

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

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Data types and visualization types

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

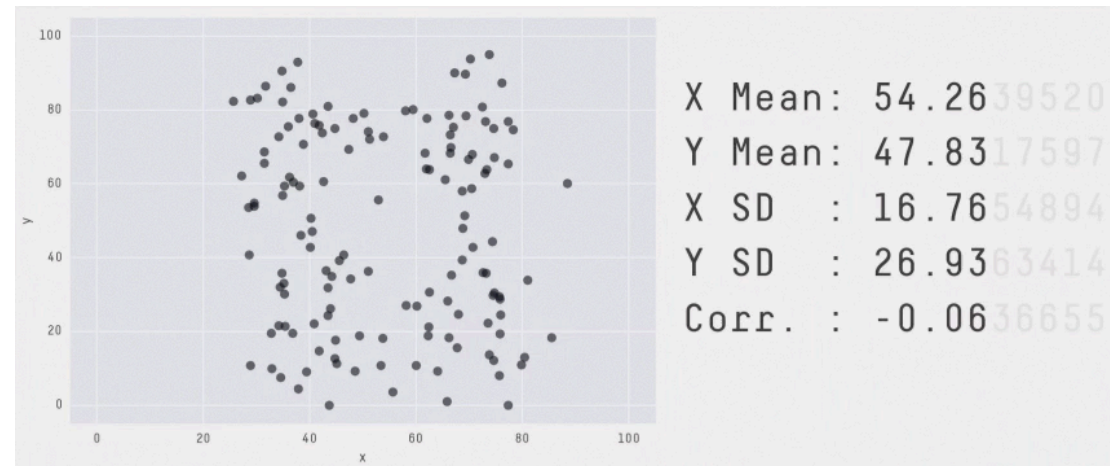
Before you run any analysis, build any machine learning system, etc, always visualize your data

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

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

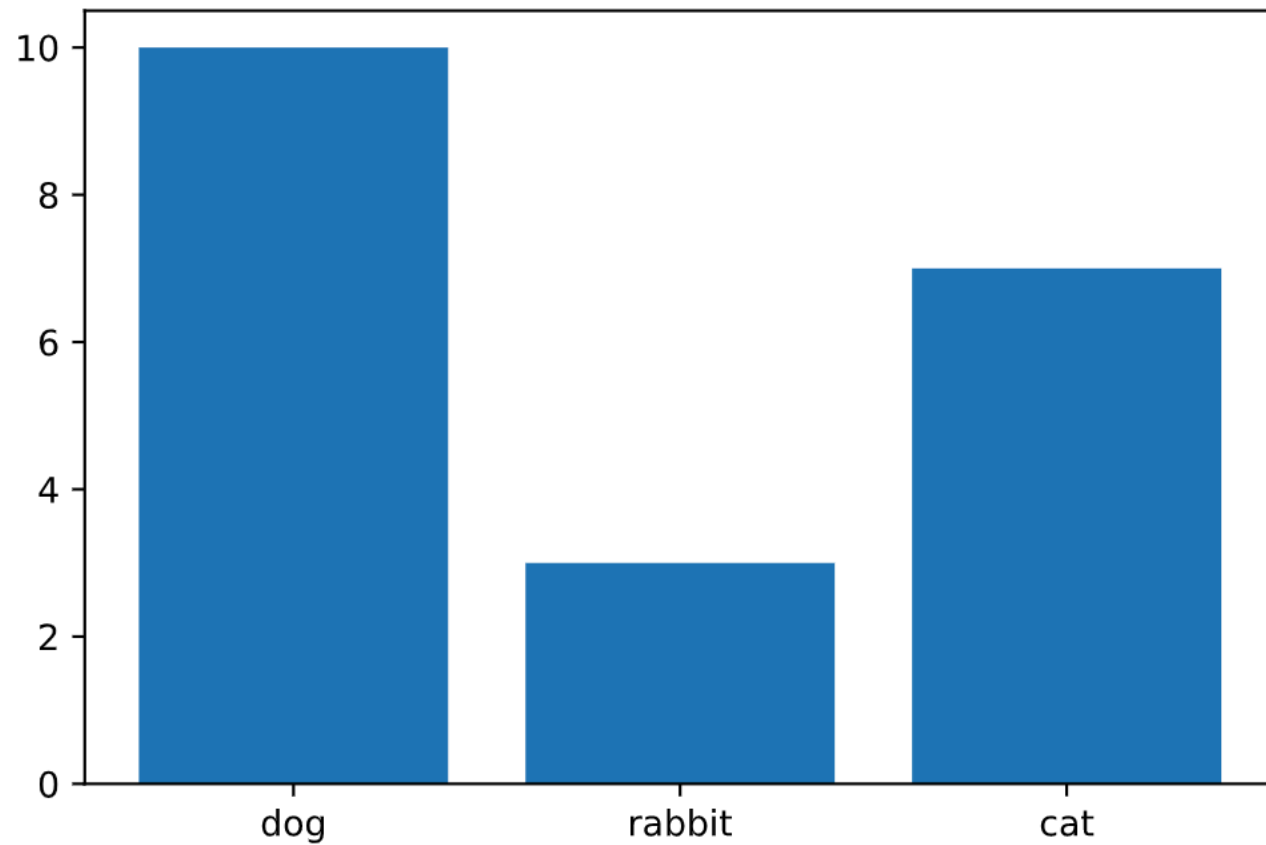
- 3D+: scatter matrix, bubble chart

1D DATA

Bar chart

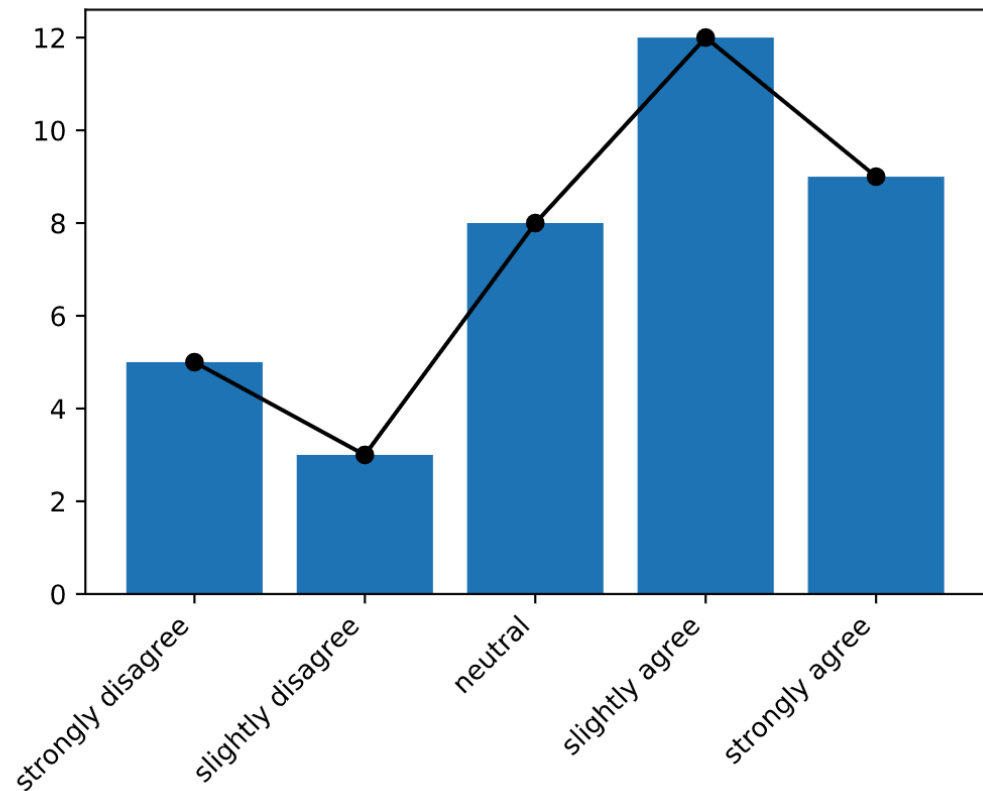
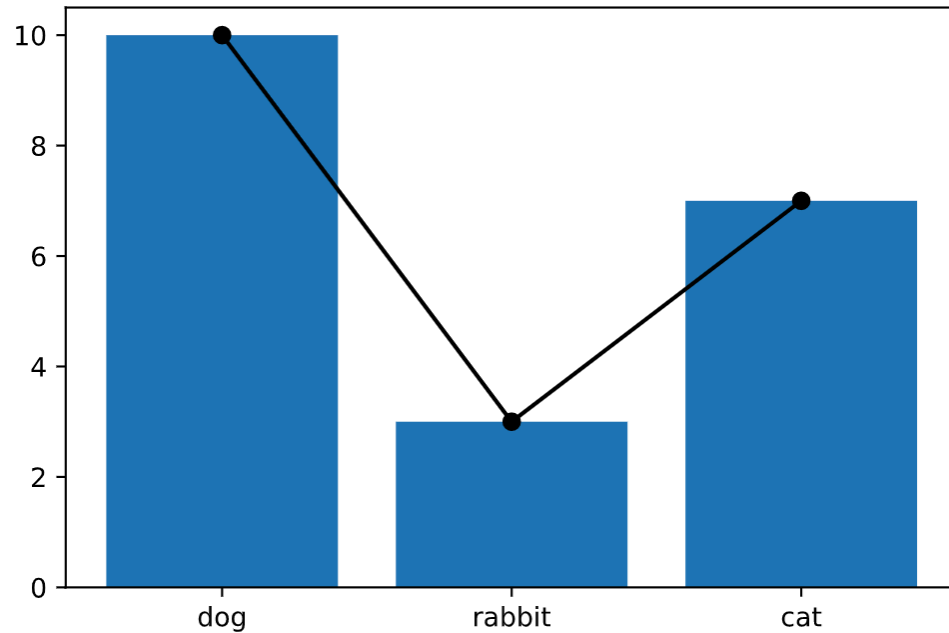
	Data
Nominal	✓
Ordinal	✓
Interval	X
Ratio	X

