Machine Learning in Geoscience

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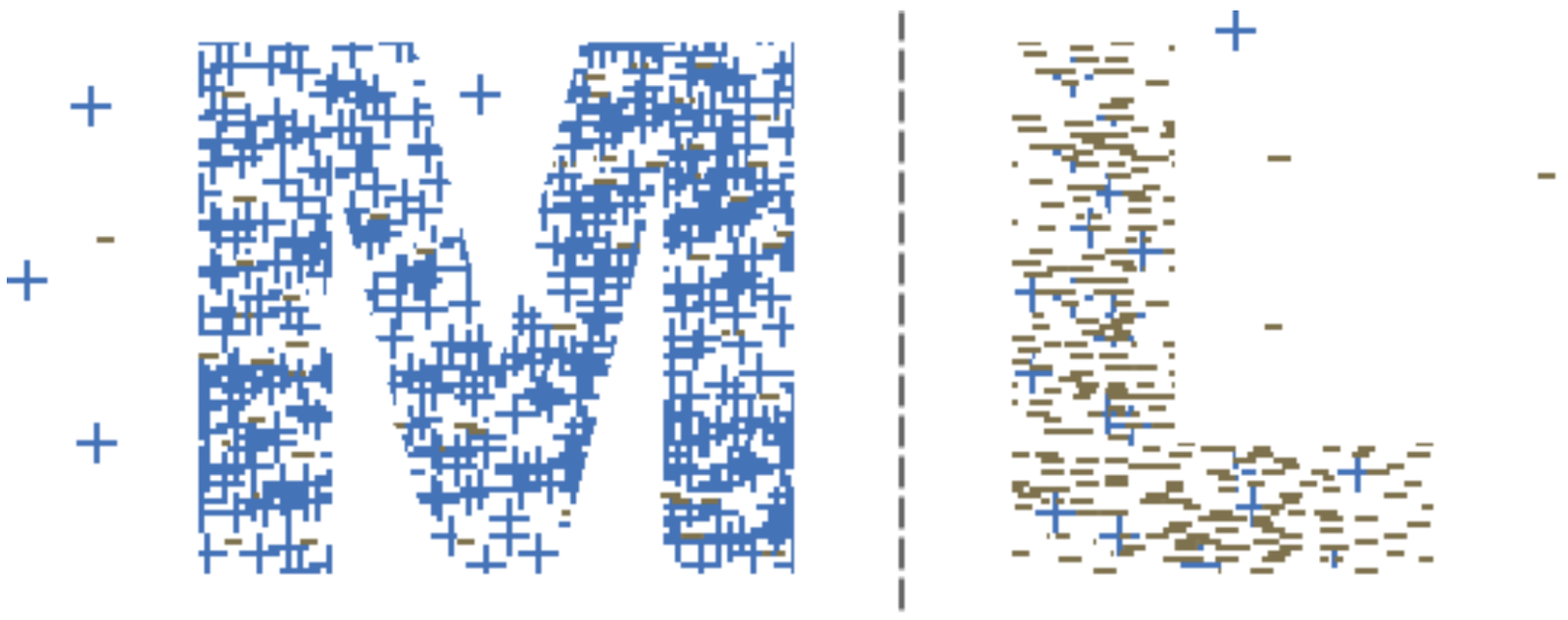


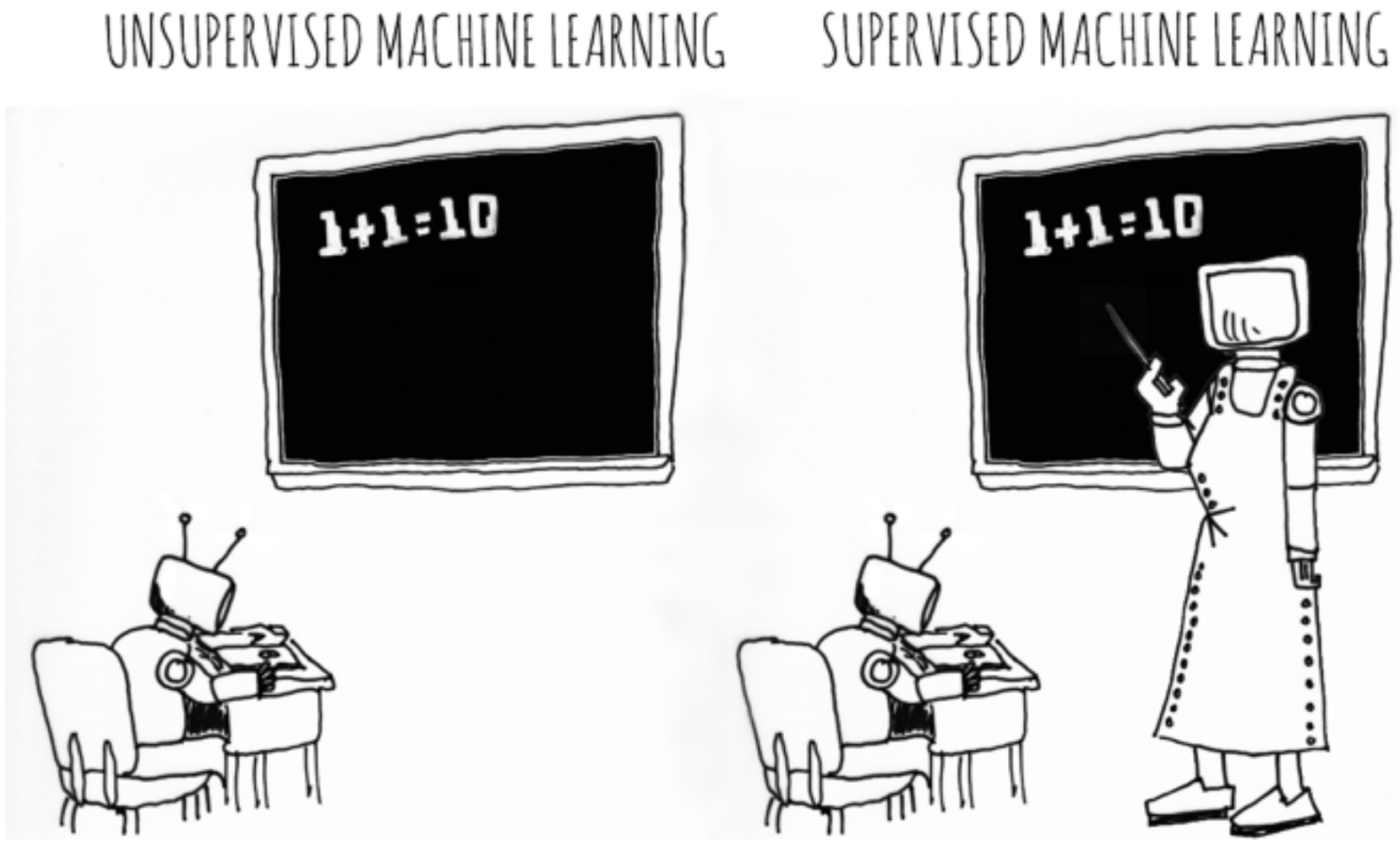
Introduction

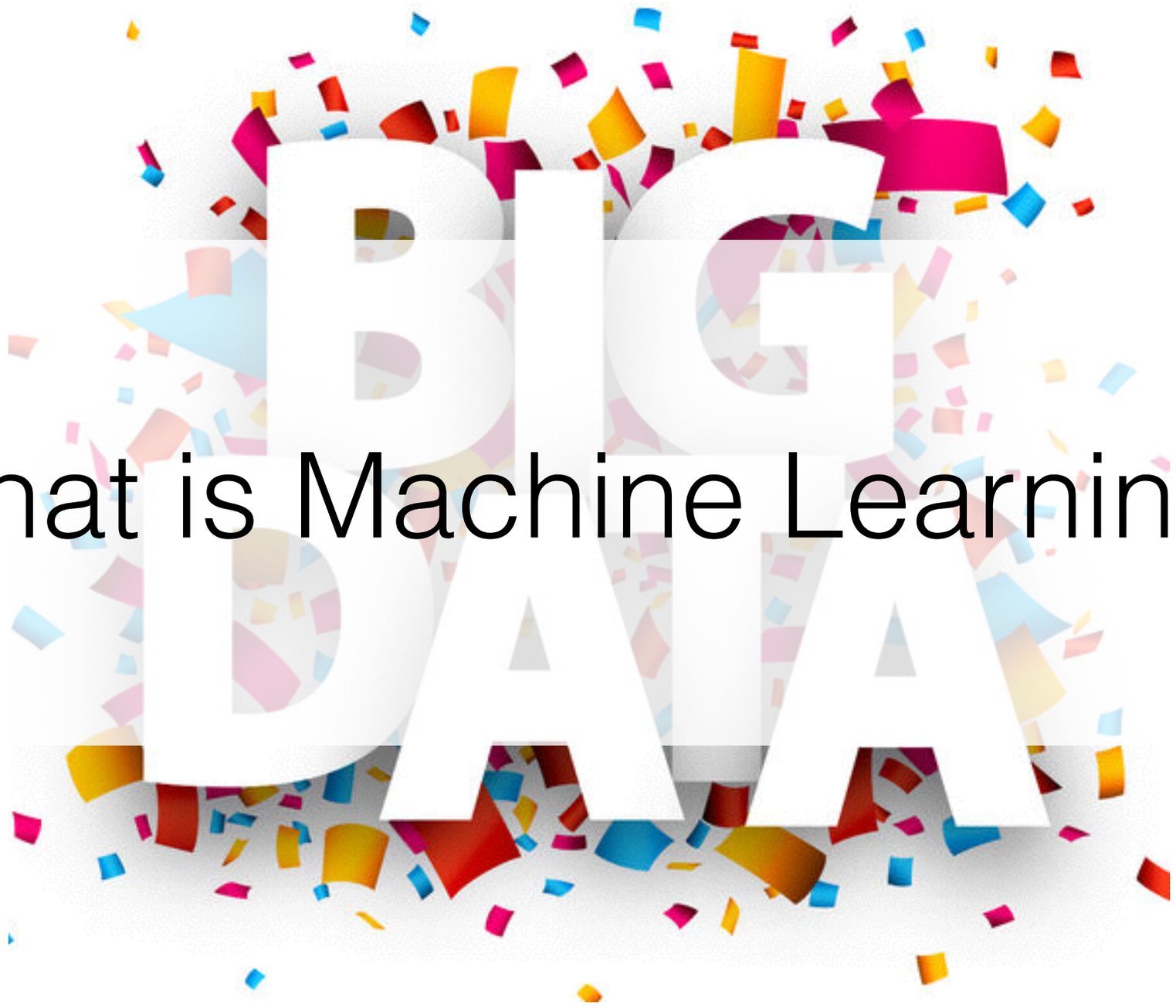
Overview

- Urban growth is one of the most important topics in urban studies.
- A city is considered as a complex system. It consists of numerous interactive sub-systems and is affected by diverse factors including governmental land policies, population growth, transportation infrastructure, and market behavior.
- To understand the driving forces of the urban form and structure change, the satellite-based estimates are considered as the appropriate methods to monitor these dynamically change in a long term.
- Furthermore, modeling and simulation are believed to be powerful tools to explore the mechanisms of urban evolution and provide planning support in growth management.

