Machine learning

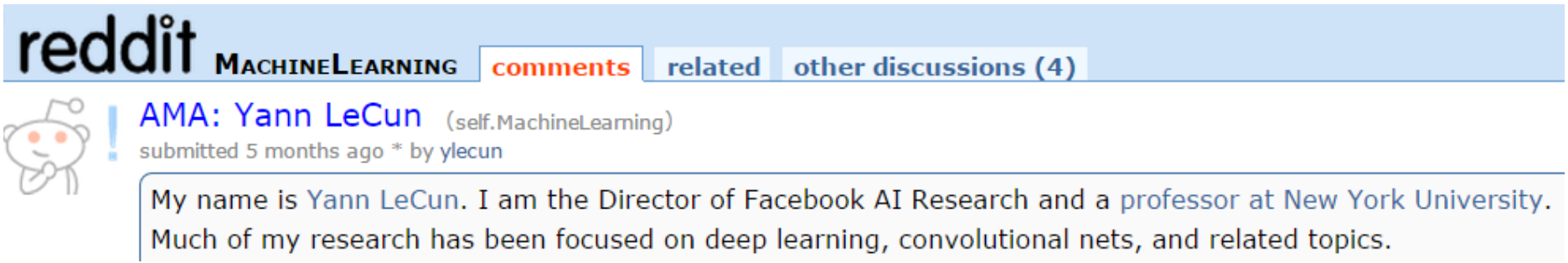
What is machine learning?

Supervised Learning

Unsupervised Learning

What is machine learning?

WHAT IS MACHINE LEARNING? 4



Seriously, I don't like the phrase "Big Data". I prefer "**Data Science**", which is the **automatic (or semi-automatic) extraction of knowledge from data**. That is here to stay, it's not a fad. The amount of data generated by our digital world is growing exponentially with high rate (at the same rate our hard-drives and communication networks are increasing their capacity). But the amount of human brain power in the world is not increasing nearly as fast. This means that now or in the near future **most of the knowledge in the world will be extracted by machine and reside in machines**. It's inevitable. En entire industry is building itself around this, and a new academic discipline is emerging.

Source: http://www.reddit.com/r/MachineLearning/comments/25lnbt/ama_yann_lecun

One definition: "Machine learning is the semi-automatic extraction of knowledge from data."

- **Knowledge from data:** Starts with a question that might be answerable using data
- **Automatic extraction:** A computer provides the insight
- **Semi-automatic:** Requires many smart decisions by a human

Supervised Learning

TYPES OF MACHINE LEARNING

There are two main categories of machine learning: **supervised learning** and **unsupervised learning**.

Supervised learning (aka "predictive modeling"):

- Predict an outcome based on input data
- Example: predict whether an email is spam or ham
- Goal is "generalization"

Unsupervised learning:

- Extracting structure from data
- Example: segment grocery store shoppers into "clusters" that exhibit similar behaviors
- Goal is "representation"

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Unsupervised learning:

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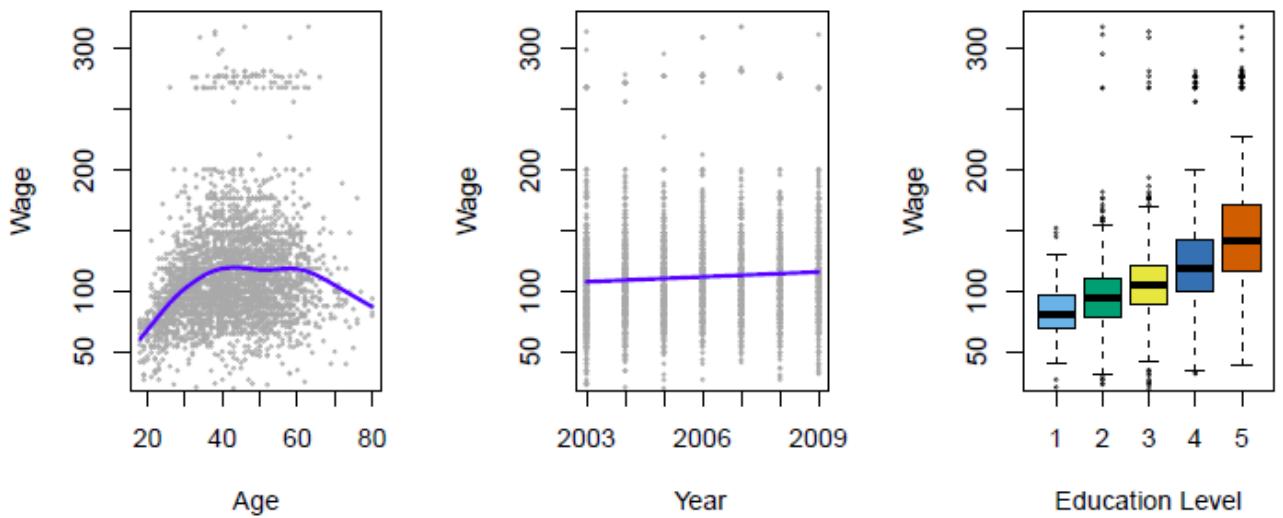
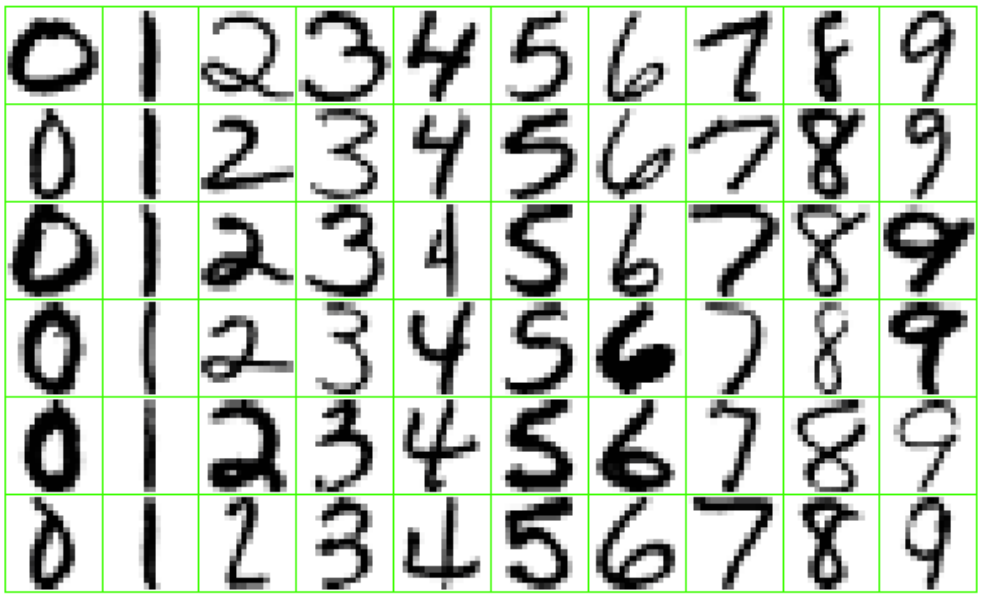
Predict salary using demographic data



Income survey data for males from the central Atlantic region of the USA in 2009

Source: https://class.stanford.edu/c4x/HumanitiesScience/StatLearning/asset/introduction.pdf

Identify the numbers in a handwritten zip code



Source: https://class.stanford.edu/c4x/HumanitiesScience/StatLearning/asset/introduction.pdf

There are two categories of supervised learning:

Regression

- Outcome we are trying to predict is continuous
- Examples: price, blood pressure

Classification

- Outcome we are trying to predict is categorical (values in a finite set)
- Examples: spam/ham, cancer class of tissue sample

REGRESSION OR CLASSIFICATION?

Problem: Children born prematurely are at high risk of developing infections, many of which are not detected until after the baby is sick

Goal: Detect subtle patterns in the data that predicts infection before it occurs

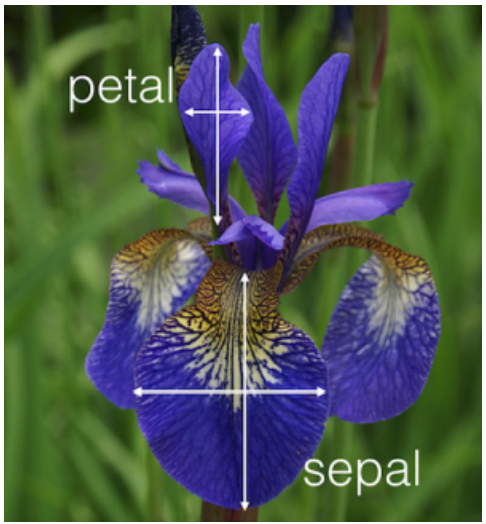
Data: 16 vital signs such as heart rate, respiration rate, blood pressure, etc…