↑
Suggestions, not rules



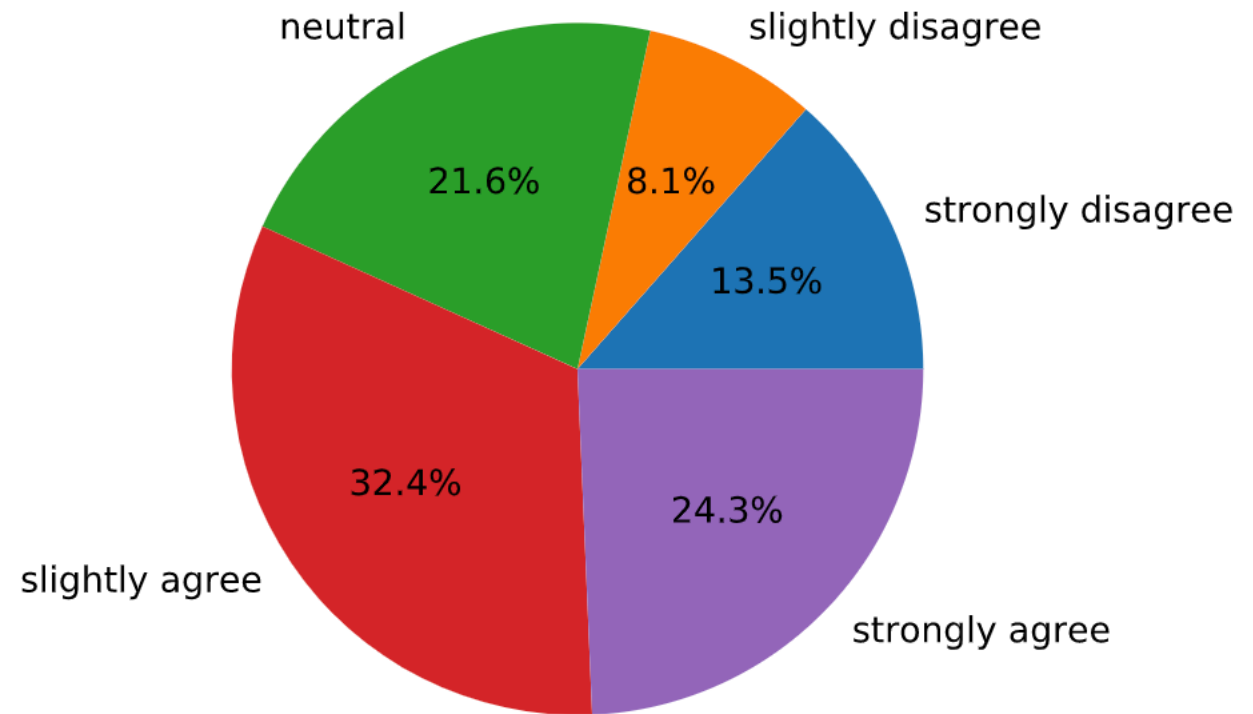
Bar chart (bad)

Don't use lines within a bar chart for categorical or ordinal features!