Research purpose

- Utilizing the Deep Learning of Machine learning to simulate and predict the mechanisms of urban expanding and evolution.





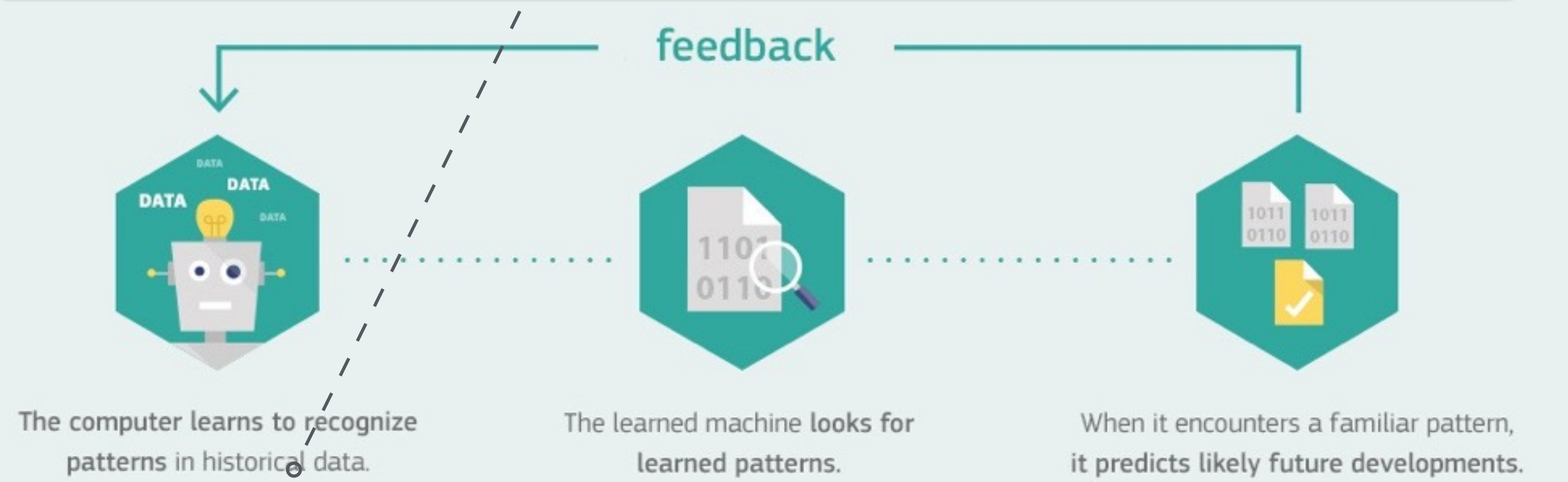
What is Machine Learning?

Research background

- Remote sensing multispectral image data, behavioral geography data (person trip), transportation network data… —> **big data** of geography

- How geography might provide a useful lens through which to understand big data as a phenomenon in its own right?
  Machine learning is believed to be the powerful tool to explore and analyze the geography big data.

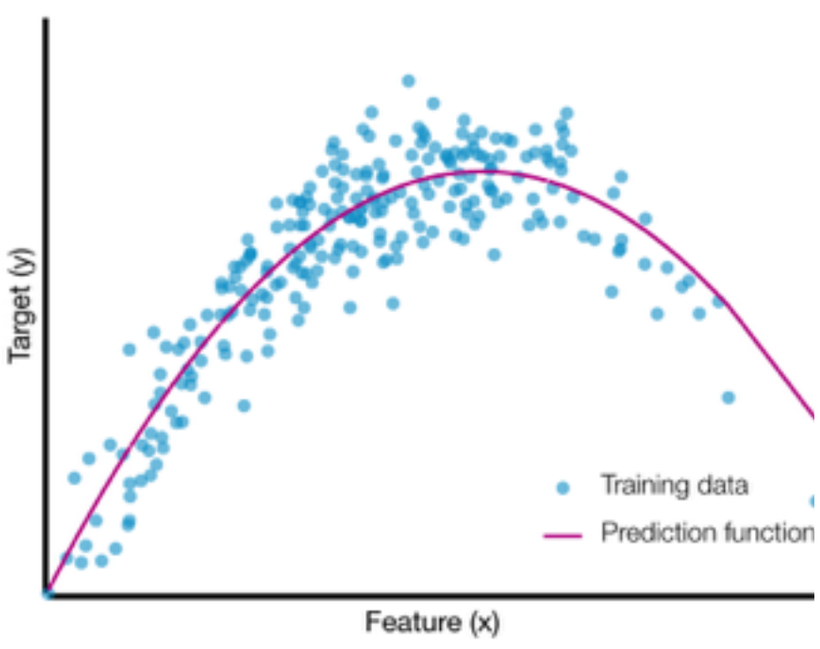
What is machine learning?
Machine learning evolved from the study of **pattern recognition** and **computational learning theory** in **artificial intelligence (AI).**

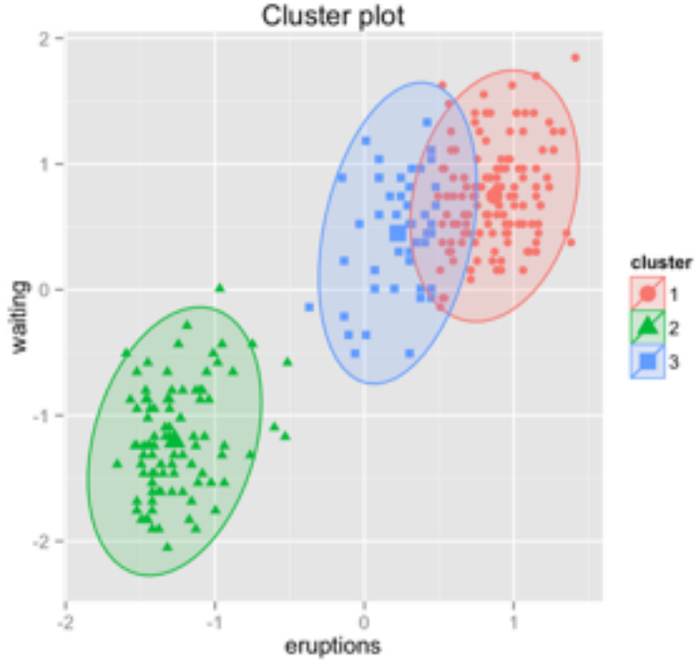


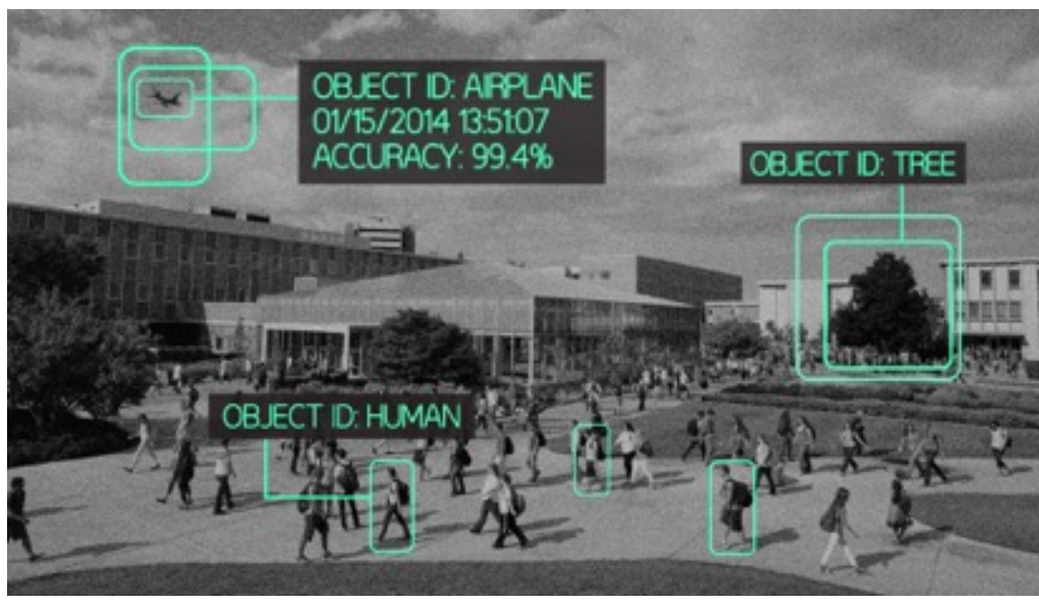
https://www.gaussalgo.com/machine-learning/

Machine Learning:

"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 tasks in T, as measured by P, improves with experience E" — *T.Michell (1997)*

