neither will an automated algorithm

> This is especially important to keep in mind as you hear stories of "superhuman" performance of AI methods (it is possible, but takes a long time, and is not the norm)

Visualization vs. statistics

Visualization almost always presents a more informative (though less quantitative) view of your data than statistics (the noun, not the field)



[Source: https://twitter.com/JustinMatejka/status/770682771656368128 Credit: @JustinMatejka, @albertocairo]

This is a mathematical property: n data points and m equations to satisfy, with $n > m$

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Data types

Nominal: categorical data, no ordering

Example – Pet: {dog, cat, rabbit, …}

Operations: $=, \neq$

Ordinal: categorical data, with ordering

Example – Rating: {1,2,3,4,5}

Operations: $=, \neq, \geq, \leq, >, <$

Interval: numerical data, zero has no fixed meaning

Example – Temperature Fahrenheit

Operations: $=, \neq, \geq, \leq, >, <, +, -$

Ratio: numerical data, zero has special meaning

Example – Temperature Kelvin

Operations: $=, \neq, \geq, \leq, >, <, +, -, \div$

Poll: Nominal and ordinal values

Which of the following questions that may be asked on a survey would be considered *ordinal*? (unchecked ones are *nominal*)

1. Gender: {male, female, other, prefer not to disclose}

2. Yearly income: {<$18k, $18-40k, $40-75k, >$75k}

3. Reaction to question: {Strongly disagree, slightly disagree, neutral, slightly agree, strongly agree}

4. May we add you to our mailing list: {No, Yes}

Poll: Interval and ratio values

Which of the following quantities would be considered *ratio*? (unchecked values are *interval*)

1. Length (meters)
2. Length (feet)
3. Velocity (meters/second)
4. IQ Score

Visualization Types

Most discussion of visualization types emphasizes what elements the chart is trying to convey

Instead, we are going to focus on the type and dimensionality of the underlying data

Visualization types (not an exhaustive list):

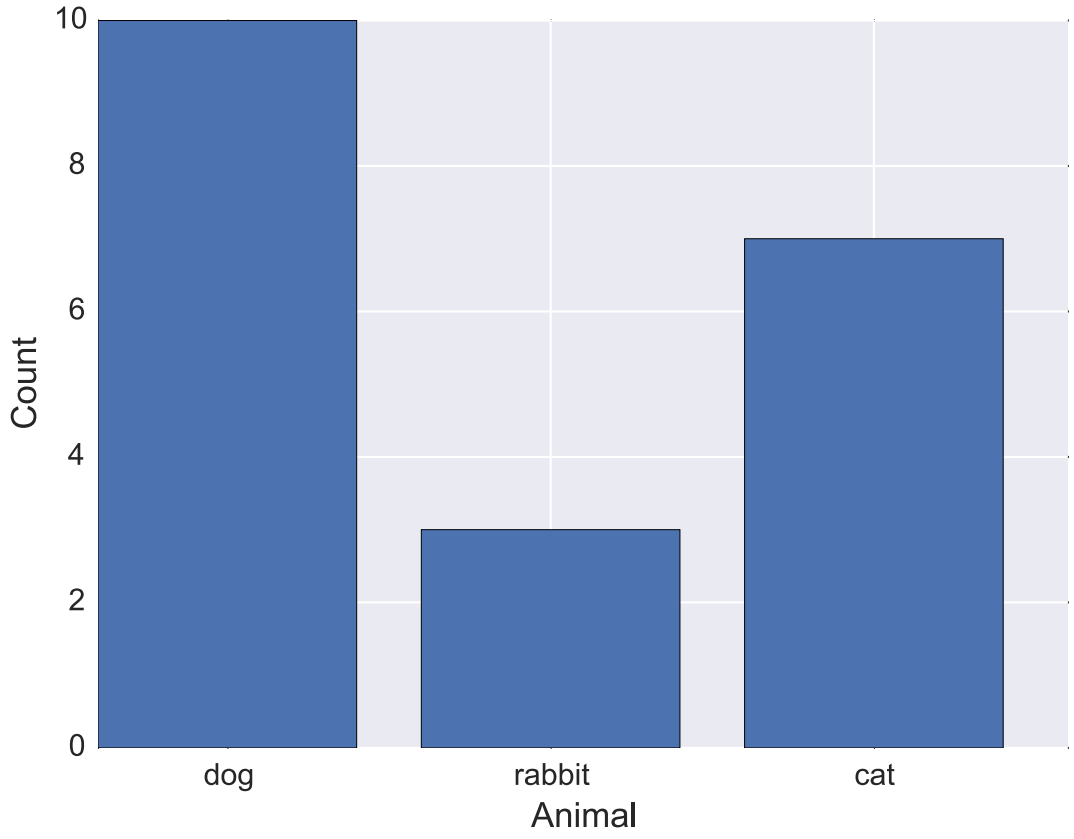
- 1D: bar chart, pie chart, histogram
- 2D: scatter plot, line plot, box and whisker plot, heatmap
- 3D+: scatter matrix, bubble chart