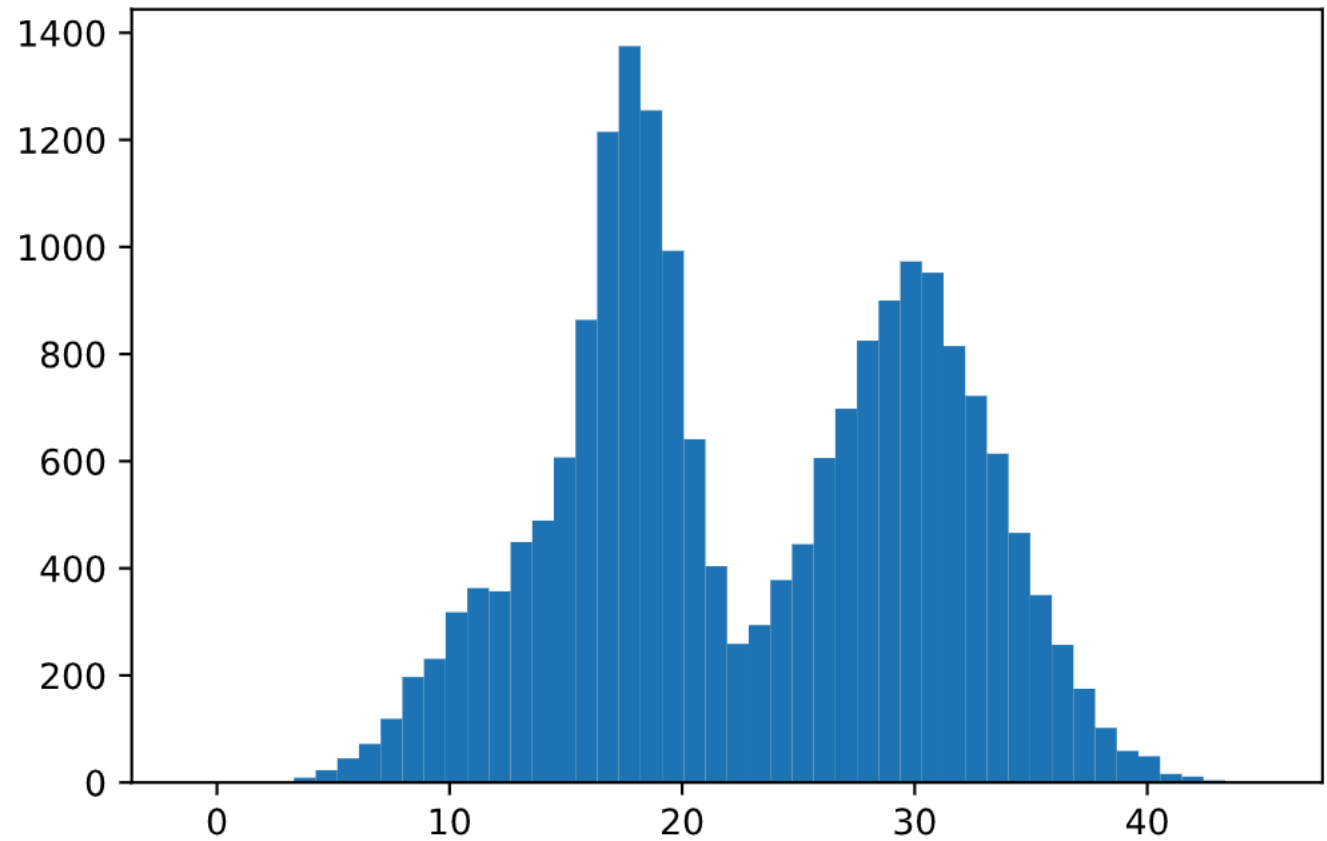
Pie chart

	Data
Nominal	X
Ordinal	X
Interval	X
Ratio	X



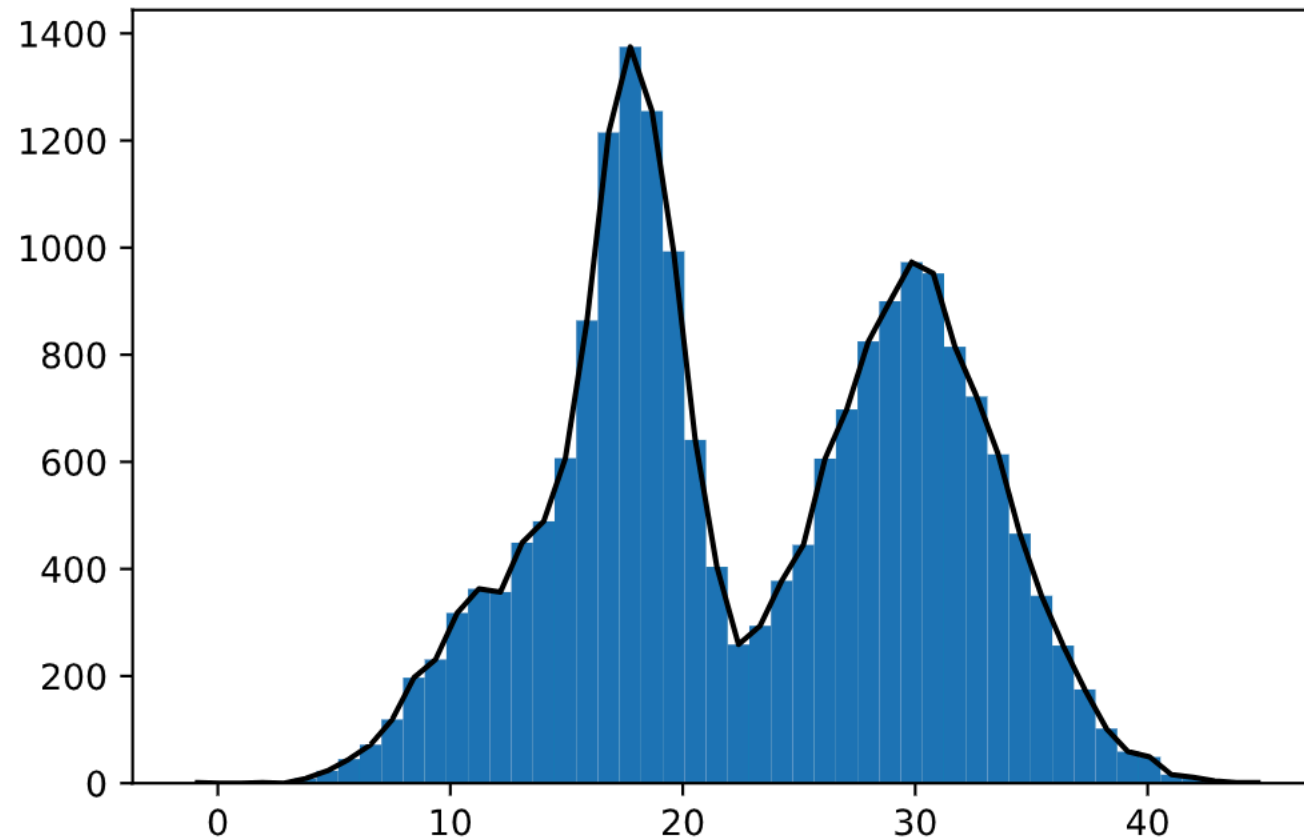
Histogram

	Data
Nominal	X
Ordinal	X
Interval	✓
Ratio	✓



Histogram

OK to use lines within a histogram (but not very informative)