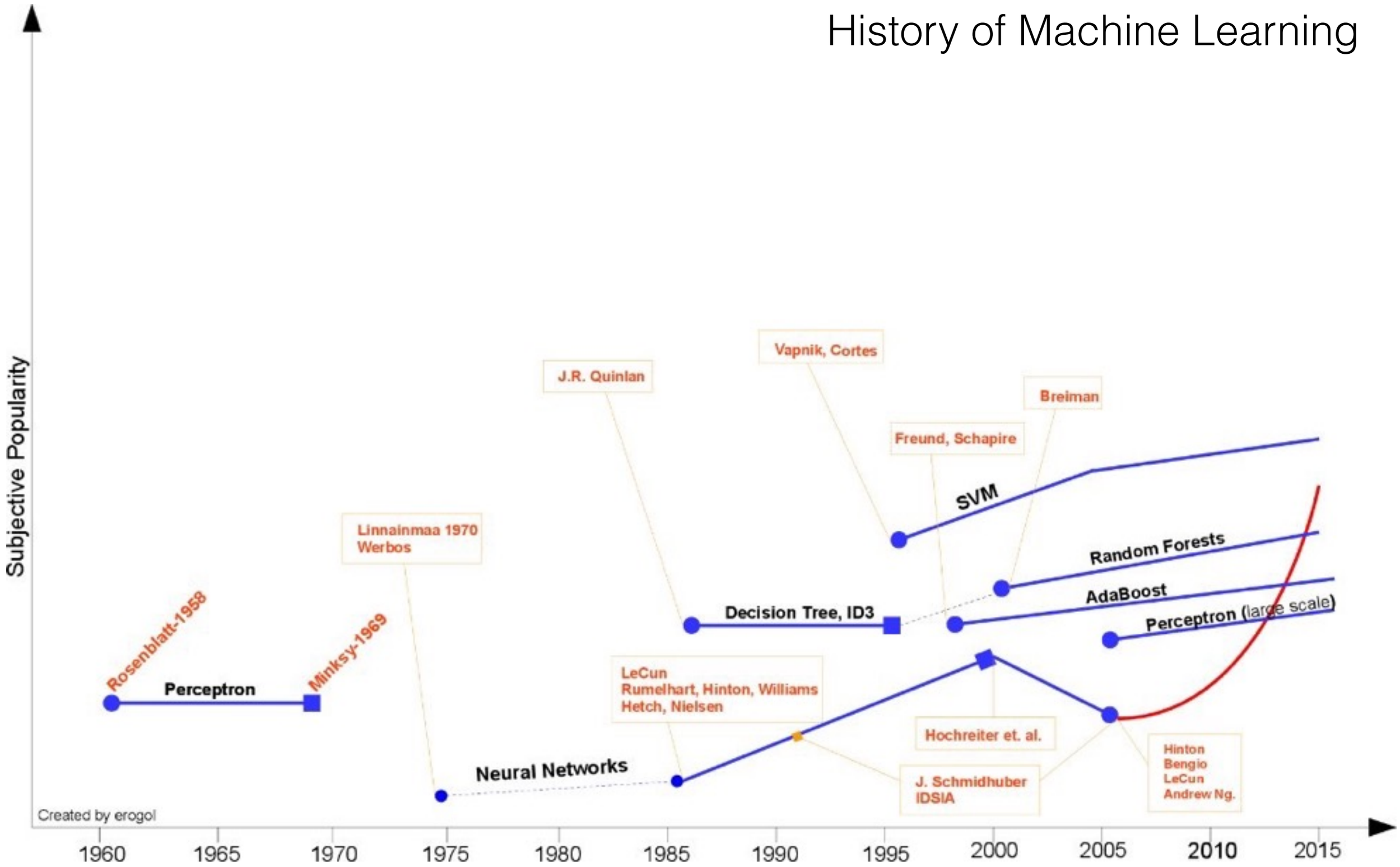






regression **clustering** **classification**

History of Machine Learning

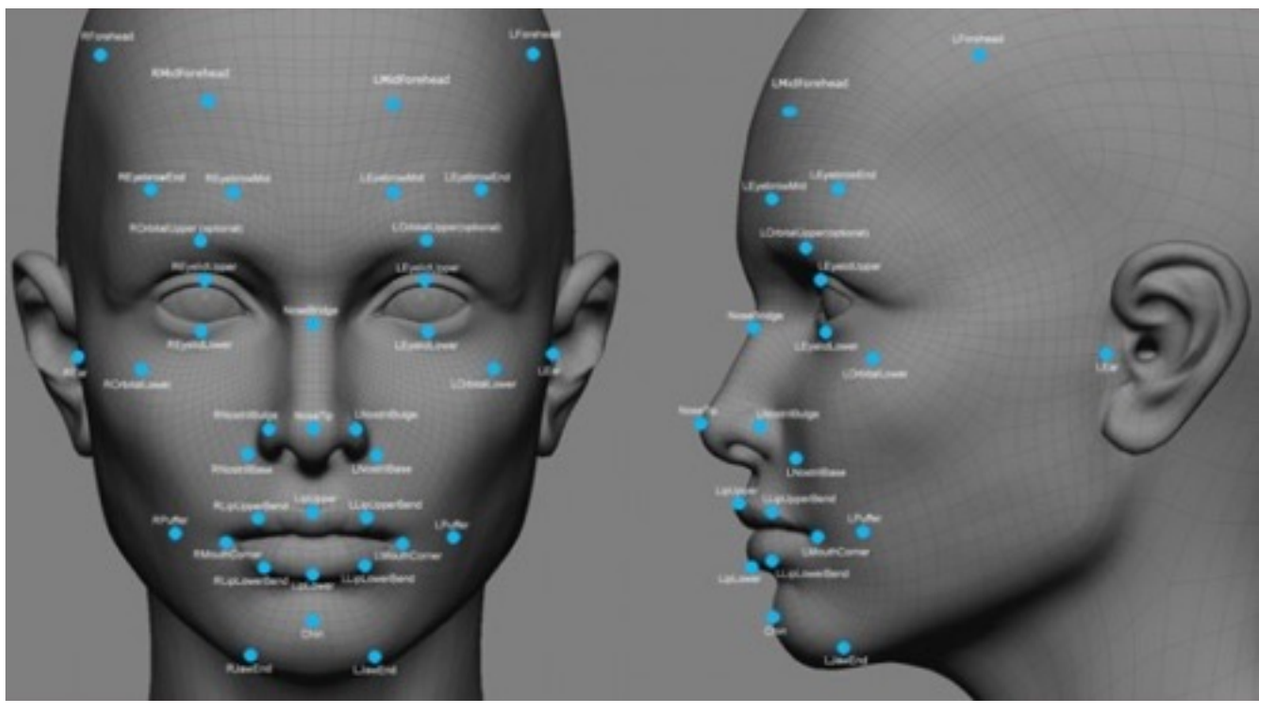


Erin Golge illustrates his subjective Machine learning timeline.
http://www.erogol.com/brief-history-machine-learning/

It is all about machine learning…

Intelligent voice assistant
http://www.apple.com/ios/siri/

Predictive policing
http://www.predpol.com/



Facial recognition
http://www.face-rec.org/

Self-driving car
https://www.google.com/selfdrivingcar/

How to connect the machine learning with geospatial data?

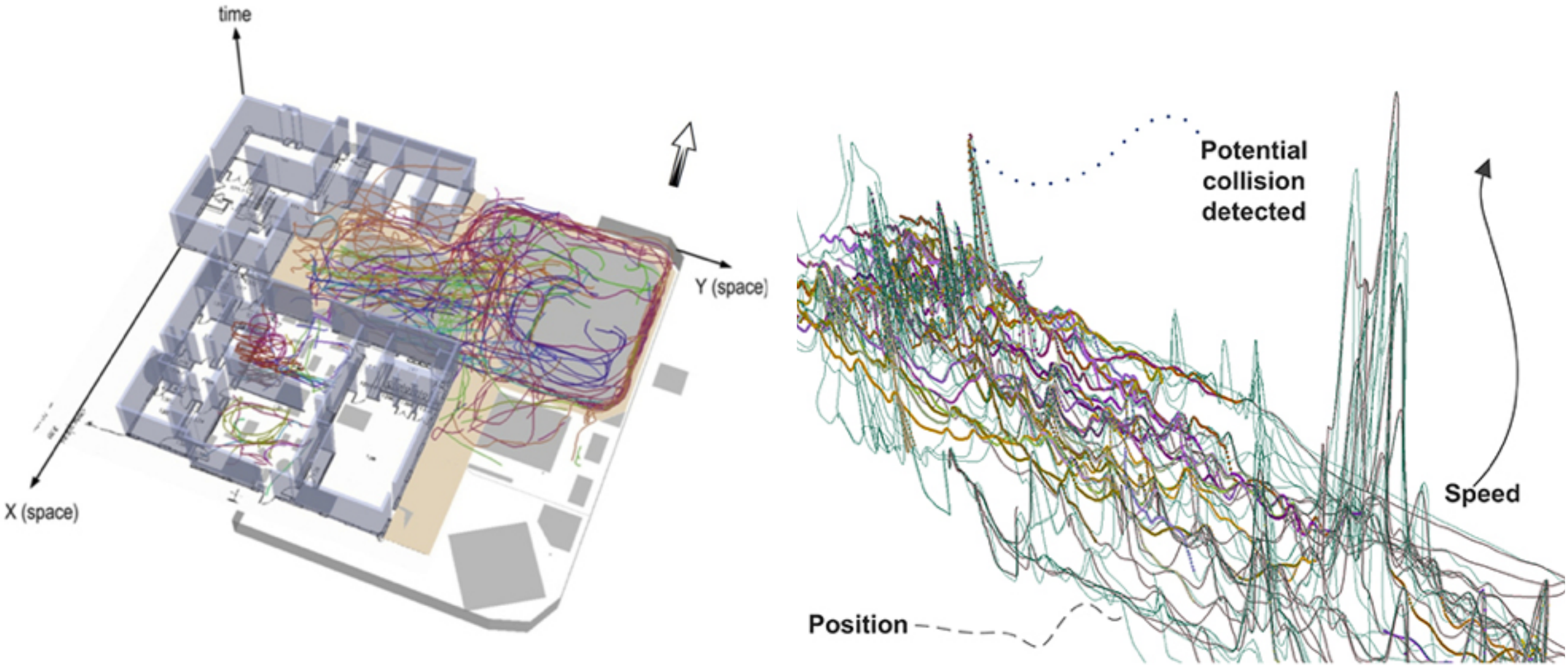
Geospatial Big Data

Remote sensing multispectral image data,
behavioral geography data (person trip),
transportation network data,