Impact: Model is able to predict the onset of infection 24 hours before the traditional symptoms of infection appear

Image: http://www.babycaretips4u.com/wp-content/uploads/2014/03/premature-baby.jpg
Case Study: http://www.amazon.com/Big-Data-Revolution-Transform-Think/dp/0544002695

REGRESSION OR CLASSIFICATION?

REGRESSION OR CLASSIFICATION?



Fisher's *Iris* Data

Sepal length	Sepal width	Petal length	Petal width	Species
5.1	3.5	1.4	0.2	*I. setosa*
4.9	3.0	1.4	0.2	*I. setosa*
4.7	3.2	1.3	0.2	*I. setosa*
4.6	3.1	1.5	0.2	*I. setosa*
5.0	3.6	1.4	0.2	*I. setosa*
5.4	3.9	1.7	0.4	*I. setosa*
4.6	3.4	1.4	0.3	*I. setosa*
5.0	3.4	1.5	0.2	*I. setosa*

MACHINE LEARNING TERMINOLOGY

150 observations *(n = 150)*

Feature matrix "X" has n rows and p columns

Response "y" is a vector with length n

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5.0	3.4	1.5	0.2	*I. setosa*

response

4 features (p = 4)

Observations are also known as: samples, examples, instances, records

Features are also known as: predictors, independent variables, inputs, regressors, covariates, attributes

Response is also known as: outcome, label, target, dependent variable

Regression problems have a continuous response. **Classification problems** have a categorical response. The type of supervised learning problem has nothing to do with the type of features! Features may be numbers or categories for both regression and classification problems.

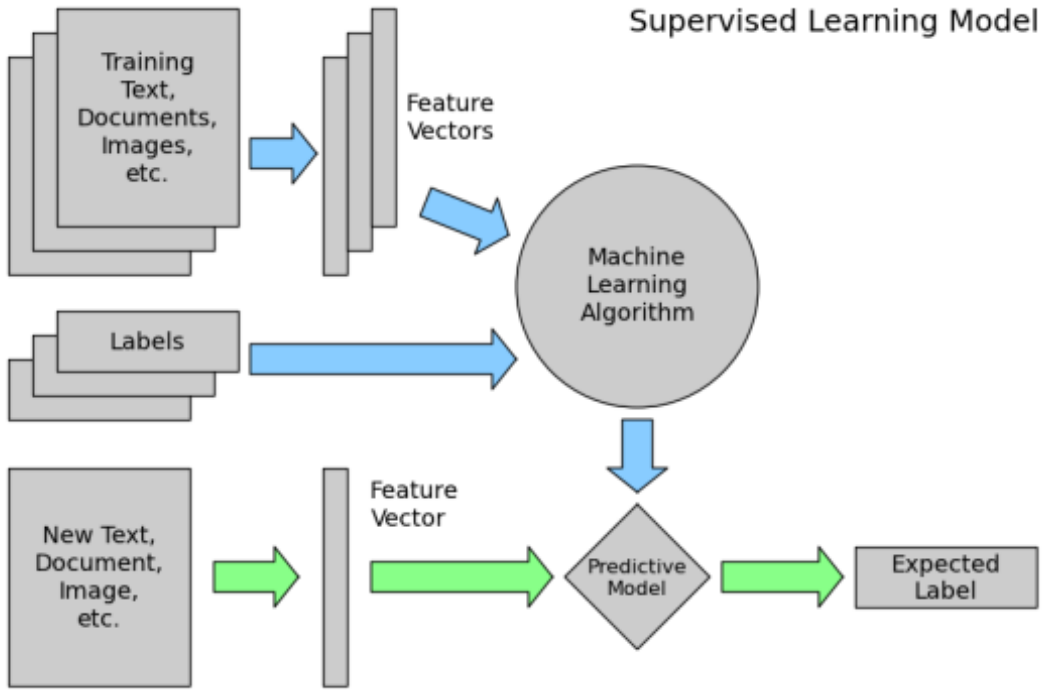
How does supervised learning "work"?