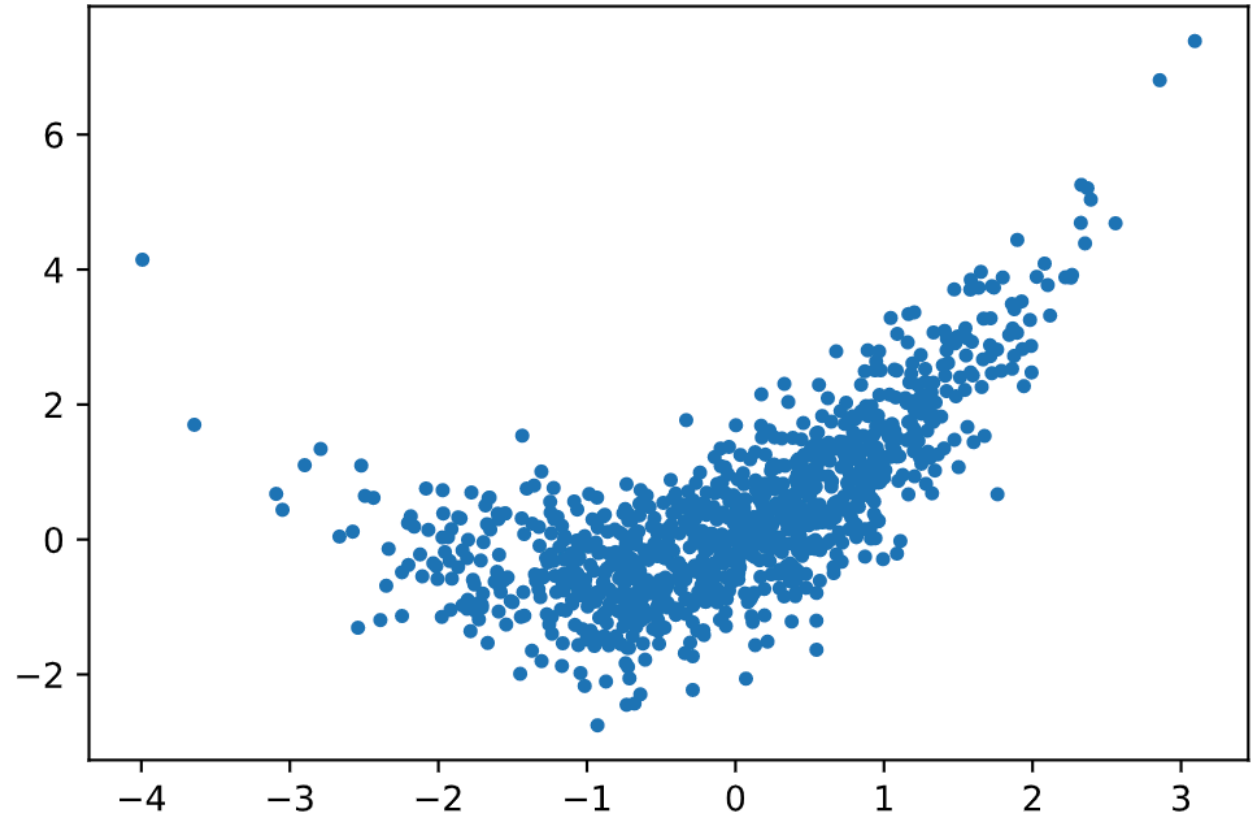


2D DATA

Scatter plot

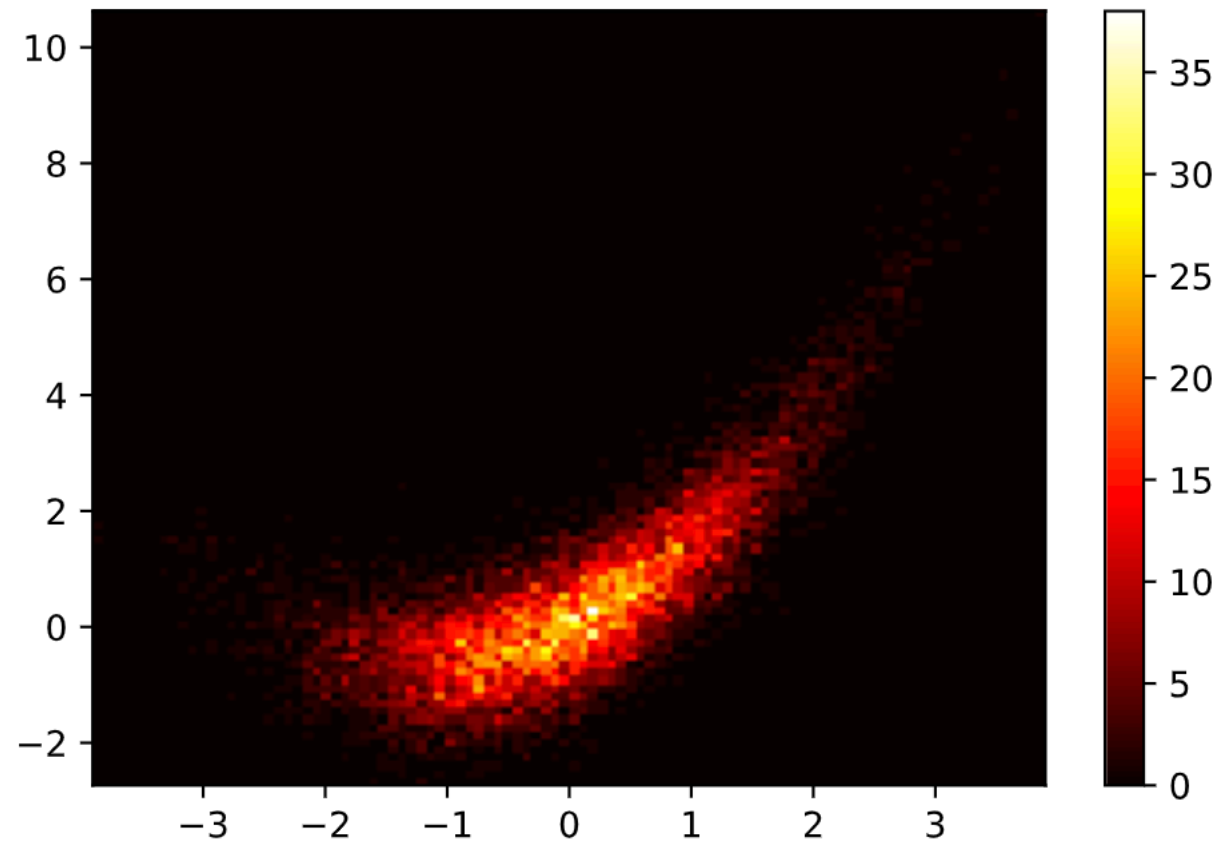
	Dim 1	Dim 2
Nominal	X	X
Ordinal	X	X
Interval	✓	✓
Ratio	✓	✓

Why not ordinal data in first dimension?



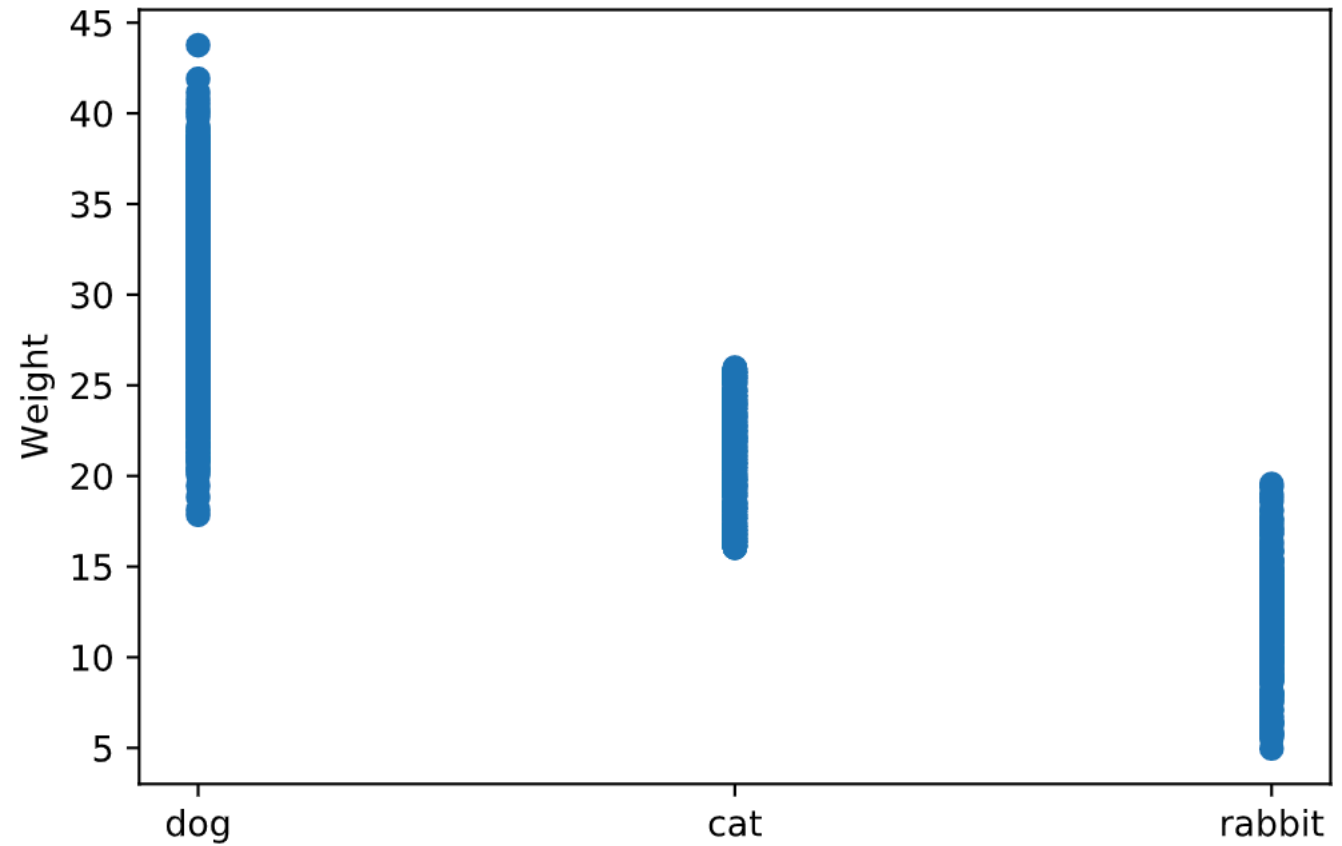
Heatmap (density, or 2D histogram)