…

http://2012.bedreinnovation.dk/aktivitet/data-mining-og-machine-learning-i-praksis

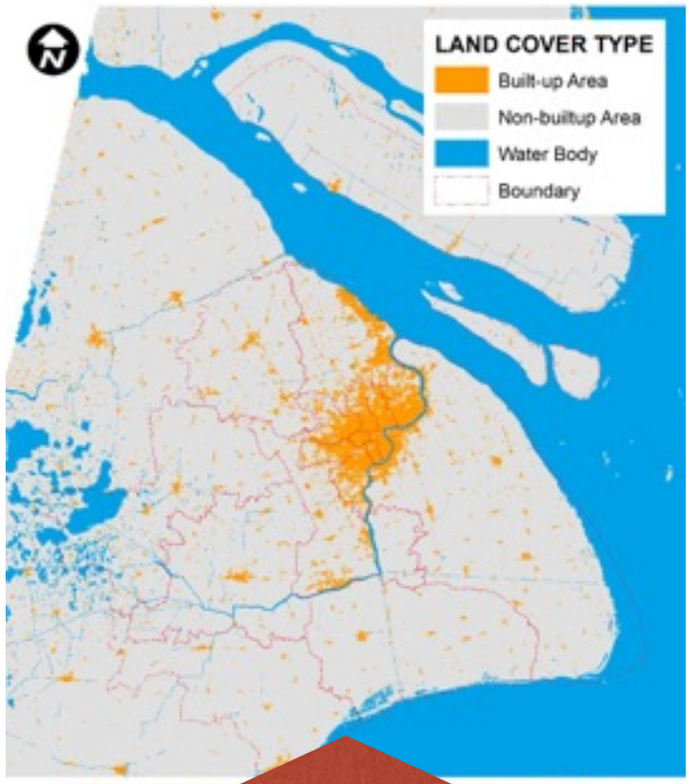
Geosimulation



Machine-learning behavioral geography (left), Big data movement analytics (right)
Center for GIS, Department of Geographical Sciences, and UMIACS, University of Maryland
http://www.geosimulation.org/

Machine learning in remote sensing

Machine Learning Classification Results

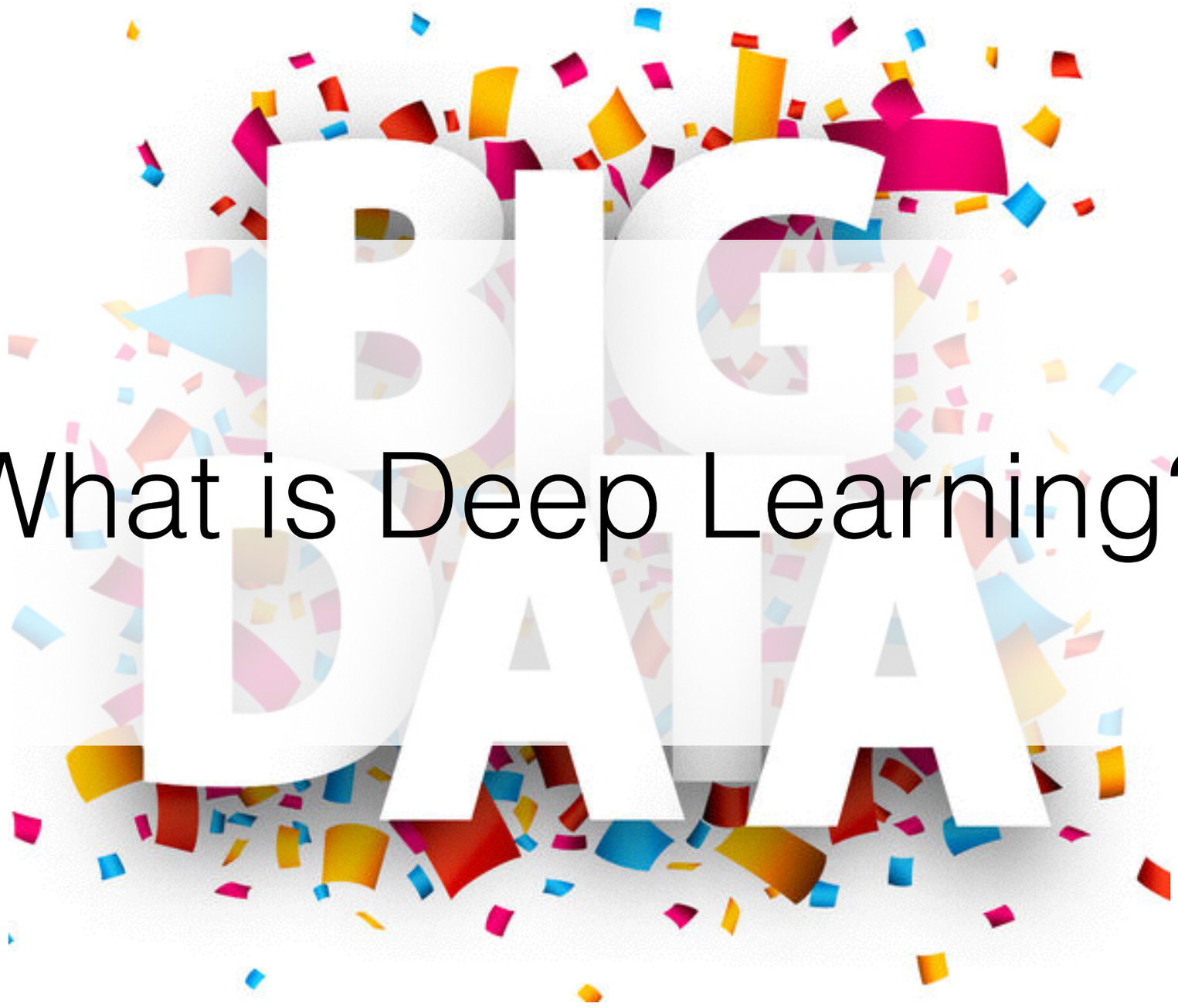


Landsat Satellite Images

1988

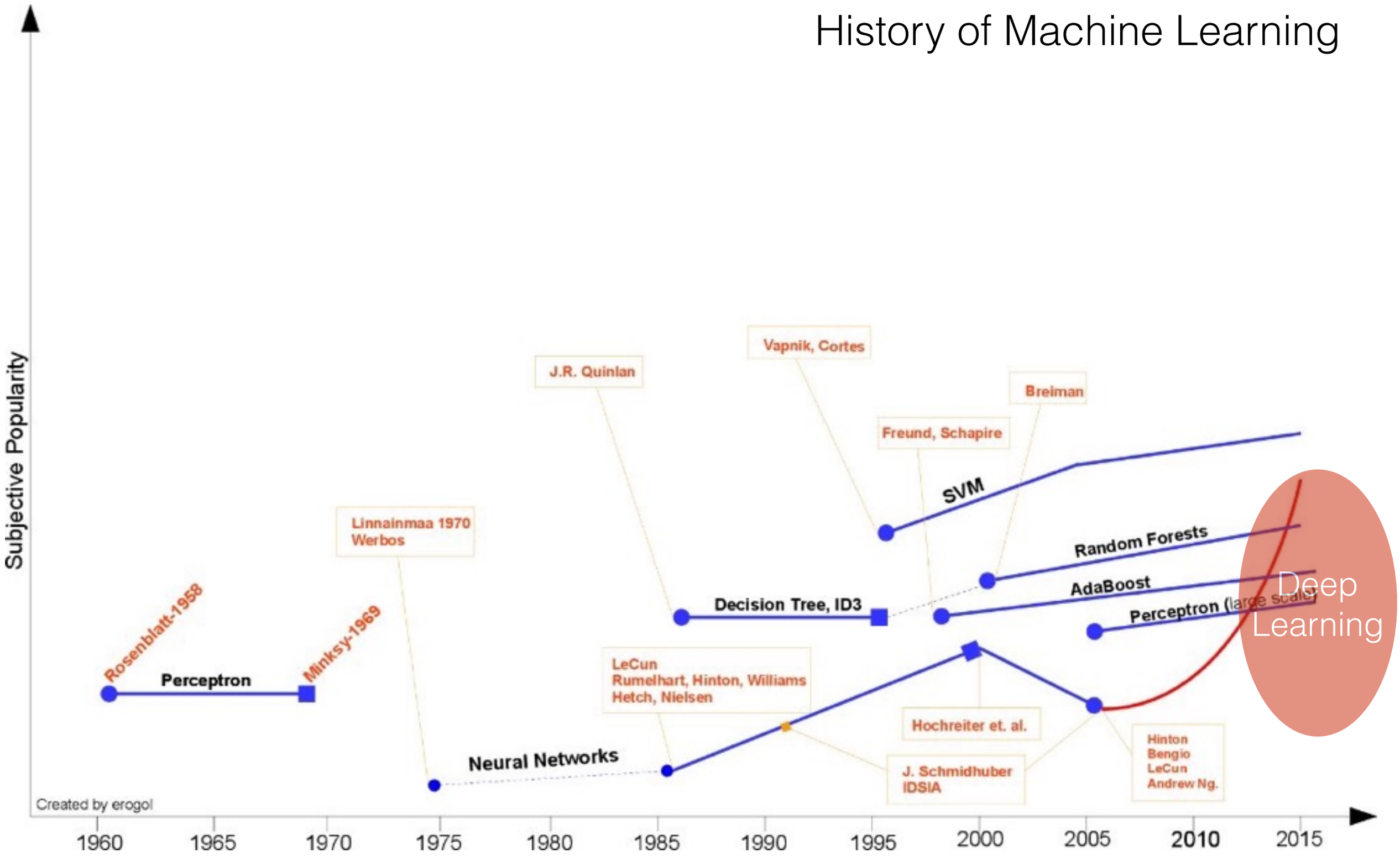
2000

2013



What is Deep Learning?

