COMPUTATIONAL SOCIAL SCIENCE METHODS IN R

Machine learning in Social Science Studies

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WHAT IS MACHINE LEARNING?

Reading

Raschka, Sebastian, and Vahid Mirjalili. Python machine learning. Packt Publishing Ltd, 2017.

WHAT IS MACHINE LEARNING?

- Field of study that gives computers the ability to learn without being explicitly programmed (Arthur Samuel, 1959)
- it learns a function that maps an input to an output based on a training dataset (set of examples of input and output)
- Machine learning is not a single approach but rather a diverse array of techniques: classification, regression, clustering, Bayesian networks, etc…
- spam filter, image detection, self-driving car, AlphaGo….etc

Definition of machine learning algorithm

A machine learning algorithm is an algorithm that is able to learn from data.

> *“ A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at task in T, as measured by P, improves with experience E.” (Mitchell, T. 1997)*

Three elements

- Experience E : train the algorithm (model) by maximizing the performance P on the training set E.
- Task T : task is solved by the model trained by E.
- Performance P : it should increase with E.

Goal

- learning from data
- execute task T based on experience E with optimal performance P

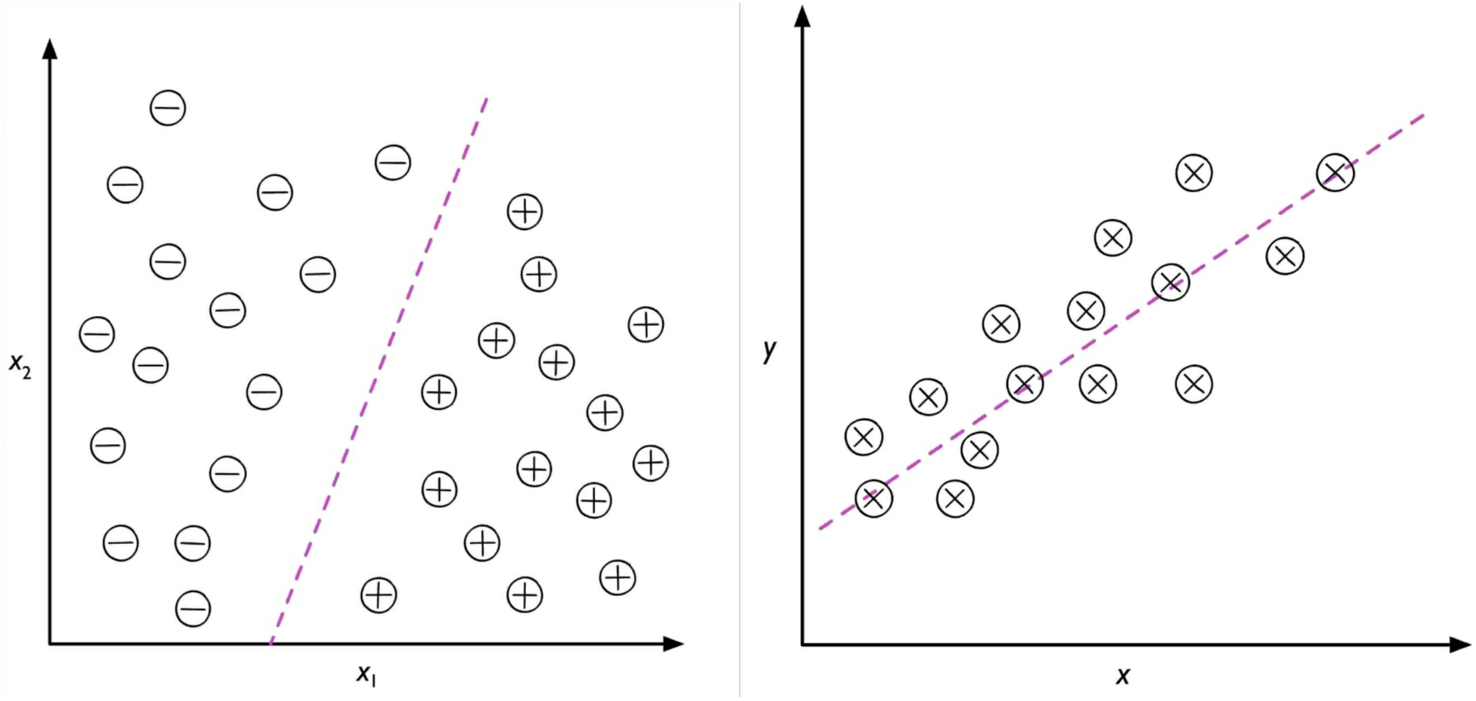
Three types of machine learning

- Supervised learning
- Unsupervised learning
- Reinforcement learning

SUPERVISED LEARNING

- Right answers are given: labeled data
- Direct feedback
- Predict outcome/future
- Two kinds in terms of outputs:
  - Regression: predict continuous valued output
  - Classification: Predict discrete valued output
- Example: linear/logistic regression, SVM, Neural Network etc

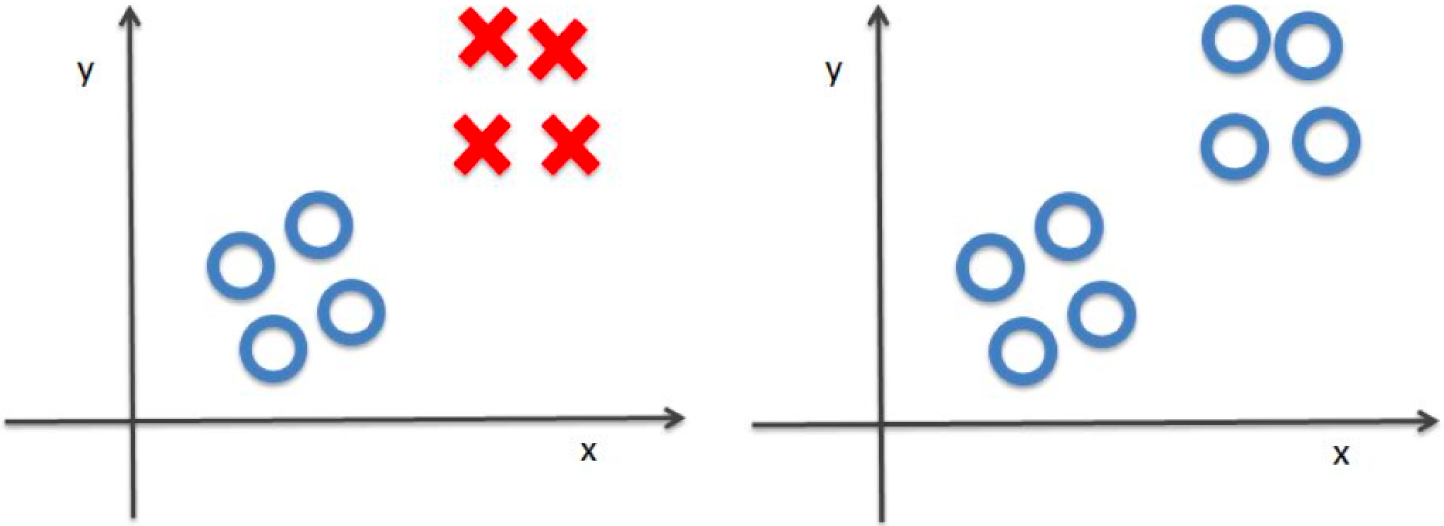
CLASSIFICATION VS. REGRESSION



UNSUPERVISED LEARNING

- We can’t give right answer to all data as the data increase exponentially with the development of technology
- No labeled data
- No feedback
- Find hidden structure in data
- Example: K-means, Gaussian mixture models, PCA etc