	Dim 1	Dim 2
Nominal	X	X
Ordinal	X	X
Interval	✓	✓
Ratio	✓	✓



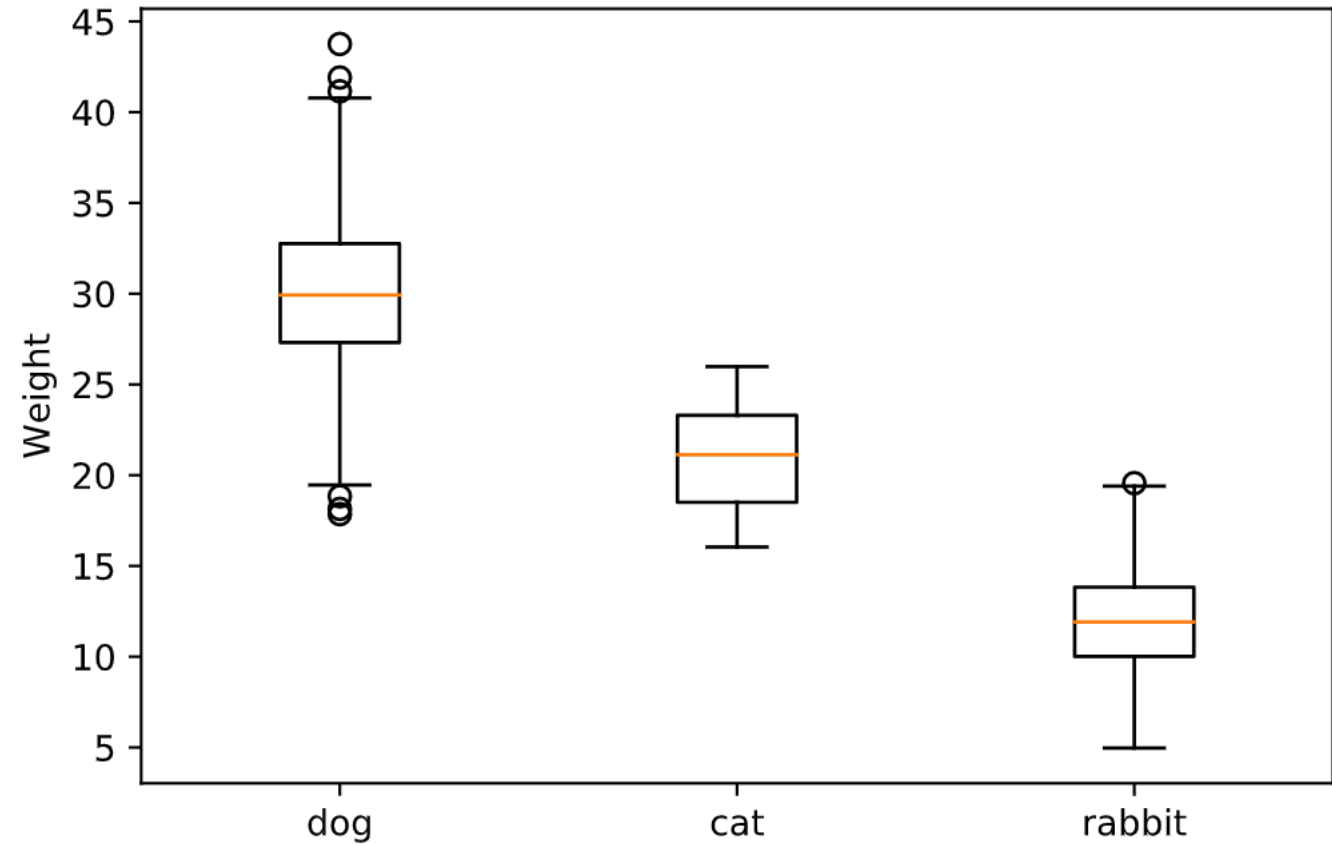
Scatter plot (bad)