1. Train a **machine learning model** using **labeled data**
   - "Labeled data" is data with a response variable
   - "Machine learning model" learns the relationship between the features and the response

2. Make predictions on **new data** for which the response is unknown

The primary goal of supervised learning is to build a model that "generalizes": It accurately predicts the **future** rather than the **past**!

How does supervised learning “work”?

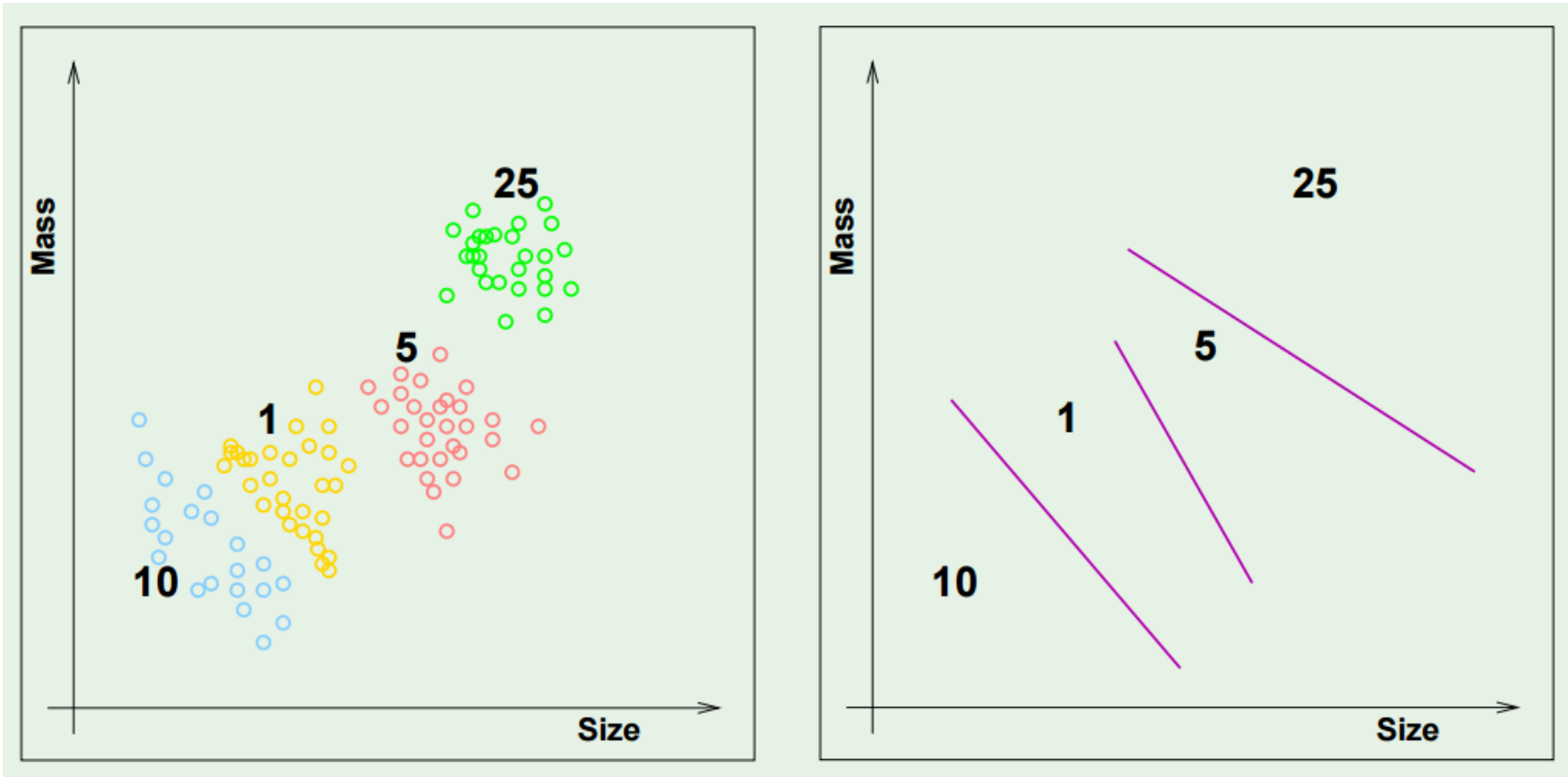


Supervised learning example: Coin classifier

- Observations: Coins
- Features: Size and mass
- Response: Coin type, hand-labeled