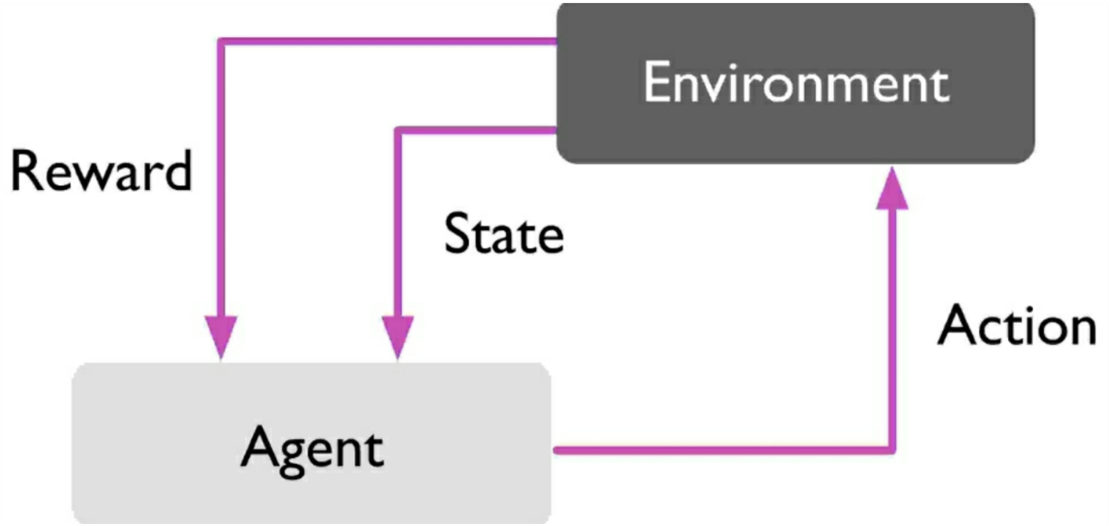
SUPERVISED VS. UNSUPERVISED



classification vs. clustering

REINFORCEMENT LEARNING

- Decision process
- Reward system
- Learn series of actions
- Example: Chess game



MACHINE LEARNING IN SOCIAL SCIENCE STUDIES

Reading and Acknowledgement

Grimmer et al. 2021. Machine Learming for Social Science: An Agnostic Approach. Annual Reviews of Political Science. 24:395-419 link

WHY MACHINE LEARNING?

- Data abundance (large, new form) + computational power
- Machine learning tools are used to extract meaning from data sets both massive and small
- Provide more diverse approach to answer social science questions

How it is used (can be used) in Social Science

- Discovery
- Measurement
- Inference
  - Causal
  - Prediction

> *The abundance of data and resources facilitates the move away from a deductive social science to a more sequential, interactive and ultimately inductive approach to inference. (Grimmer et al. 2021)*

Machine learning focuses **Prediction**

- approxiated by something like R^2
- focuses on $\hat{y}$ (the prediction of the outcome)
- introduce more complex models than traditional linear models common in the social science
- provide better predictive performance

(Traditional) Social science focuses on the relationships of the variables

- Social Scientists focuses on $\hat{\beta}$ (the parameter of the model)
  - the predictions can be a more opaque function of the inputs
  - the models may not easily provide meaningful estimates of uncertainty
  - the estimation routines are more computationally intensive

Deductive model of social science?

- the most common process in the social science
- quantitative tests and variables must be defined a priori (e.g., King et al. 1995)
    - help to reduce false discoveries that can result from researcher discretion.
    - most efficient way to conduct research when data were scarce

Inductive approach?

- the importance of more inductive forms of analysis in qualitative research has been suggested by qualitative scholars
- researchers often discover new directions, questions, and measures within quantitative data
- machine learning can facilitate those discoveries

Measurement

- Machine learning methods are useful for a wide range of measurement strategies
- it can improve the classification of observations into categories
    - it is used to extrapolate the hand coding decisions of coders to other data
    - it greately reduce the cost of using otherwise difficult-to-use data
    - **text, image**, video

Example: Text classification

- Kim and Ogawa. 2022. The Impact of Politicians' Behaviors on Hate Speech Diffusion: Analysis Focusing on Adoption Threshold of Hate Speech on Twitter in Japan. SocArXiv link
- Hate speech text classification
- Classified 200,000 tweet posts into two categories, hate speech or not.

Example: Image classification

- Won et al. 2017. “Protest activity detection and perceived violence estimation from social media images.” link
- collected geotagged tweets’ images associated to major protest events.
- A multi-task convolutional neural network is used to classify images
- predict its visual attributes, perceived violence and exhibited emotions