	Dim 1	Dim 2
Nominal	X	X
Ordinal	X	X
Interval	✓	✓
Ratio	✓	✓



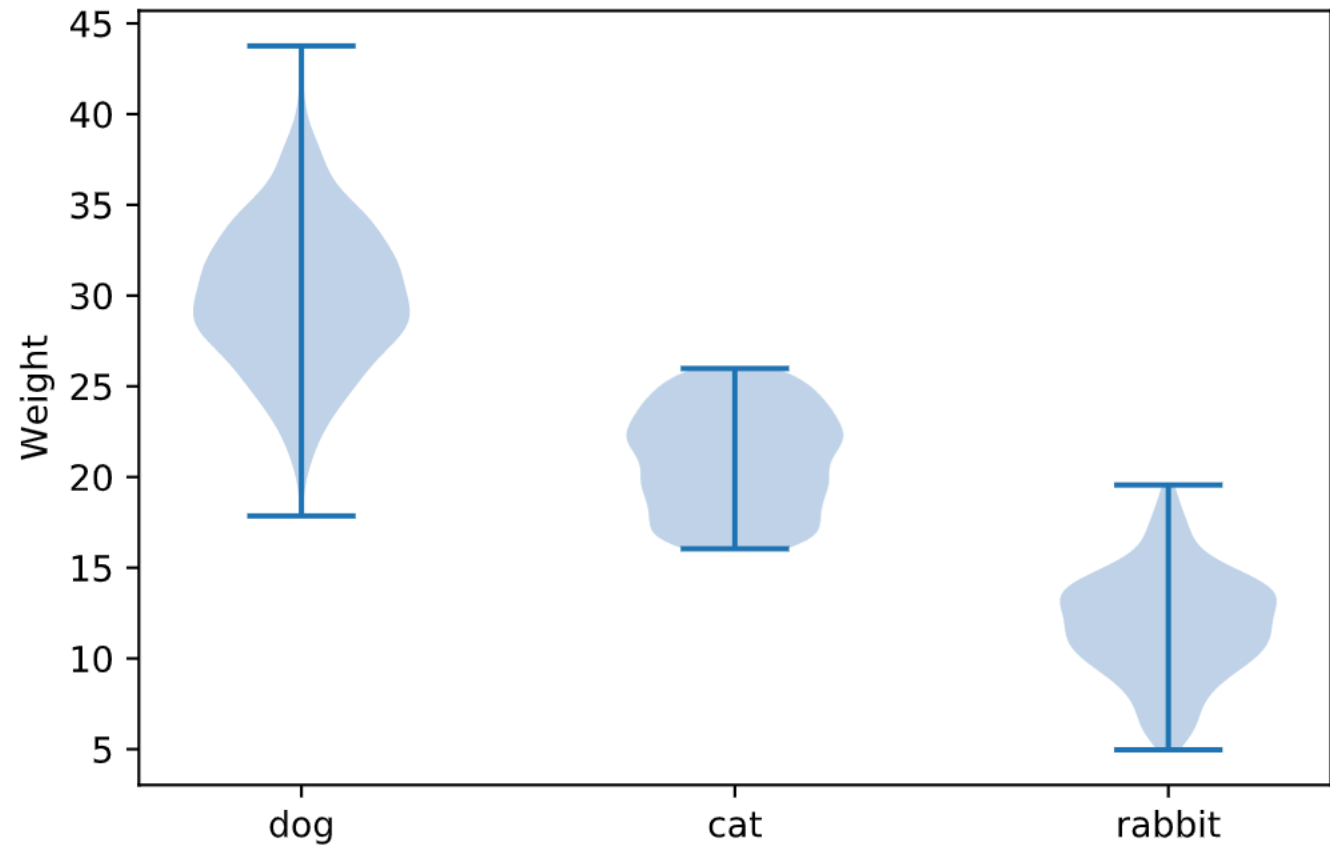
Box and whiskers

	Dim 1	Dim 2
Nominal	✓	✗
Ordinal	✓	✗
Interval	✗	✓
Ratio	✗	✓



Violin plot

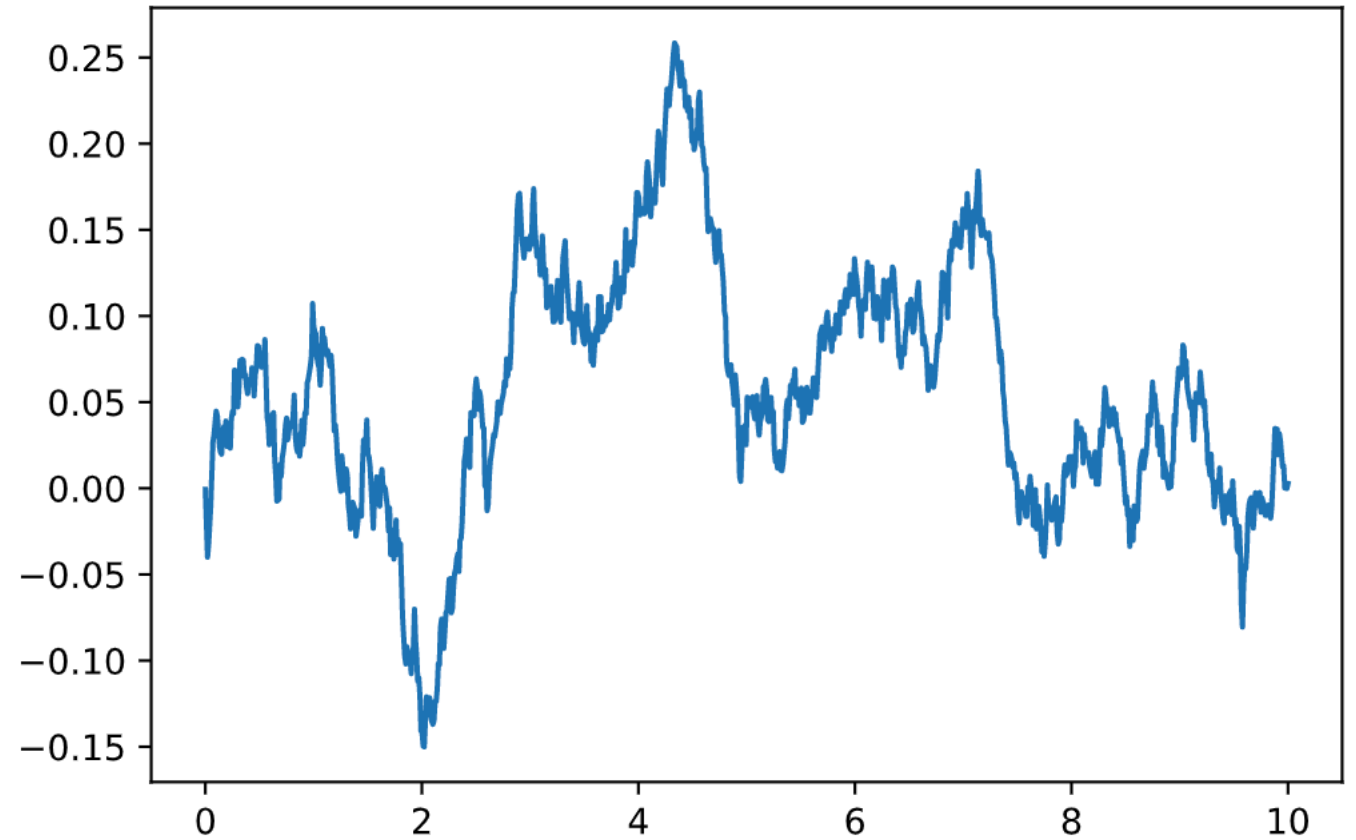
	Dim 1	Dim 2
Nominal	✓	✗
Ordinal	✓	✗
Interval	✗	✓
Ratio	✗	✓



Line plot

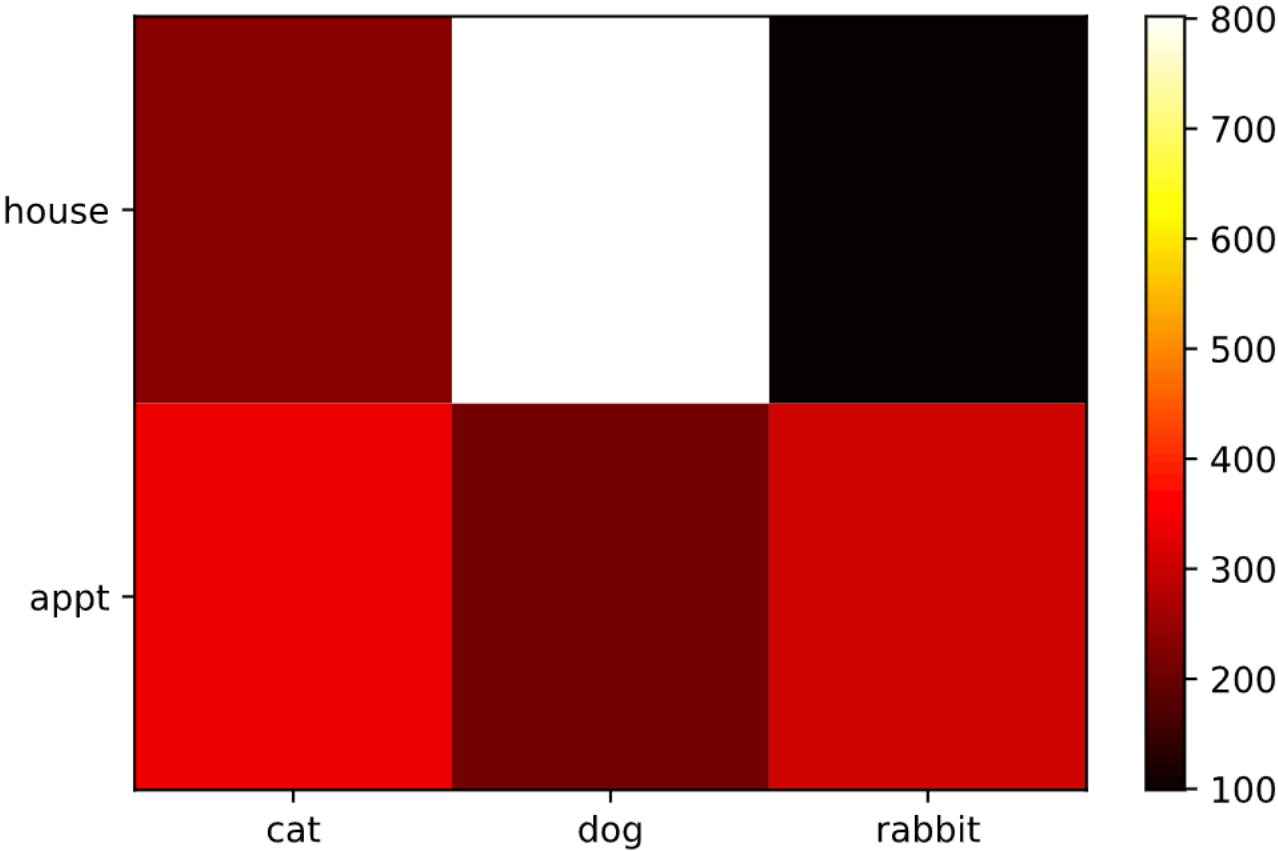
	Dim 1	Dim 2
Nominal	X	X
Ordinal	X	X
Interval	✓	✓
Ratio	✓	✓

Why not ordinal data in first dimension?



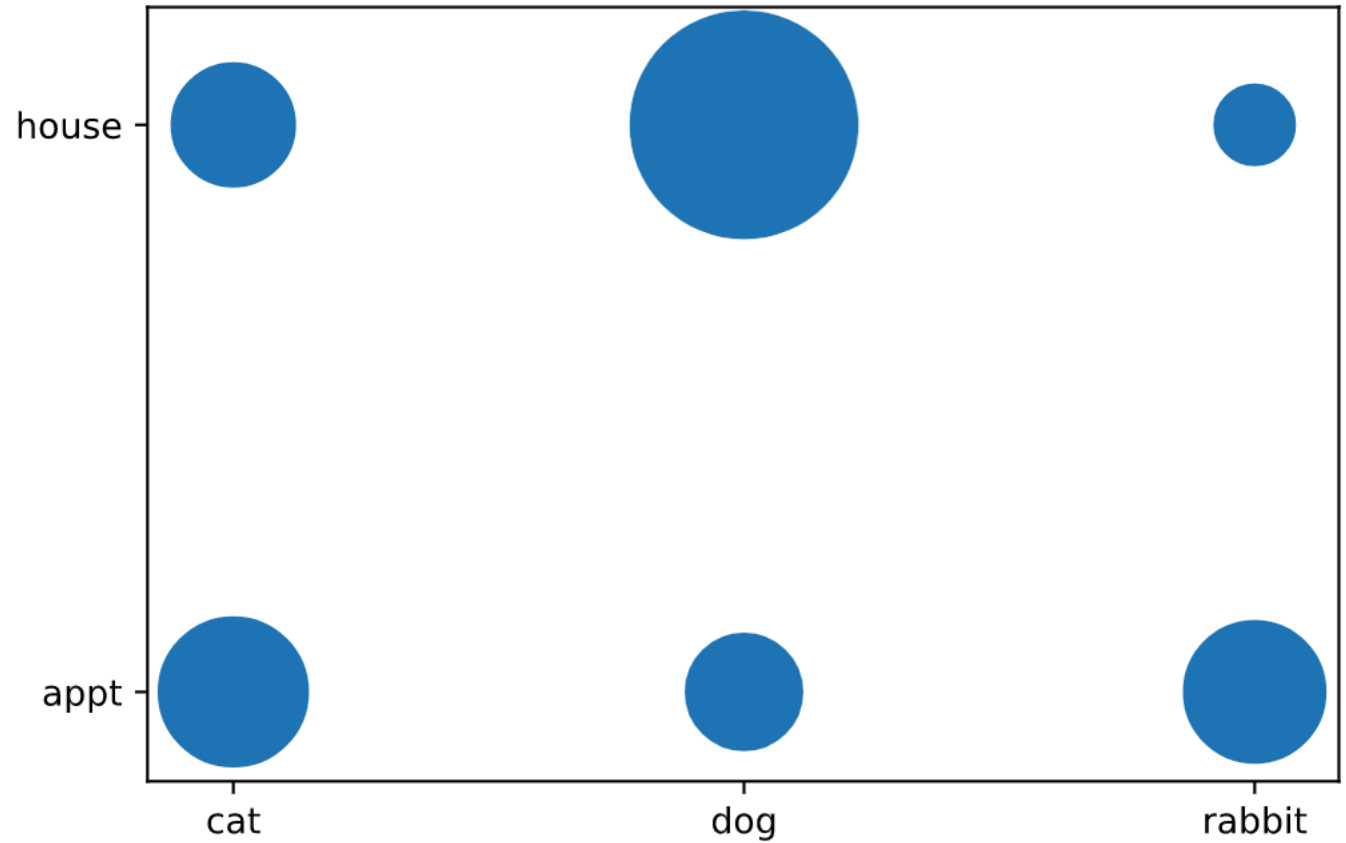
Heatmap (matrix)