History of Machine Learning



Erin Golge illustrates his subjective Machine learning timeline.
http://www.erogol.com/brief-history-machine-learning/

Springtime for AI: The Rise of Deep Learning

After decades of disappointment, artificial intelligence is finally catching up to its early promise, thanks to a powerful technique called deep learning

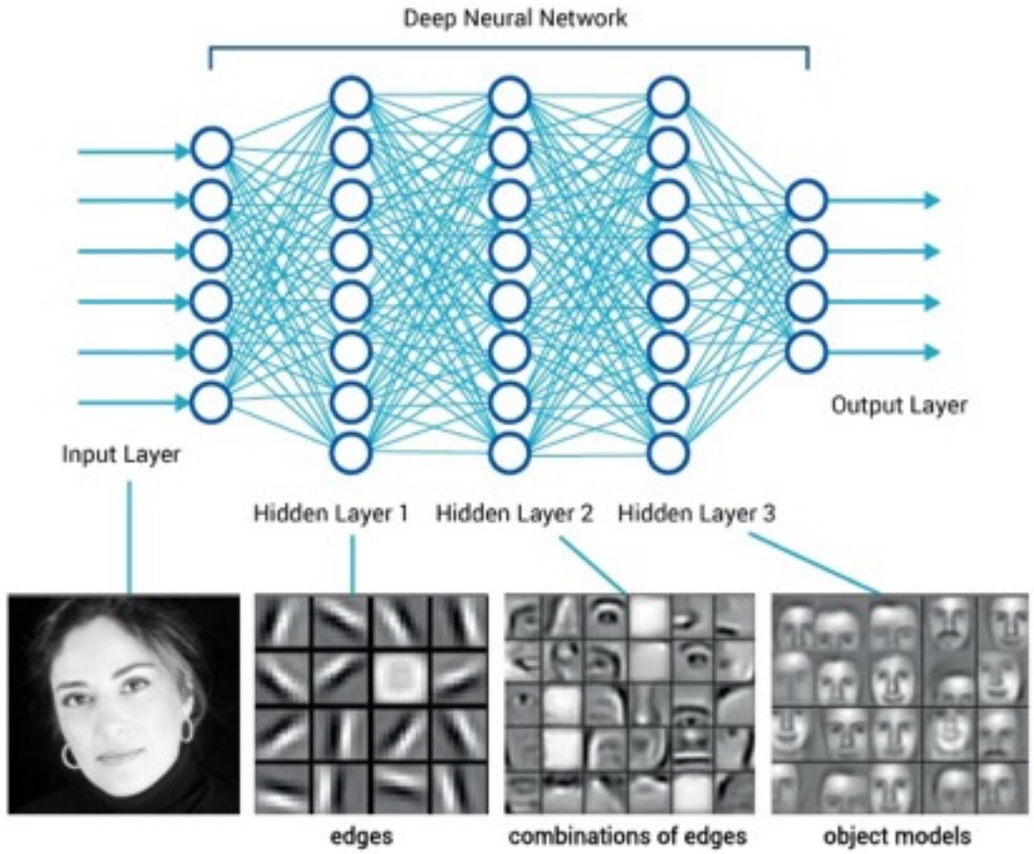
By Yoshua Bengio on June 1, 2016

- **Deep learning** (also known as deep machine learning) is a new area of Machine Learning research, which has been introduced with the objective of moving Machine Learning closer to one of its original goals: Artificial Intelligence.

- What the Deep Learning is used for?
  - Big data analysis
  - More accurate predictive analytics

Create models and learn patterns from **large-scale unlabeled data**

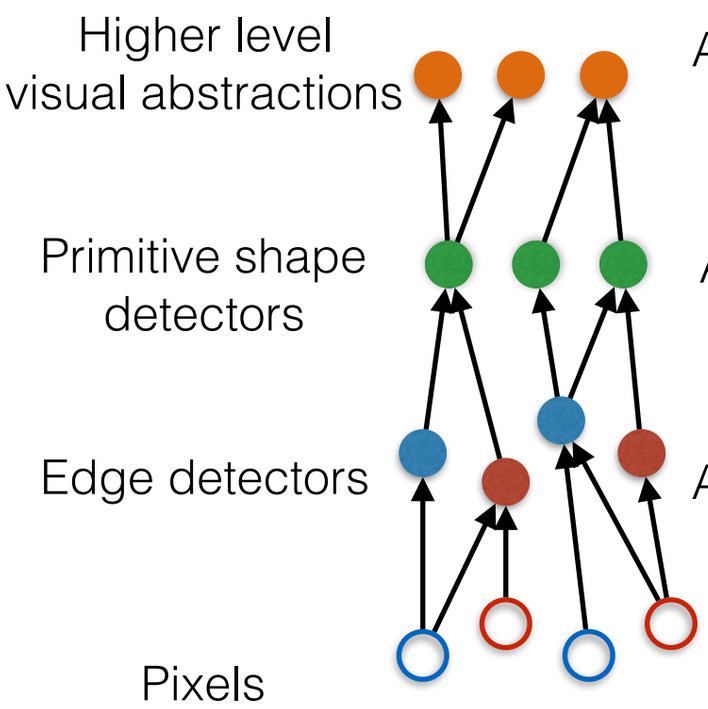
- How deep learning works?
  It covers a particular approach to building and training neural networks.



http://www.amax.com/blog/?p=804

Concept of Convolutional Neural Networks (CNN)

Deep Architecture in the Brain



Visual System

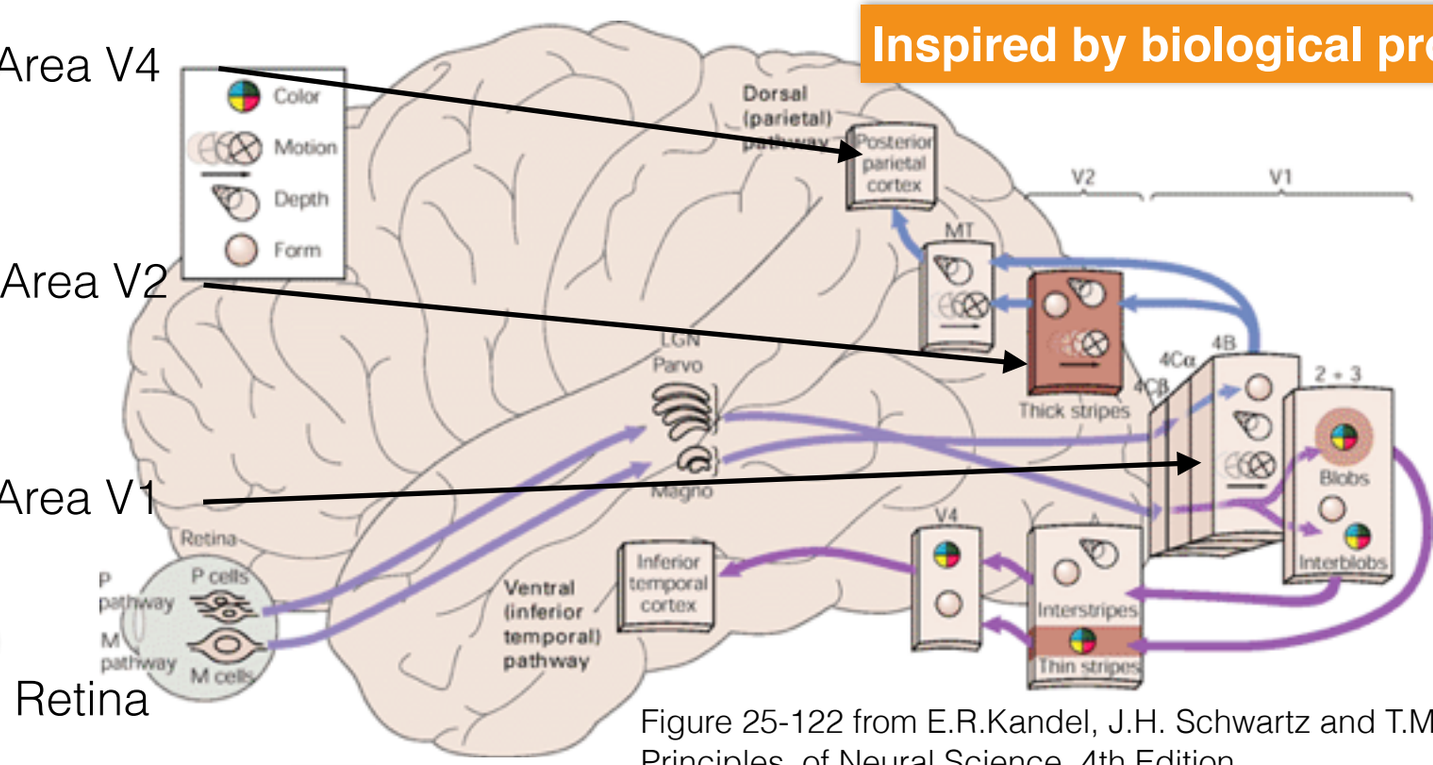
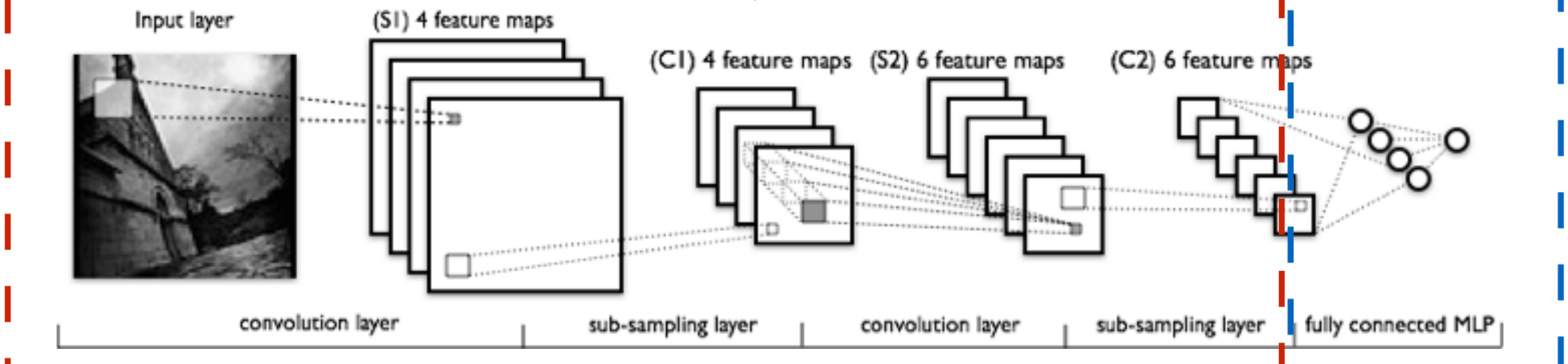


