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)
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/

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

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

**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,

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
What is Deep Learning?
Erin Golge illustrates his subjective Machine learning timeline. 
http://www.erogol.com/brief-history-machine-learning/
• **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.
Concept of Convolutional Neural Networks (CNN)

Deep Architecture in the Brain

Higher level visual abstractions
Primitive shape detectors
Edge detectors
Pixels

Visual System

Area V1
Area V2
Area V4

Retina

Inspired by biological processes

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

http://deeplearning.net/tutorial/lenet.html
Concept of Convolutional Neural Networks

Deep Architecture in the Brain

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Retina

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

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