	Dim 1	Dim 2
Nominal	✓	✓
Ordinal	✓	✓
Interval	✗	✗
Ratio	✗	✗



Bubble plot

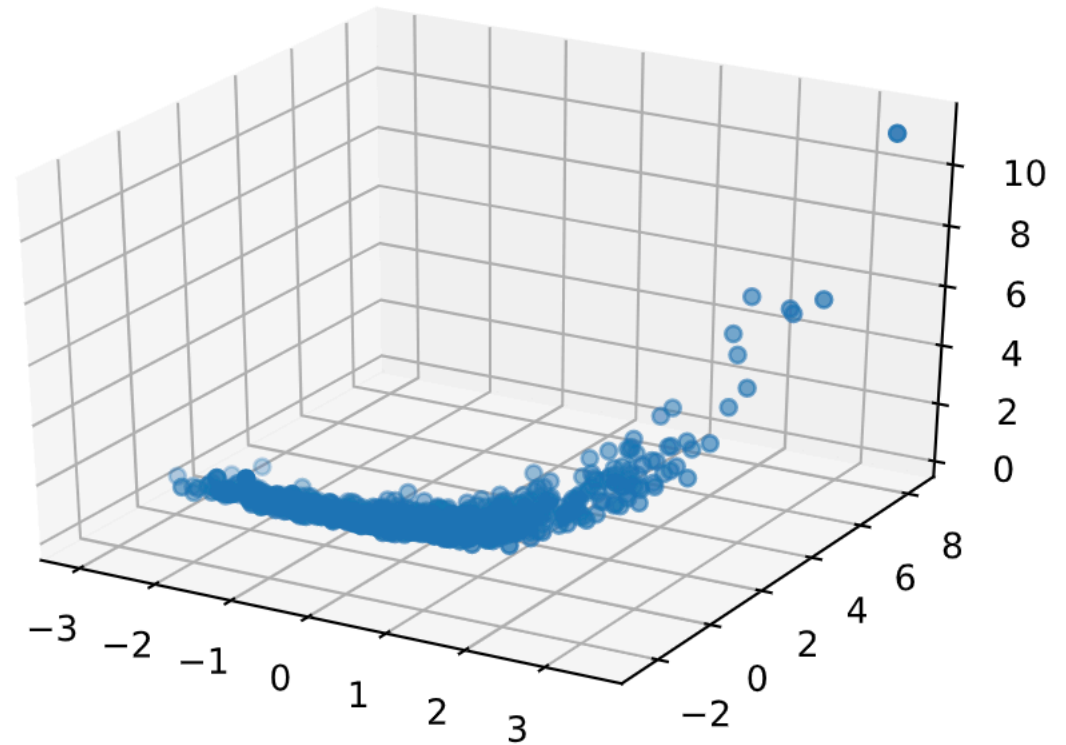
	Dim 1	Dim 2
Nominal	✓	✓
Ordinal	✓	✓
Interval	✗	✗
Ratio	✗	✗