Figure 25-122 from E.R.Kandel, J.H. Schwartz and T.M. Jessel, Eds Principles of Neural Science, 4th Edition

Inspired by biological processes

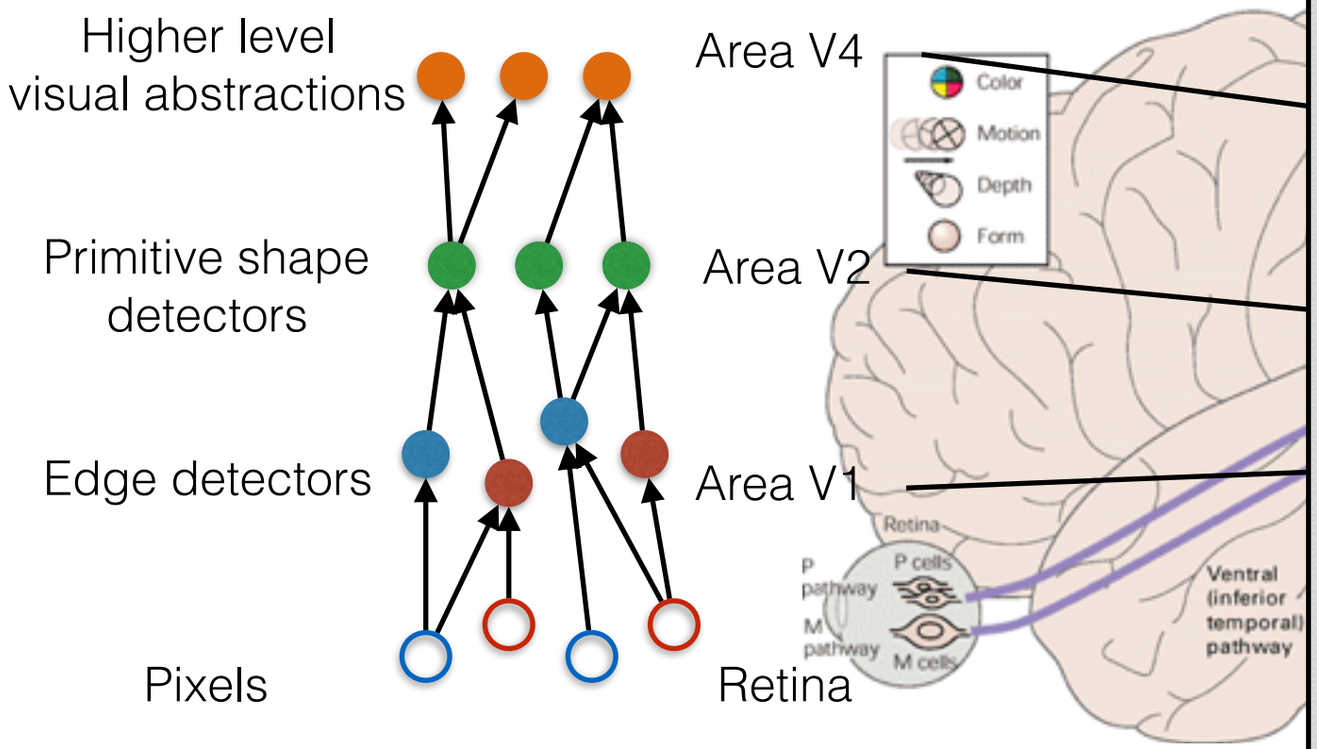


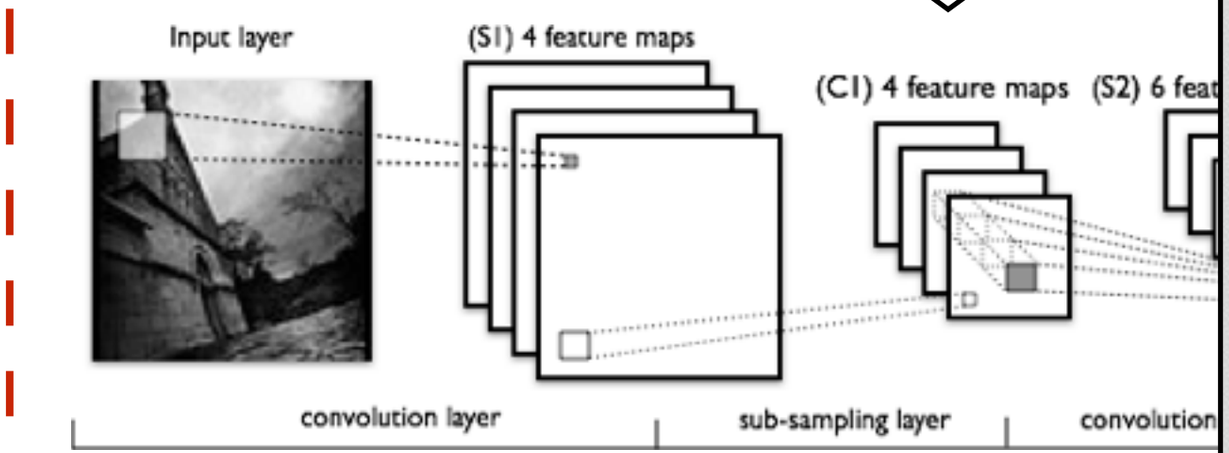
http://deeplearning.net/tutorial/lenet.html

feature extraction **classification**

Concept of Convolutional Neural Networks

Deep Architecture in the Brain



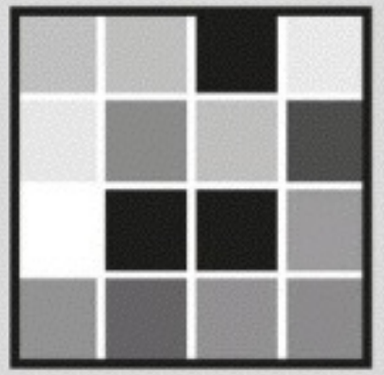


http://deeplearning.net/tutorial/lenet.html

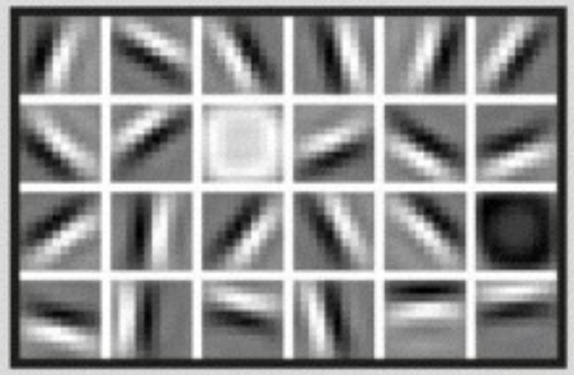
feature extraction

FACIAL RECOGNITION

Deep-learning neural networks use layers of increasingly complex rules to categorize complicated shapes such as faces.

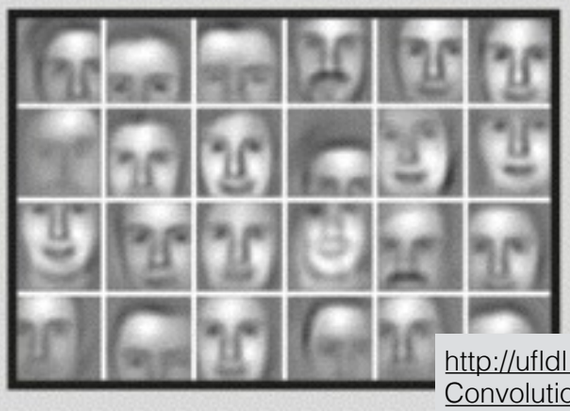


Layer 1: The computer identifies pixels of light and dark.



Layer 2: The computer learns to identify edges and simple shapes.