1D DATA

Bar Chart

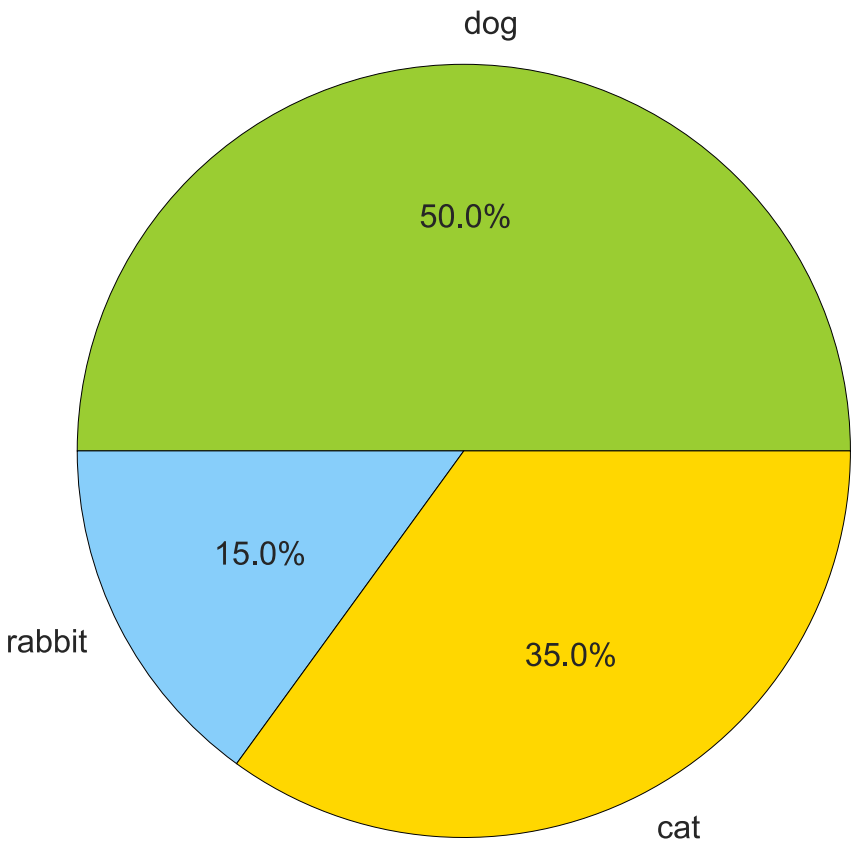
	Data
Nominal	✔
Ordinal	✔
Interval	✘
Ratio	✘