1. Train a **machine learning model** using **labeled data**
   - Model learns the relationship between the features and the coin type

2. Make predictions on **new data** for which the response is unknown
   - Give it a new coin, predicts the coin type automatically


Mass
Size
25
5
1
10
Mass
Size
25
5
1
10

Unsupervised Learning

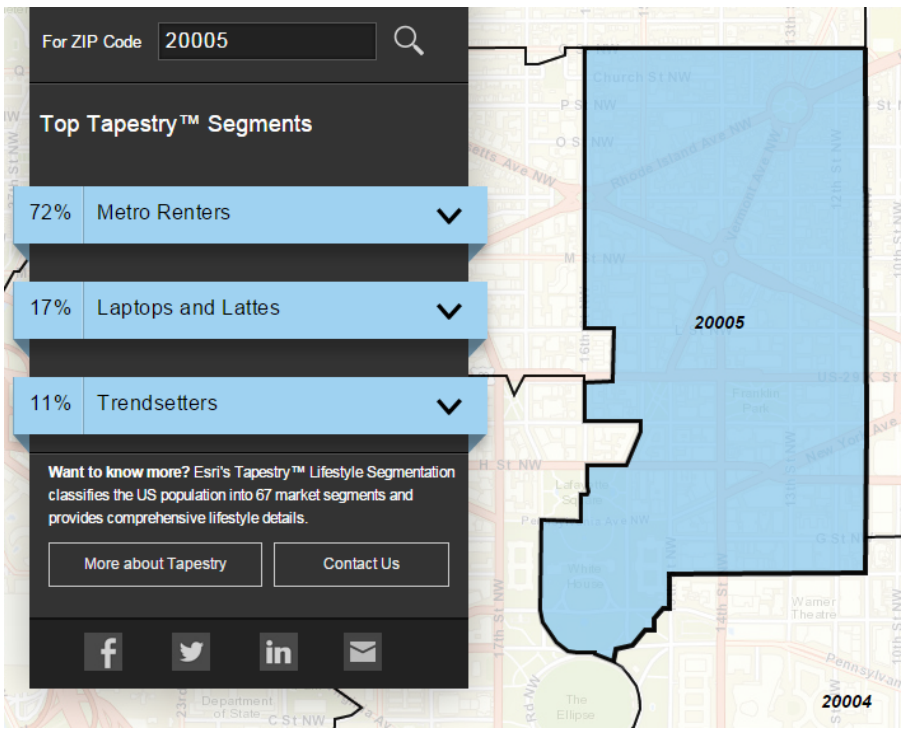
TYPES OF MACHINE LEARNING

There are two main categories of machine learning: **supervised learning** and **unsupervised learning**.

Unsupervised learning:

- Extracting structure from data
- Example: segment grocery store shoppers into "clusters" that exhibit similar behaviors
- Goal is "representation"

Group US residential neighborhoods into 67 unique segments based on demographic and socioeconomic characteristics



Metro Renters:

Young, mobile, educated, or still in school, we live alone or with a roommate in rented apartments or condos in the center of the city. Long hours and hard work don't deter us; we're willing to take risks to get to the top of our professions… We buy groceries at Whole Foods and Trader Joe's and shop for clothes at Banana Republic, Nordstrom, and Gap. We practice yoga, go skiing, and attend Pilates sessions.