3D+ DATA

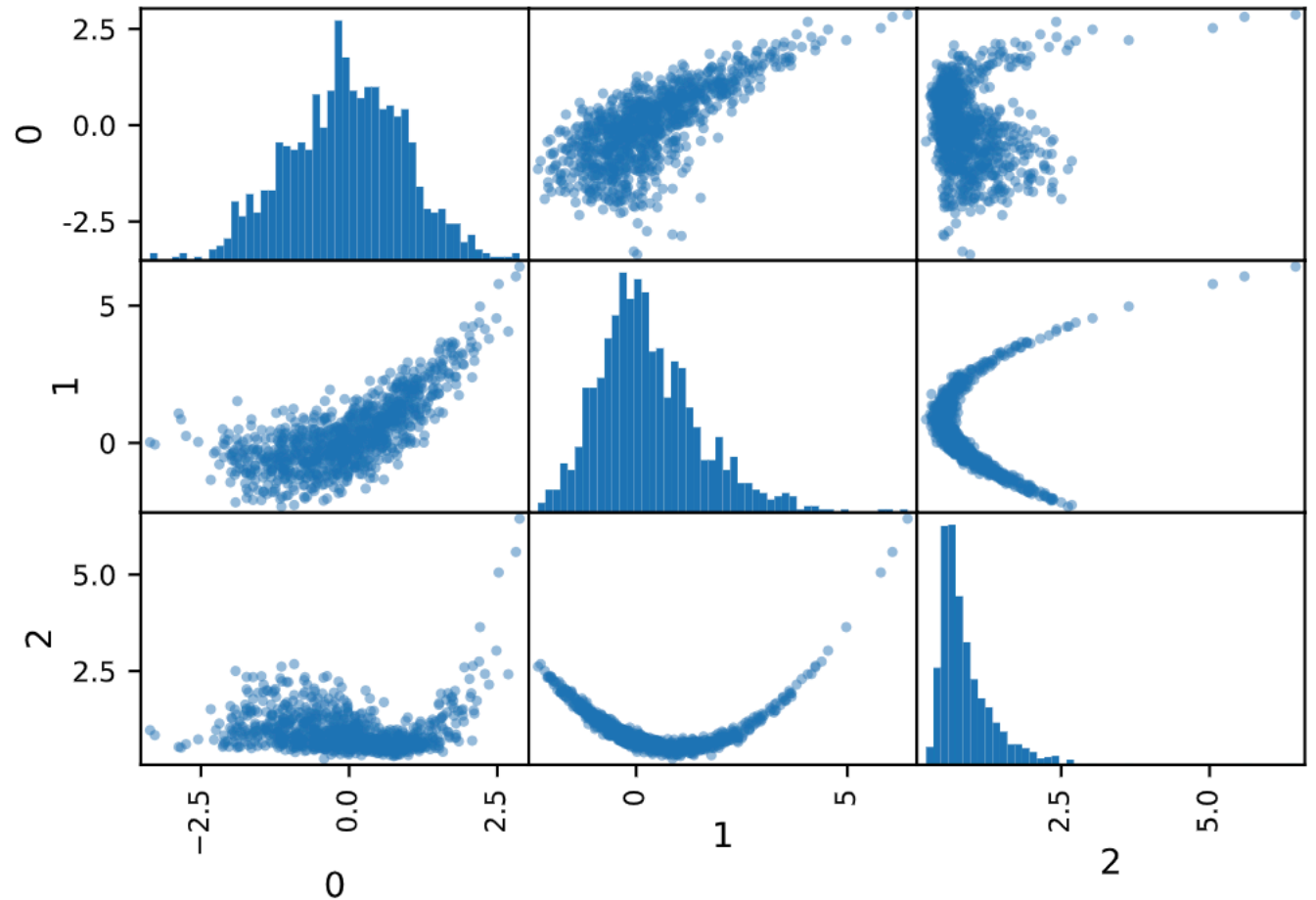
3D scatter plot

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



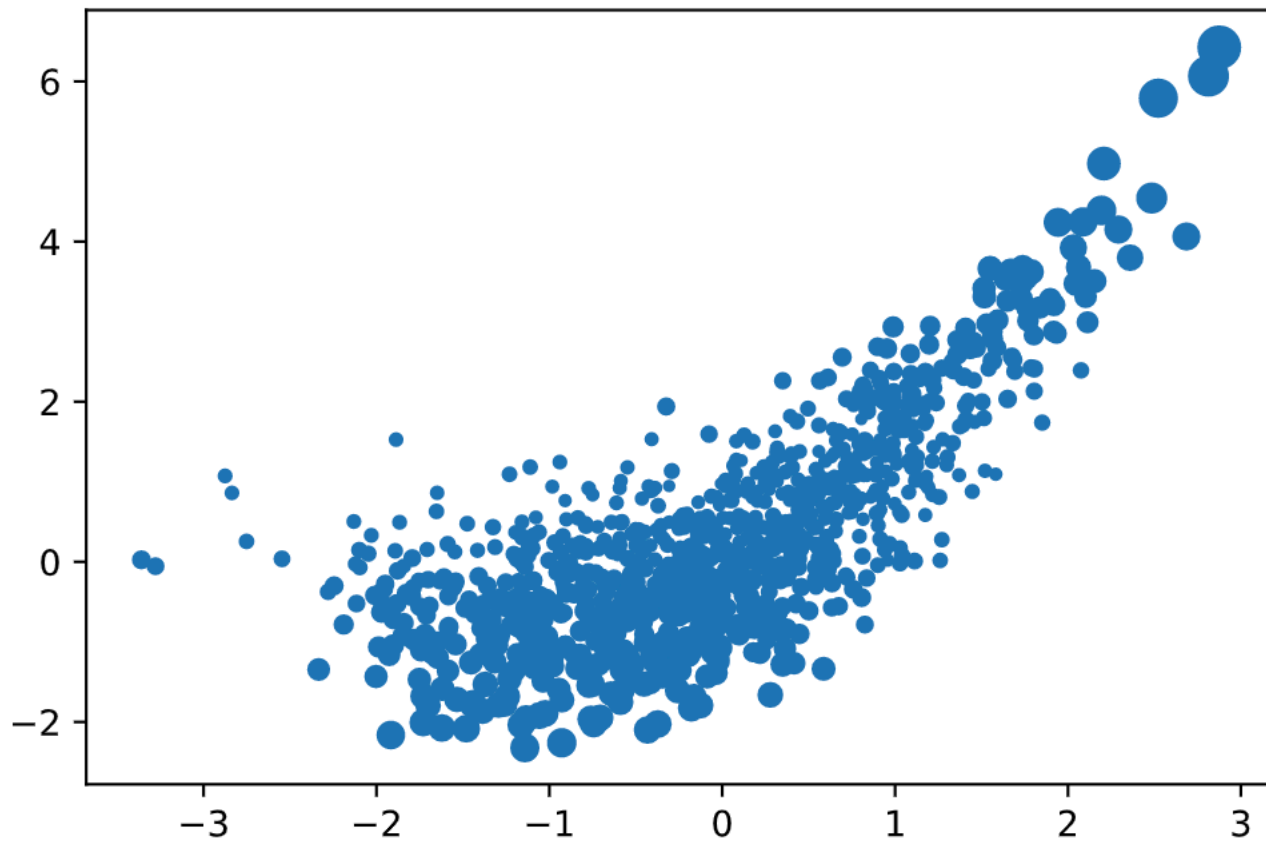
Scatter plot matrix

	Dim 1	Dim 2	Dim 3
Nominal	X	X	X
Ordinal	X	X	X
Interval	✓	✓	✓
Ratio	✓	✓	✓



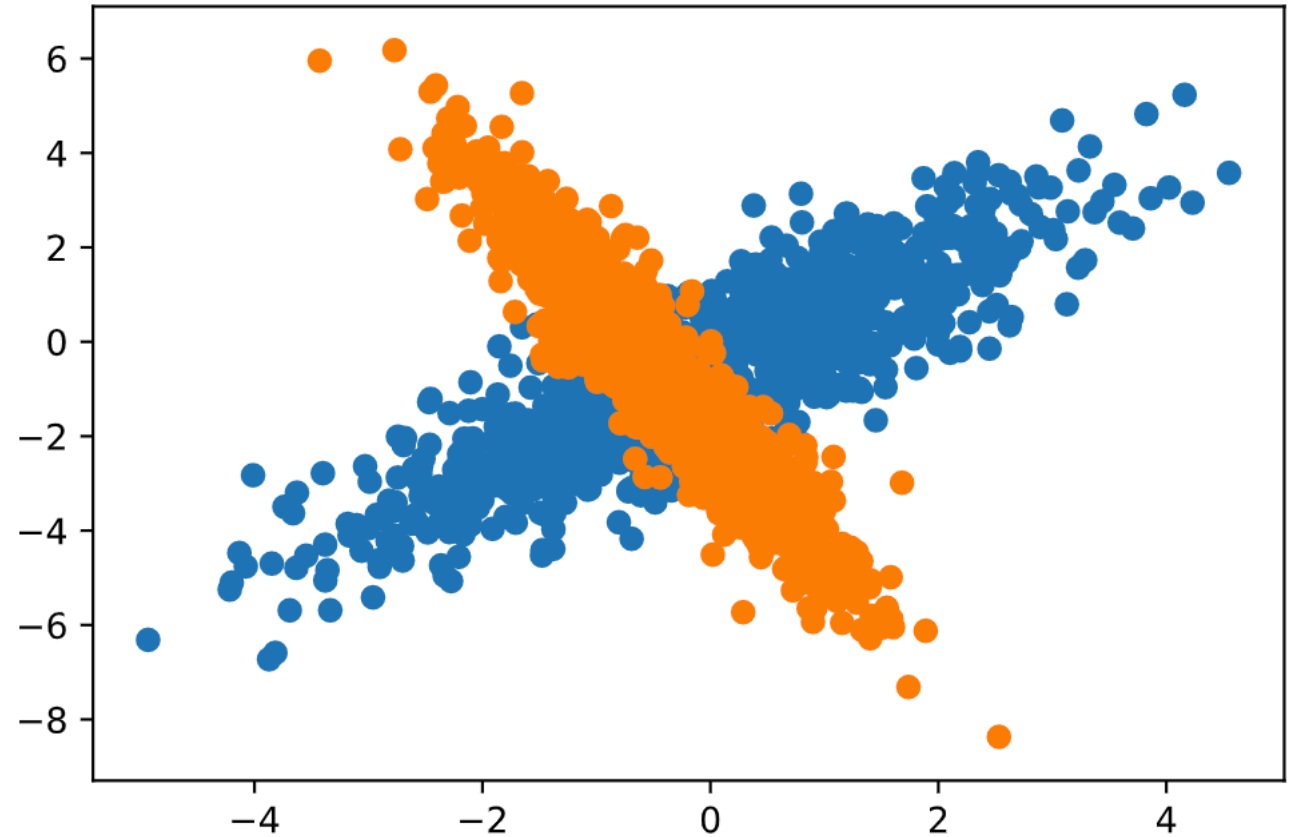
Bubble plot

	Dim 1	Dim 2	Dim 3
Nominal	X	X	X
Ordinal	X	X	X
Interval	✓	✓	✓
Ratio	✓	✓	✓



Color scatter plot

	Dim 1	Dim 2	Dim 3
Nominal	X	X	✓
Ordinal	X	X	✓
Interval	✓	✓	X
Ratio	✓	✓	X



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Matplotlib

Matplotlib is the standard for plotting in Python / Jupyter Notebook

Matplotlib used to generate fairly ugly plots by default, but in recent versions this is no longer the case, so minimal need for additional libraries

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