Suggestions, not rules



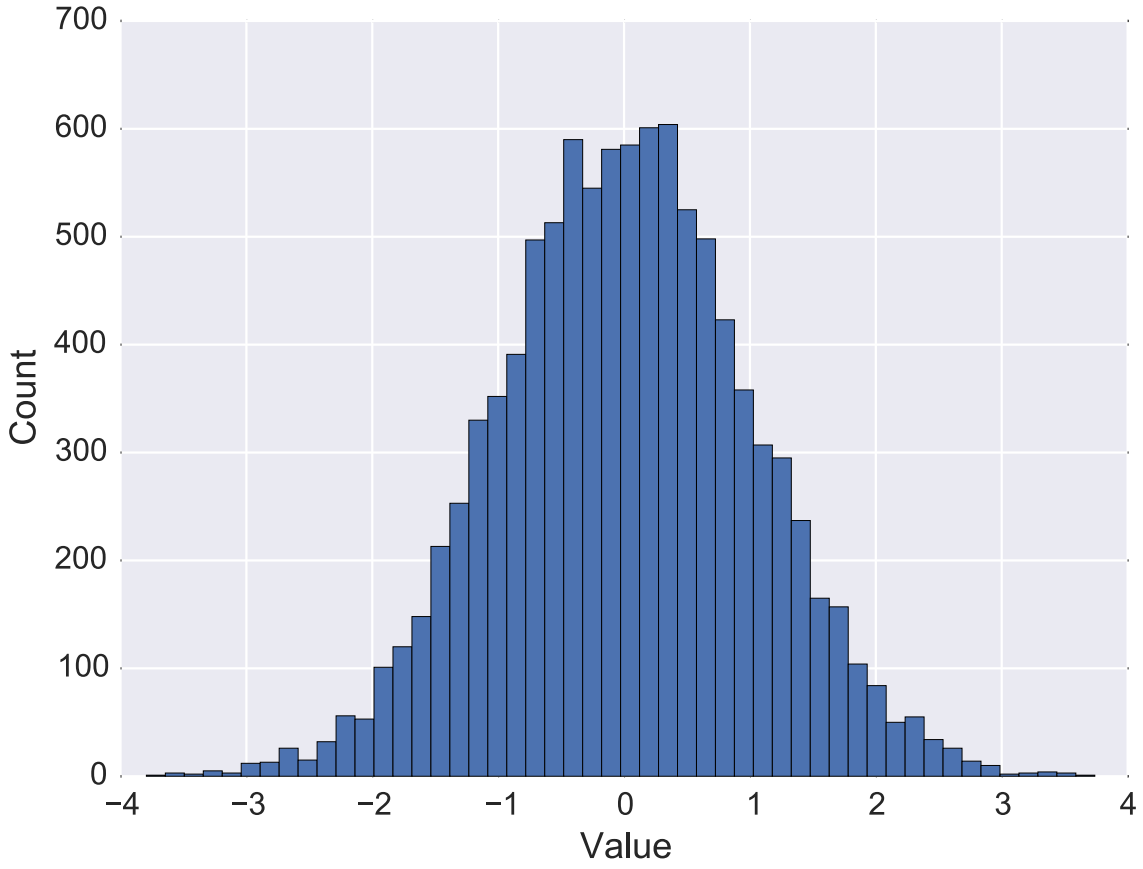
Pie Chart

	Data
Nominal	✘
Ordinal	✘
Interval	✘
Ratio	✘



Histogram

	Data
Nominal	✘
Ordinal	✘
Interval	✔
Ratio	✔

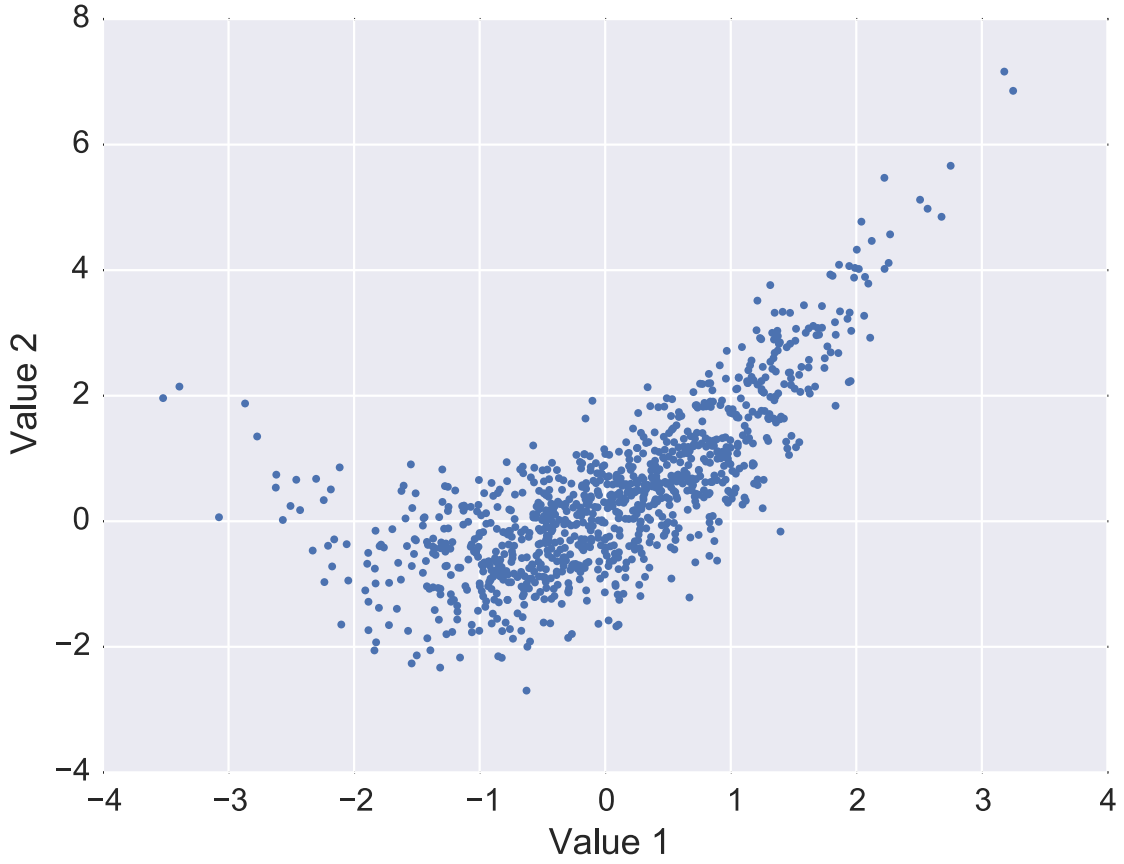


2D DATA

Scatter plot

	Dim 1	Dim 2
Nominal	✘	✘