Source: http://www.esri.com/landing-pages/tapestry/

Common types of unsupervised learning:

- **Clustering:** group "similar" data points together
- **Dimensionality Reduction:** reduce the dimensionality of a dataset by extracting features that capture most of the variance in the data

UNSUPERVISED LEARNING

Unsupervised learning has some clear differences from supervised learning. With **unsupervised learning:**

- There is no clear objective
- There is no "right anwser" (hard to tell how well you are doing)
- There is no response variable, just observations with features
- Labeled data is not required

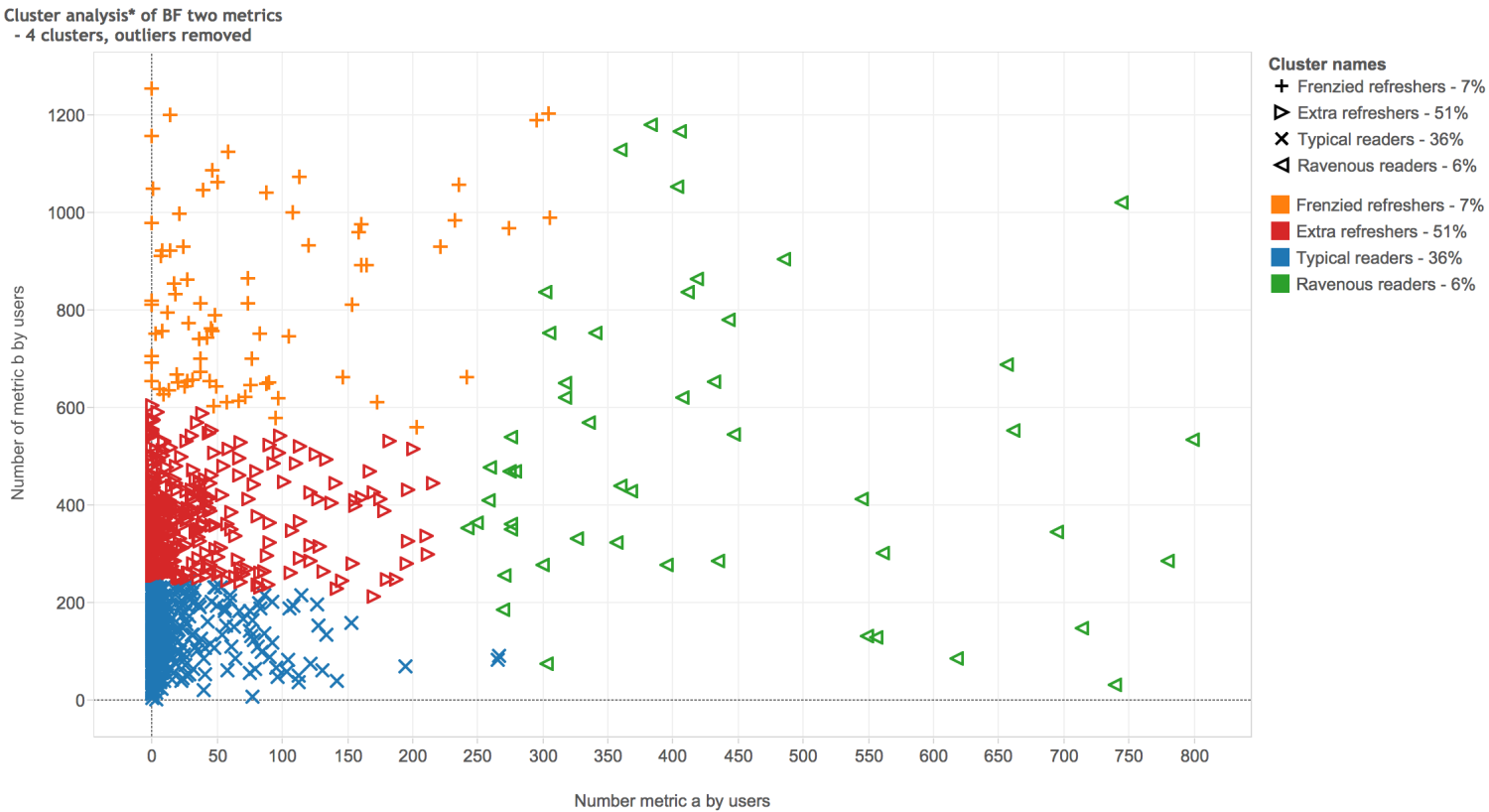
Unsupervised learning example: Coin clustering

- Observations: Coins
- Features: Size and mass
- Response: There isn't one (no hand-labeling required!)

1. Perform **unsupervised learning**
   - Cluster the coins based on "similarity"
   - You're done!

Sometimes, unsupervised learning is used as a "preprocessing" step for supervised learning. (How?)

UNSUPERVISED LEARNING



MACHINE LEARNING