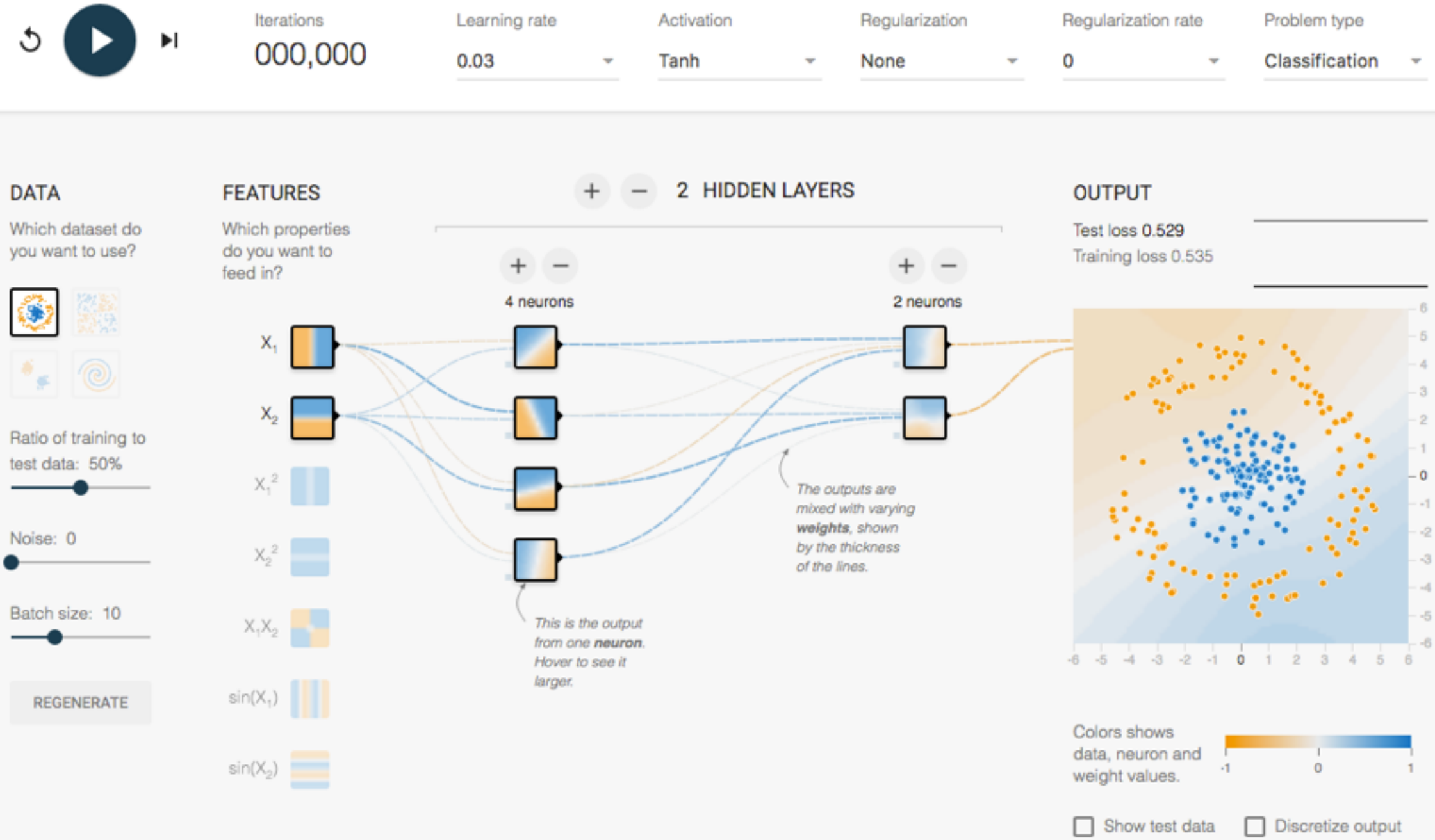
Layer 3: The computer learns to identify more complex shapes and objects.



Layer 4: The computer learns which shapes and objects can be used to define a human face.

http://ufldl.stanford.edu/tutorial/supervised/ConvolutionalNeuralNetwork/

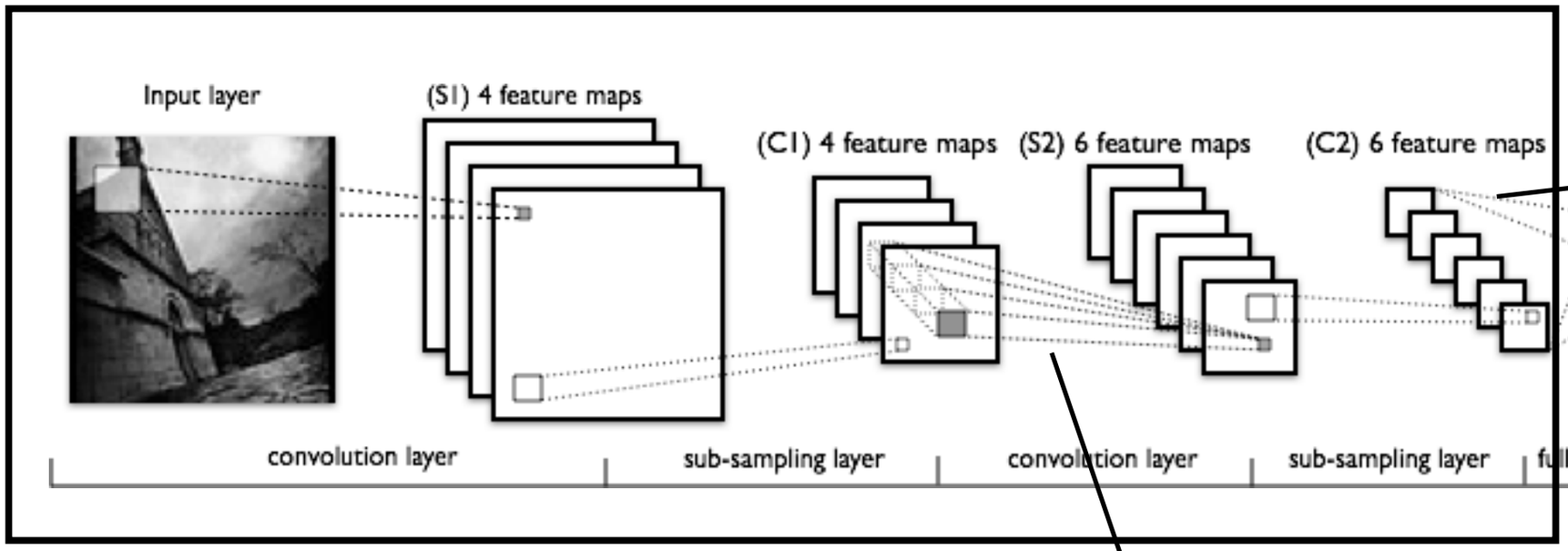
Understandting CNN

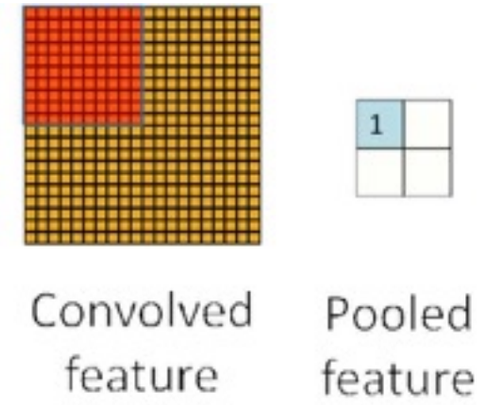


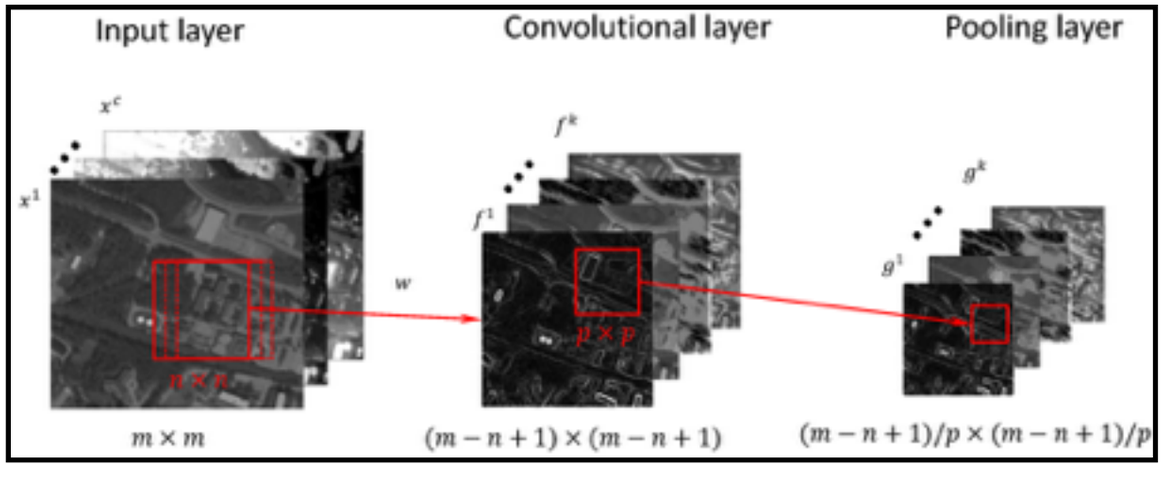
- TensorFlow is an Open Source Software Library for Machine Intelligence (CNN)

How to use Deep Learning to analyze and predict the urban land use/cover changes?