Ordinal	✘	✘
Interval	✔	✔
Ratio	✔	✔

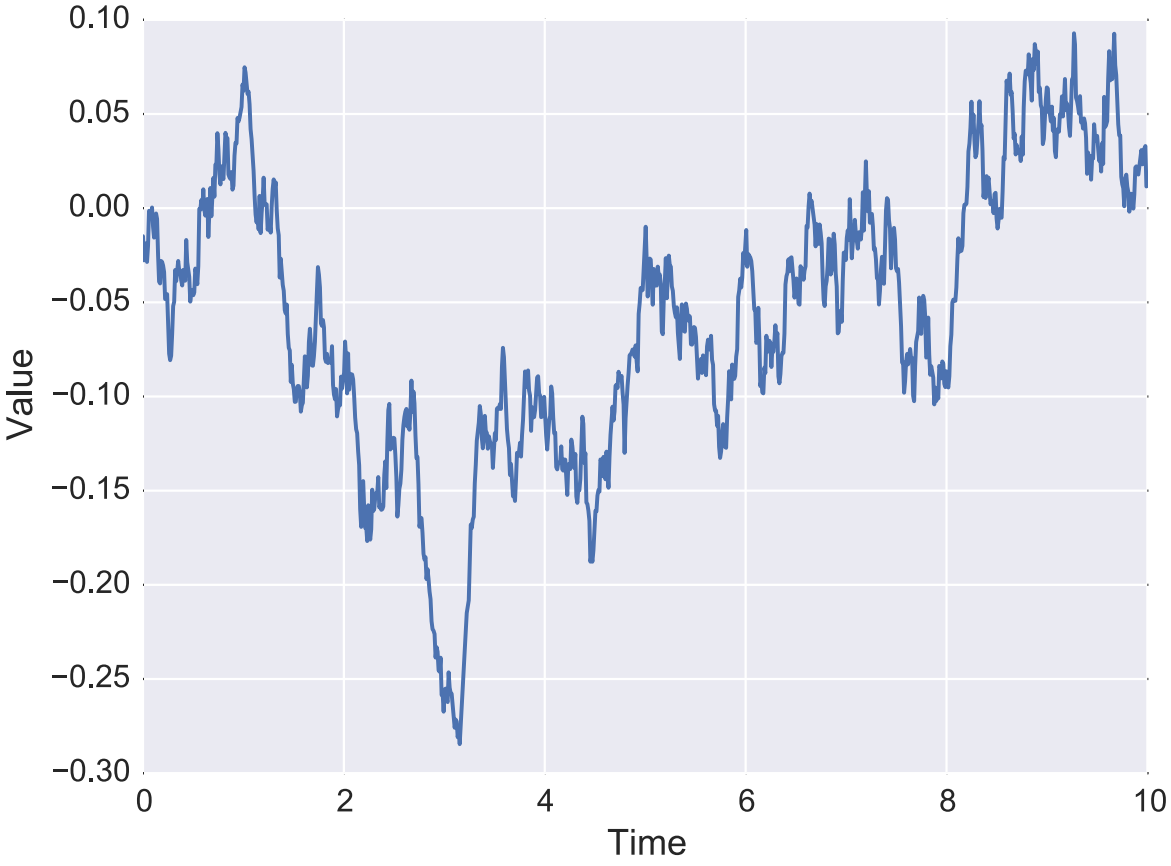
Why not ordinal data in first dimension?



Line plot

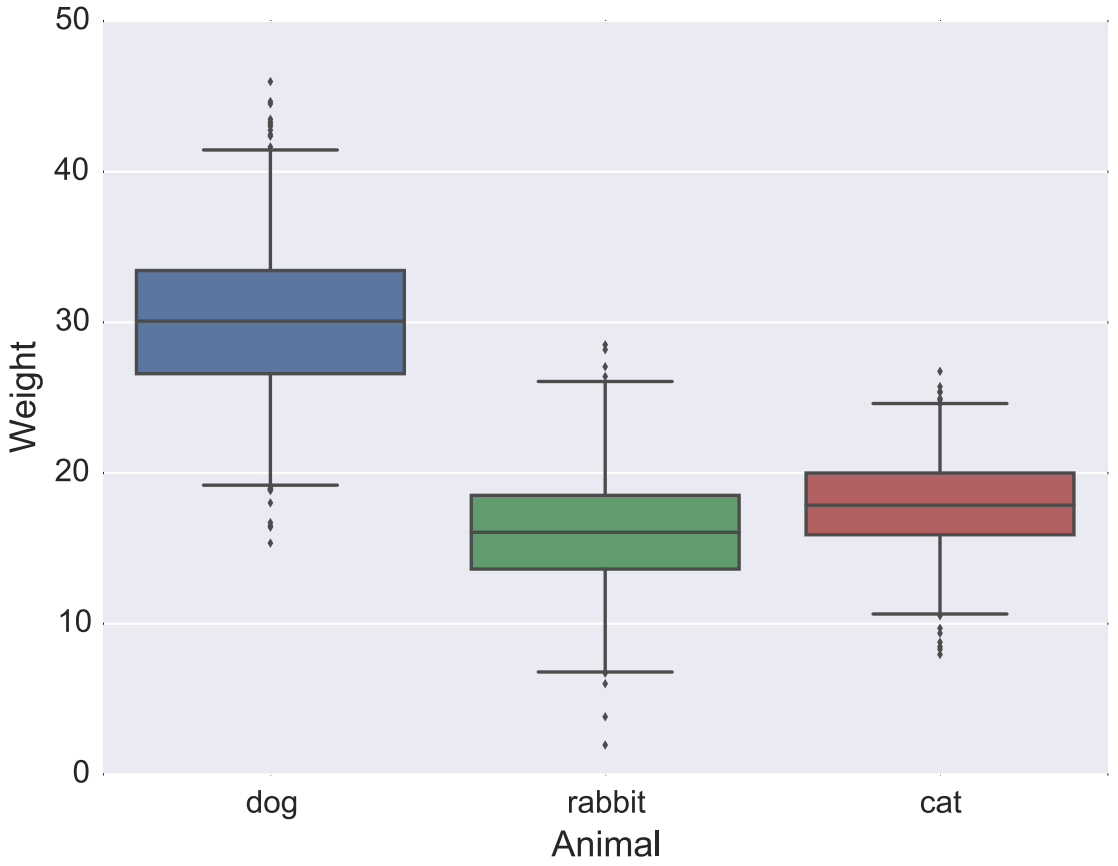
	Dim 1	Dim 2
Nominal	✘	✘
Ordinal	✘	✘
Interval	✔	✔
Ratio	✔	✔

Why not ordinal data in first dimension?



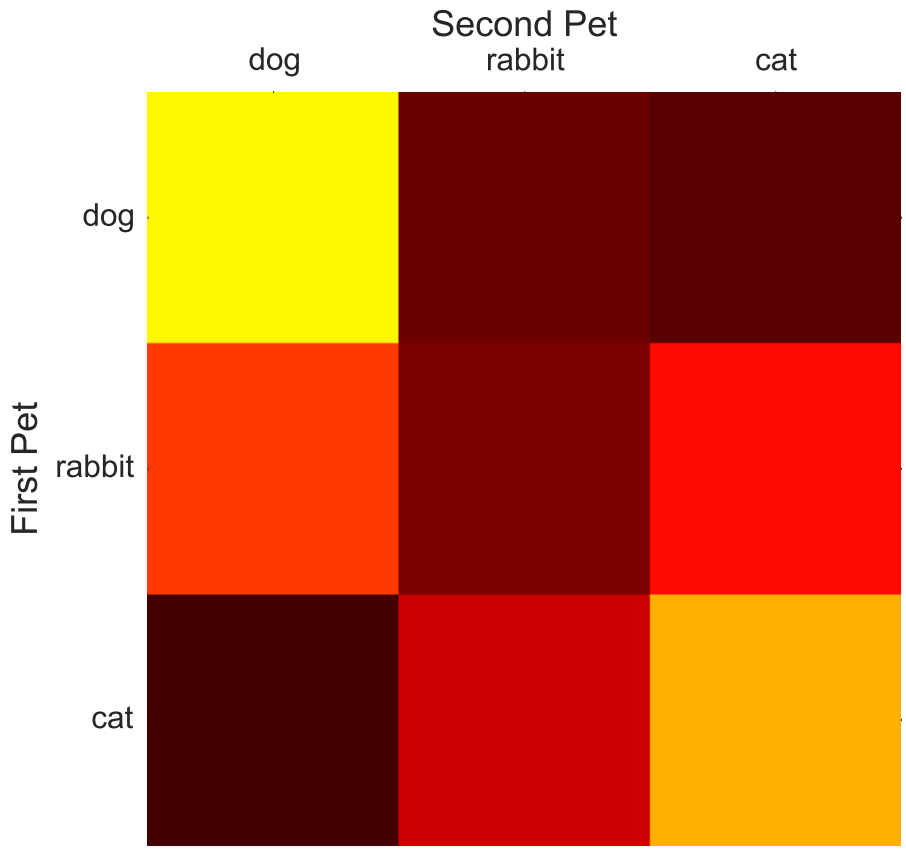
Box and whiskers

	Dim 1	Dim 2
Nominal	✔	✘
Ordinal	✔	✘
Interval	✘	✔
Ratio	✘	✔



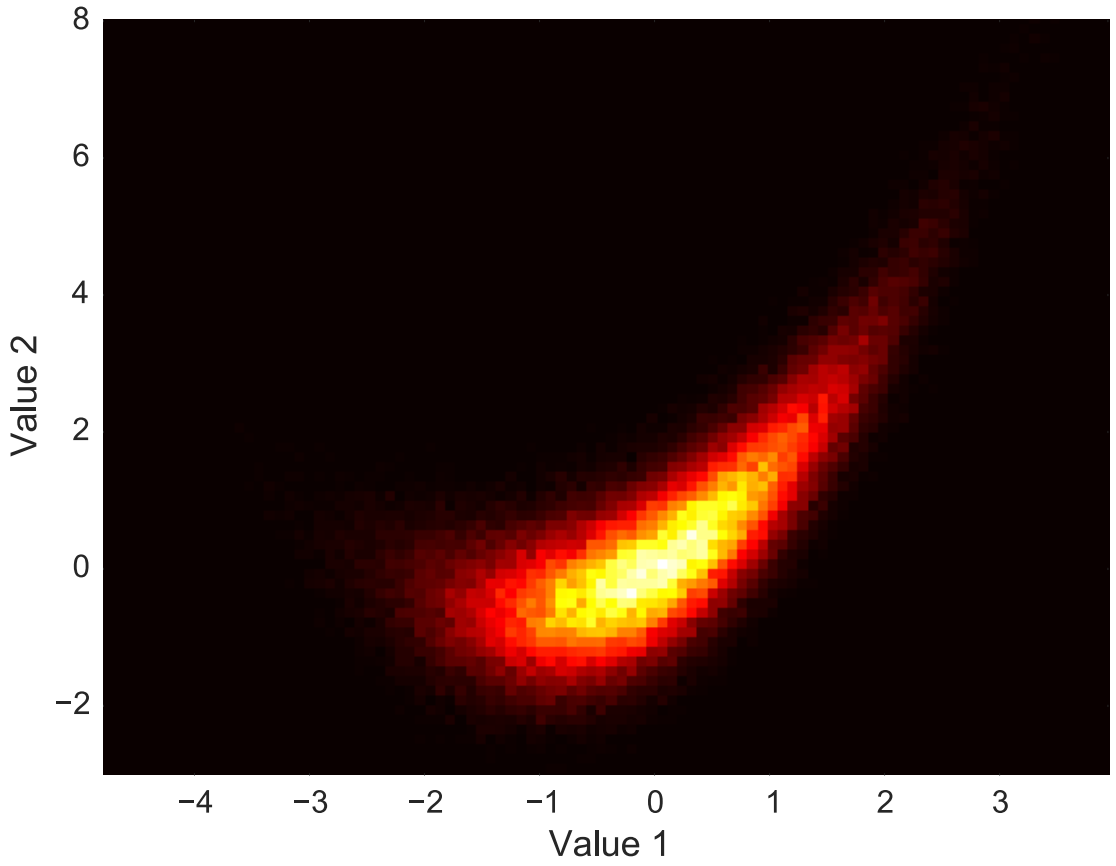
Heatmap (matrix)