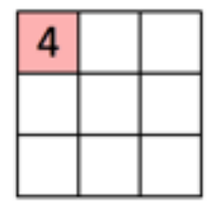
Concept Ideas:
CNN model framework for multispectral satellite image



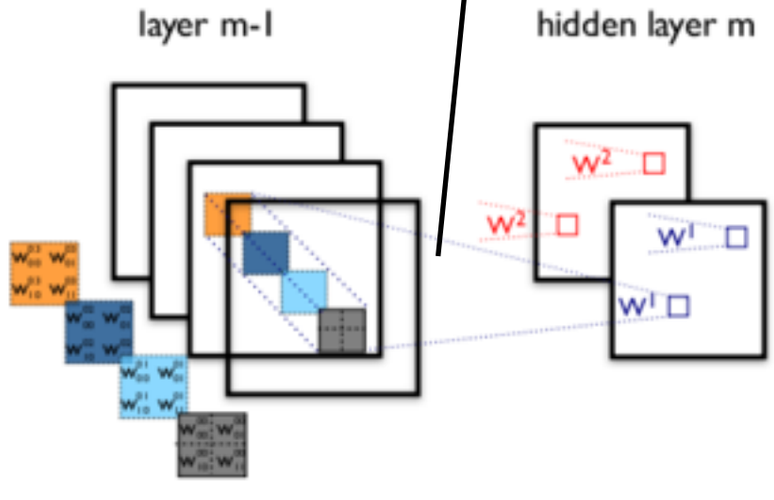




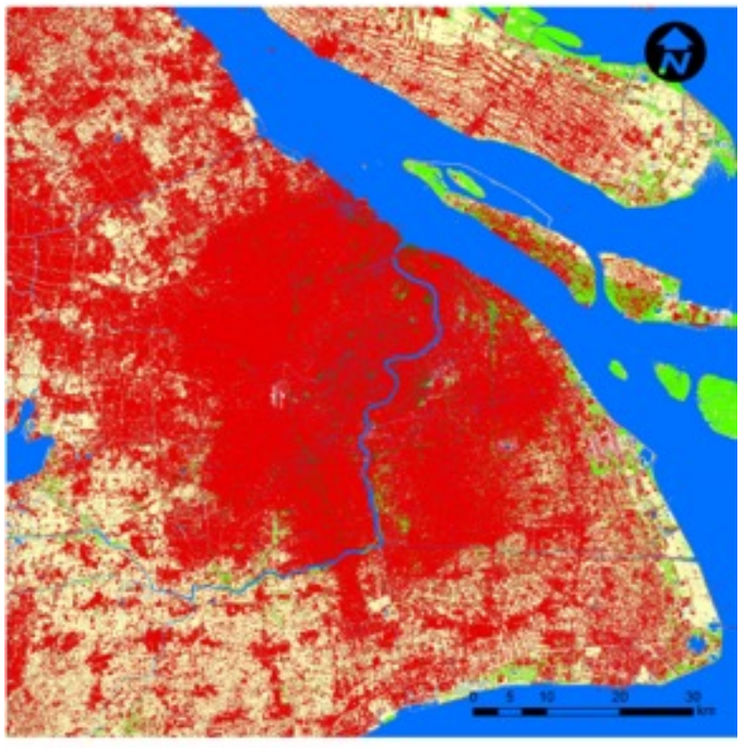
Längkvist, 2016

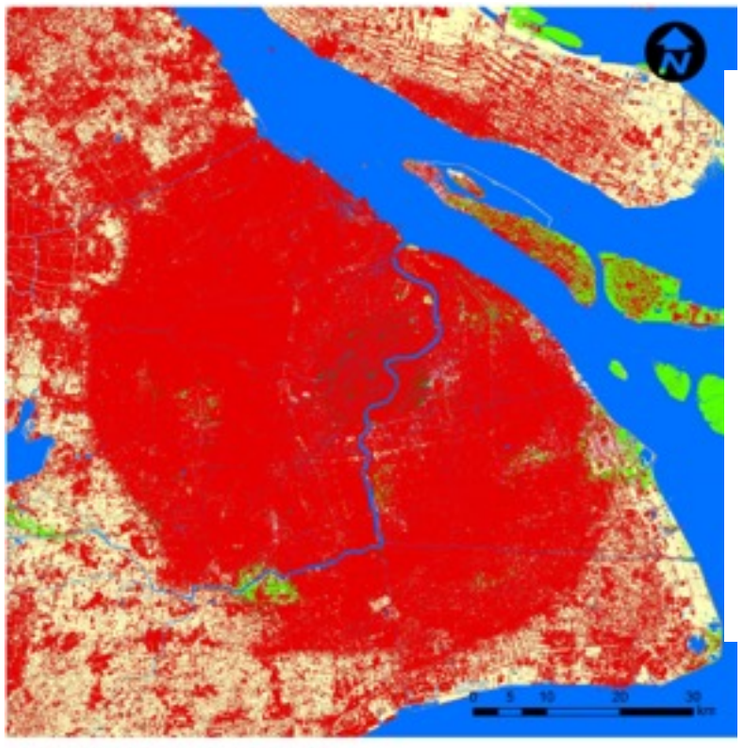


layer convolution process



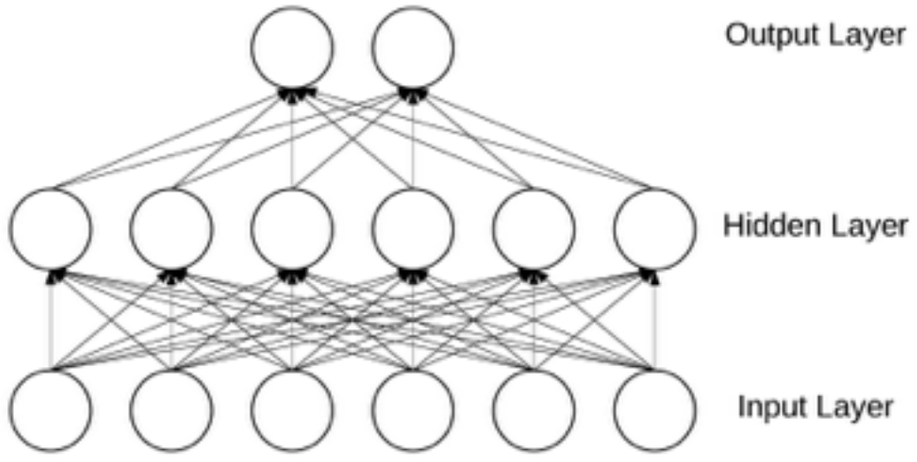
Experiment:
Multilayer Perceptron model (deep learning) for study area





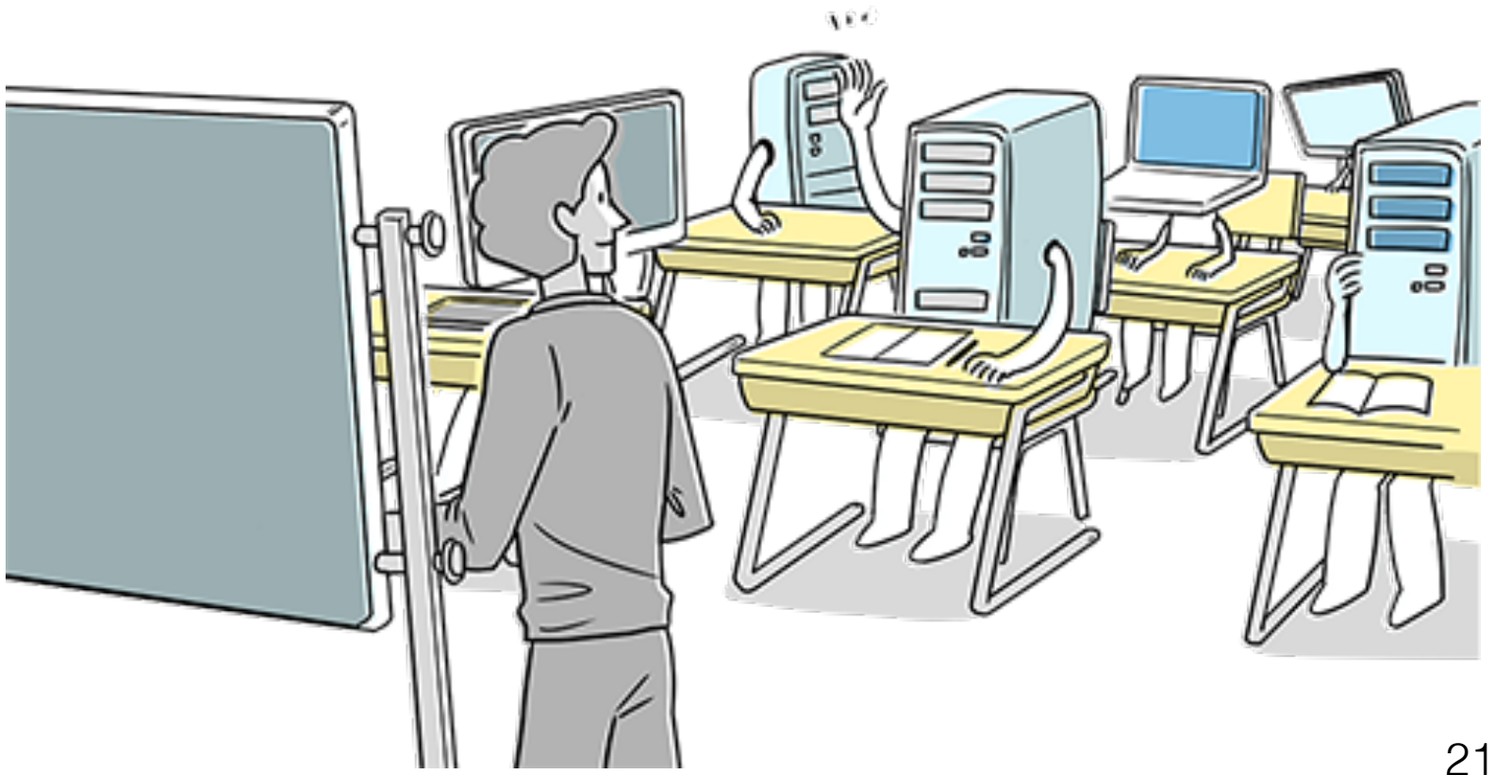
A fully connected MLP model, 6 input layer neurons, 6 hidden layer neurons and 2 output layer neurons model was constructed in this study for each sub model.

The batch size (samples per class) is 10000, and 5000 times iteration for per sub model running.



Summary

- Deep machine learning is a powerful and robust tool to analyzing and predicting the statistical, geographical and multispectral optical big data.
- We can predict and simulate the urban expanding and evolution (geographical big data) in more reasonable and scientific method with deep learning.



References

Kandel, E. R., Schwartz, J. H. 1., & Jessell, T. M. (2000). Principles of neural science (4th ed.). New York: McGraw-Hill, Health Professions Division.

Längkvist, M.; Kiselev, A.; Alirezaie, M.; Loutfi, A. Classification and Segmentation of Satellite Orthoimagery Using Convolutional Neural Networks. Remote Sens. 2016, 8, 329.