	Dim 1	Dim 2
Nominal	✔	✔
Ordinal	✔	✔
Interval	✘	✘
Ratio	✘	✘



Heatmap (density, or 2D histogram)

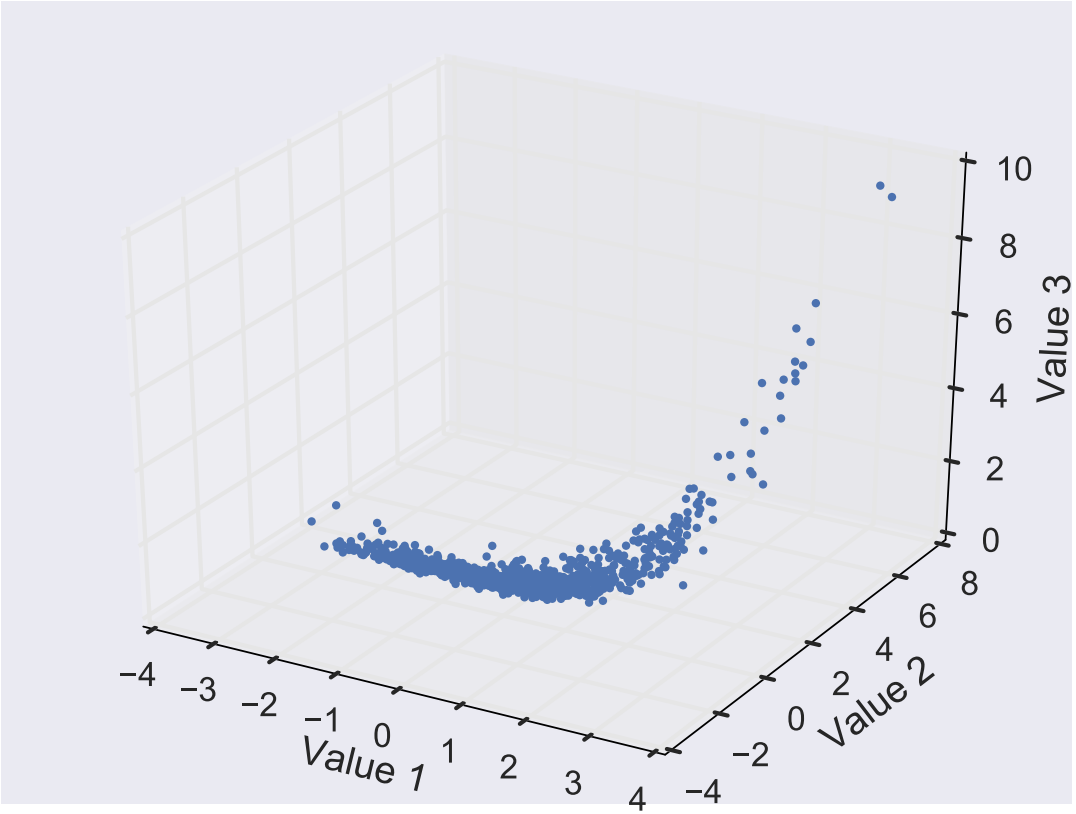
	Dim 1	Dim 2
Nominal	✘	✘
Ordinal	✘	✘
Interval	✔	✔
Ratio	✔	✔



3D+ DATA

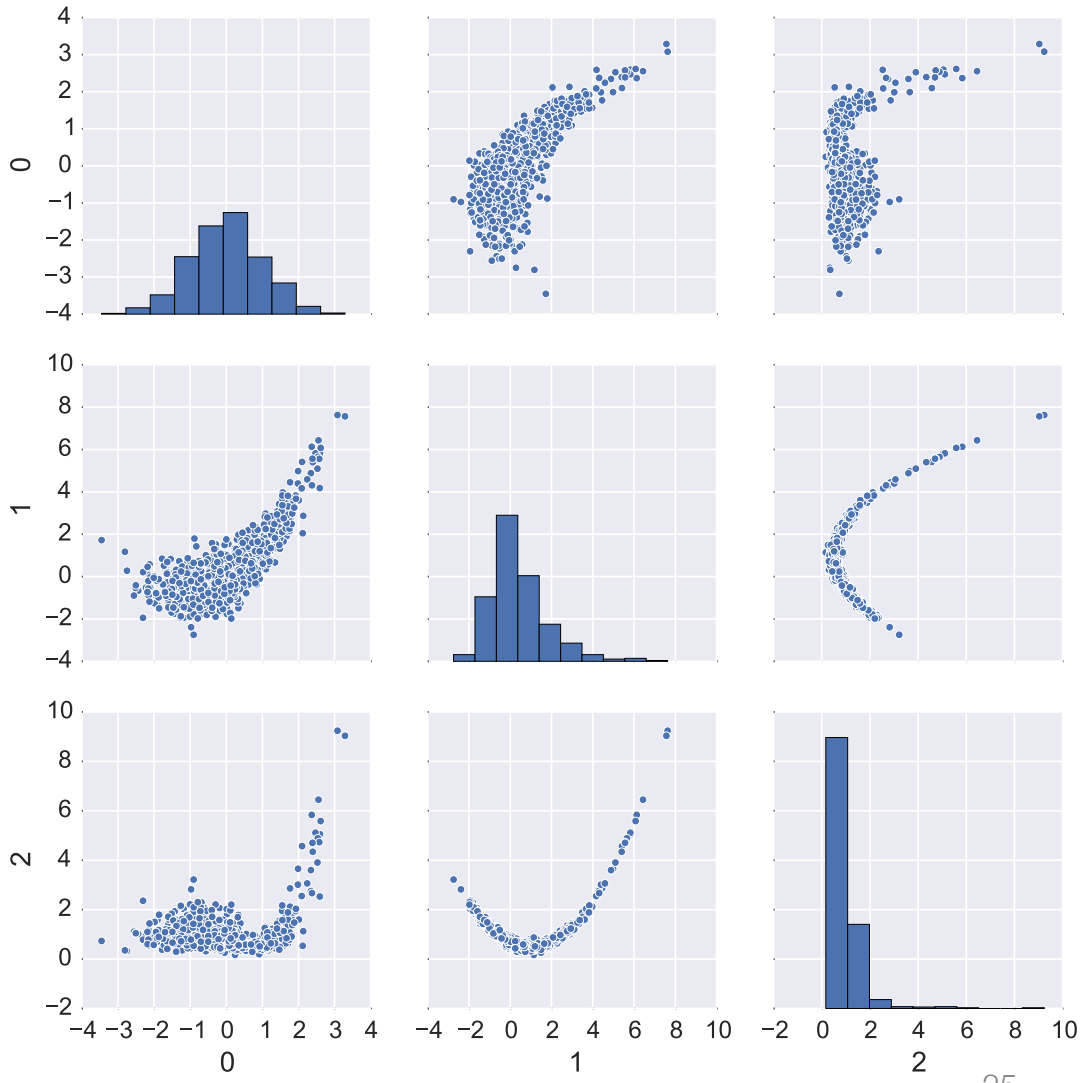
3D scatter plot

	Dim 1	Dim 2	Dim 3
Nominal	✘	✘	✘
Ordinal	✘	✘	✘
Interval	✘	✘	✘
Ratio	✘	✘	✘



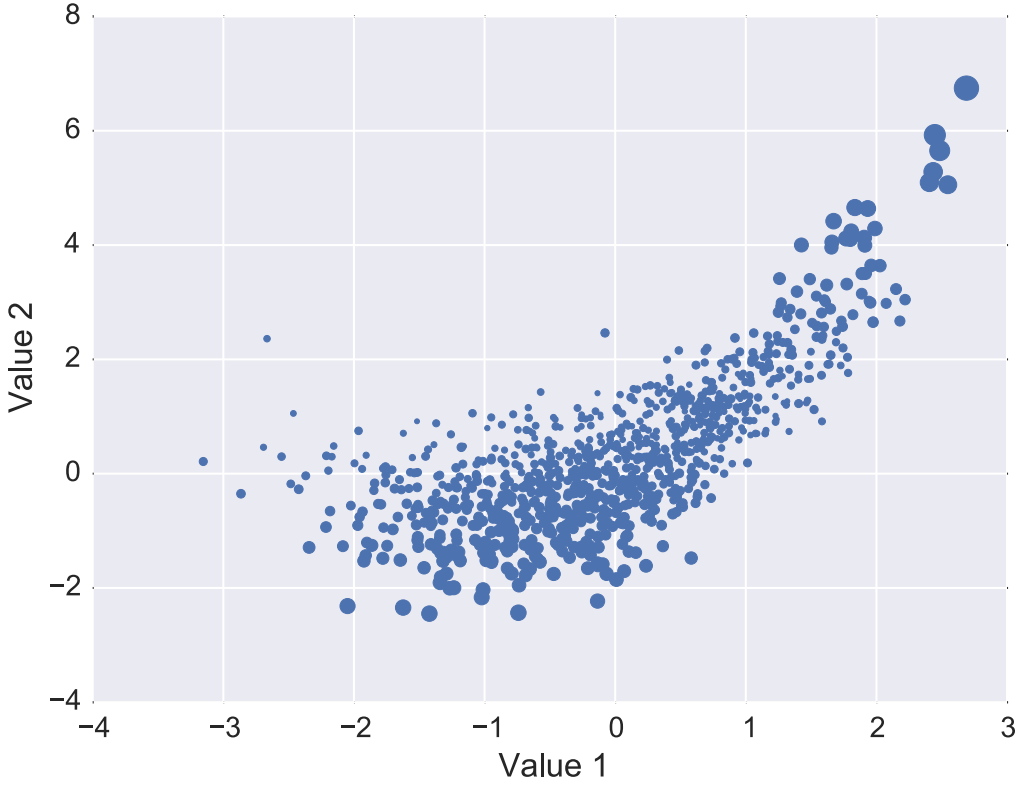
Scatter plot matrix

	Dim 1	Dim 2	Dim 3
Nominal	✘	✘	✘
Ordinal	✘	✘	✘
Interval	✔	✔	✔
Ratio	✔	✔	✔



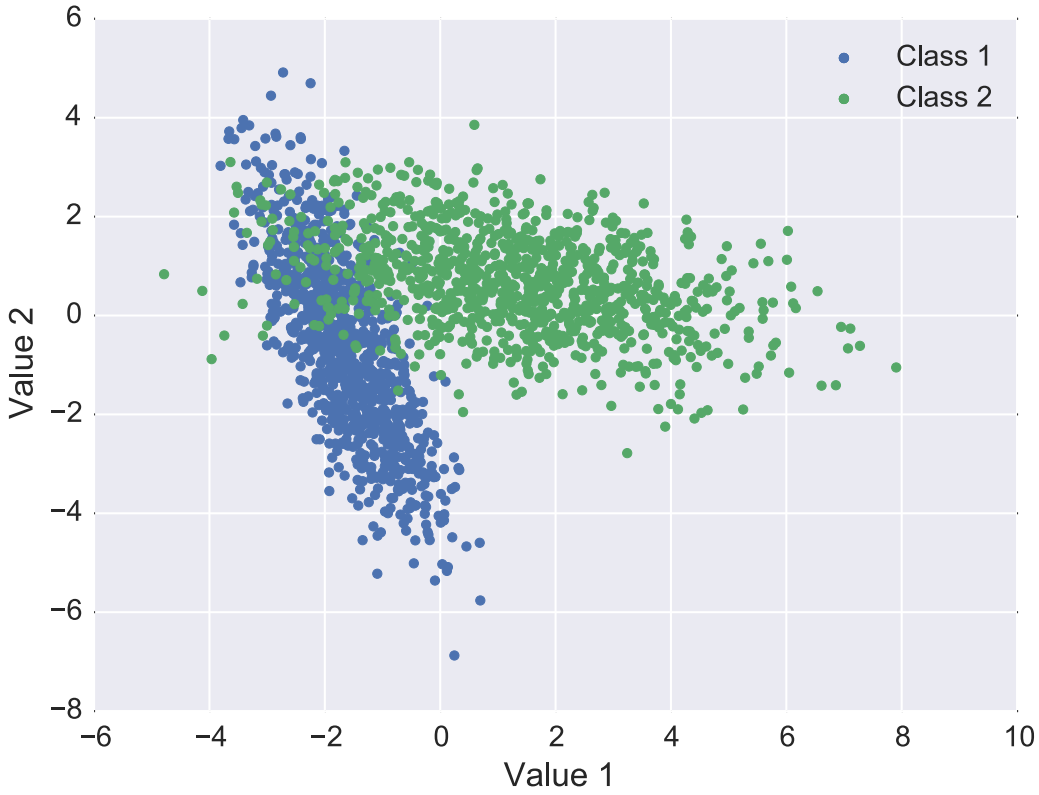
Bubble plot

	Dim 1	Dim 2	Dim 3
Nominal	✘	✘	✘
Ordinal	✘	✘	✘
Interval	✔	✔	✔
Ratio	✔	✔	✔



Color scatter plot

	Dim 1	Dim 2	Dim 3
Nominal	✘	✘	✔
Ordinal	✘	✘	✔
Interval	✔	✔	✘
Ratio	✔	✔	✘



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Matplotlib

Matplotlib is the standard for plotting in Python / Jupyter Notebook

By default, the figures look quite ugly, so a lot of styles and additional libraries have been created to give it a nicer look

It is aimed at generating static plots, not very good for interacting with data (with a few exceptions)

A number of additional libraries provide some level of interactive plot (and static plots), but matplotlib is enough of a standard that we'll use it here

Matplotlib examples

Examples of all previous plots in notebook….