Deep Learning in CEE and Earth Science

CEE 691 seminar

10/21/2019

Harry Lee

Recent paper in arXiv

arXiv.org > cs > arXiv:1909.03186

Computer Science > Computation and Language

On Extractive and Abstractive Neural Document Summarization with Transformer Language Models

Sandeep Subramanian, Raymond Li, Jonathan Pilault, Christopher Pal

(Submitted on 7 Sep 2019)

We present a method to produce abstractive summaries of long documents that exceed several thousand words via neural abstractive summarization. We perform a simple extractive step before generating a summary, which is then used to condition the transformer language model on relevant information before being tasked with generating a summary. We show that this extractive step significantly improves summarization results. We also show that this approach produces more abstractive summaries compared to prior work that employs a copy mechanism while still achieving higher rouge scores. Note: The abstract above was not written by the authors, it was generated by one of the models presented in this paper.

Subjects: **Computation and Language (cs.CL)**

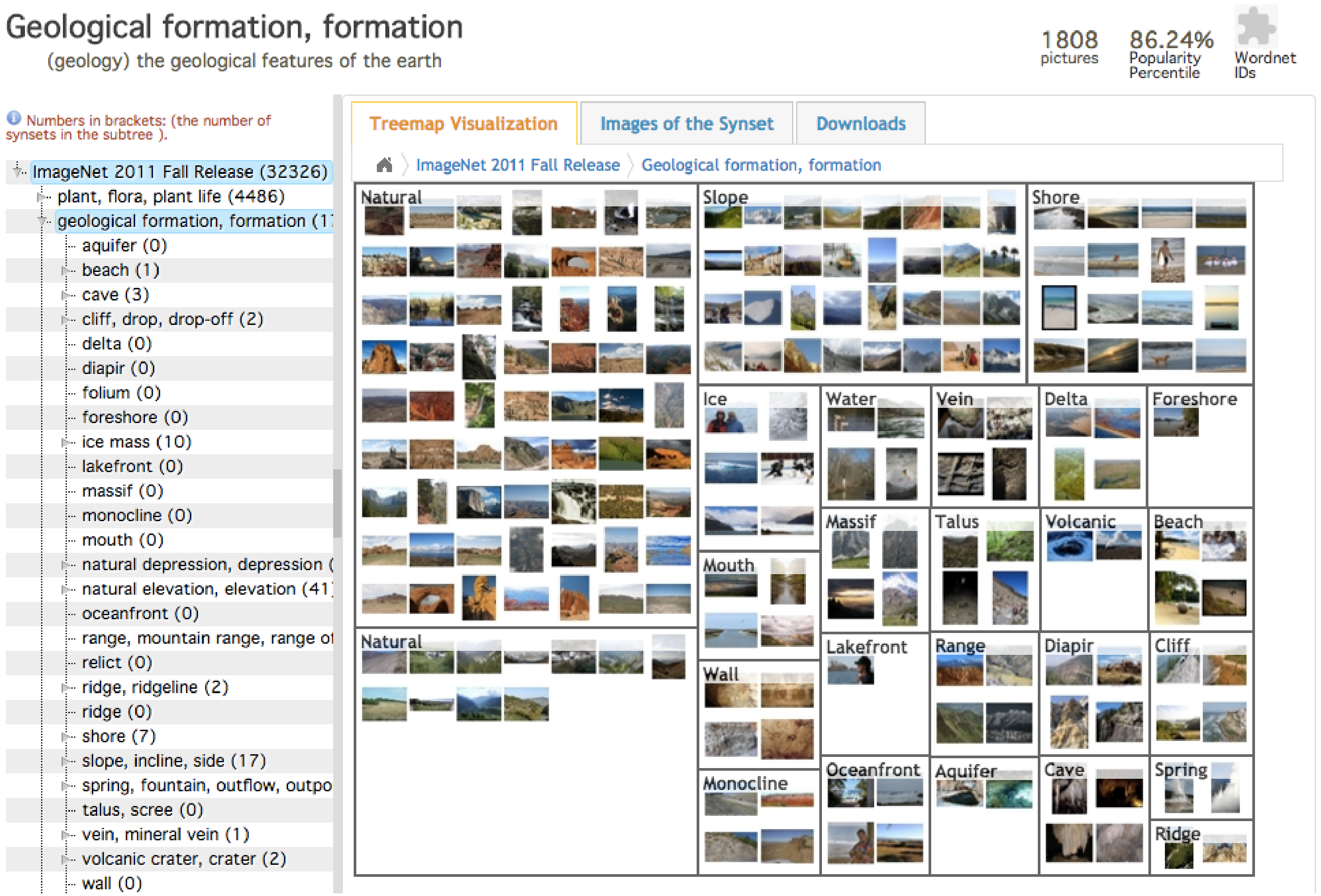
Cite as: **arXiv:1909.03186 [cs.CL]**

(or **arXiv:1909.03186v1 [cs.CL]** for this version)

> Note: The abstract above was not written by the authors, it was generated by one of the models presented in this paper.

ImageNet 2012 Challenge

Given images, can our machine tell which category it belongs to ?



In 2012, a DL-based method achieved a top-5 error of ~15% (the runner up of 26%)

What is Deep Learning?

Answer) Artificial neural networks with *multiple* layers

Yann LeCun: "Deep Learning was a rebranding of the modern incarnations of neural nets with more than two layers"

https://www.facebook.com/yann.lecun/posts/10155003011462143

What is Deep Learning?: DL vs ML vs AI

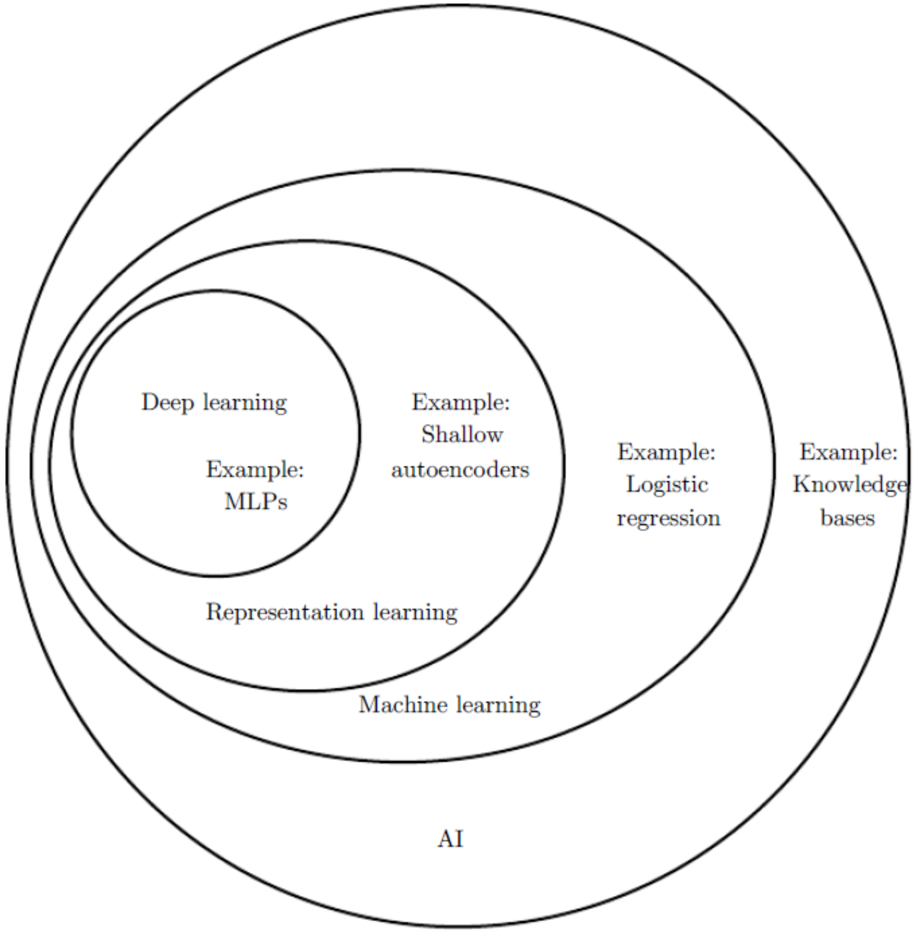


Figure 1.4: A Venn diagram showing how deep learning is a kind of representation learning, which is in turn a kind of machine learning, which is used for many but not all approaches to AI. Each section of the Venn diagram includes an example of an AI technology.

Goodfellow et. al. 2016

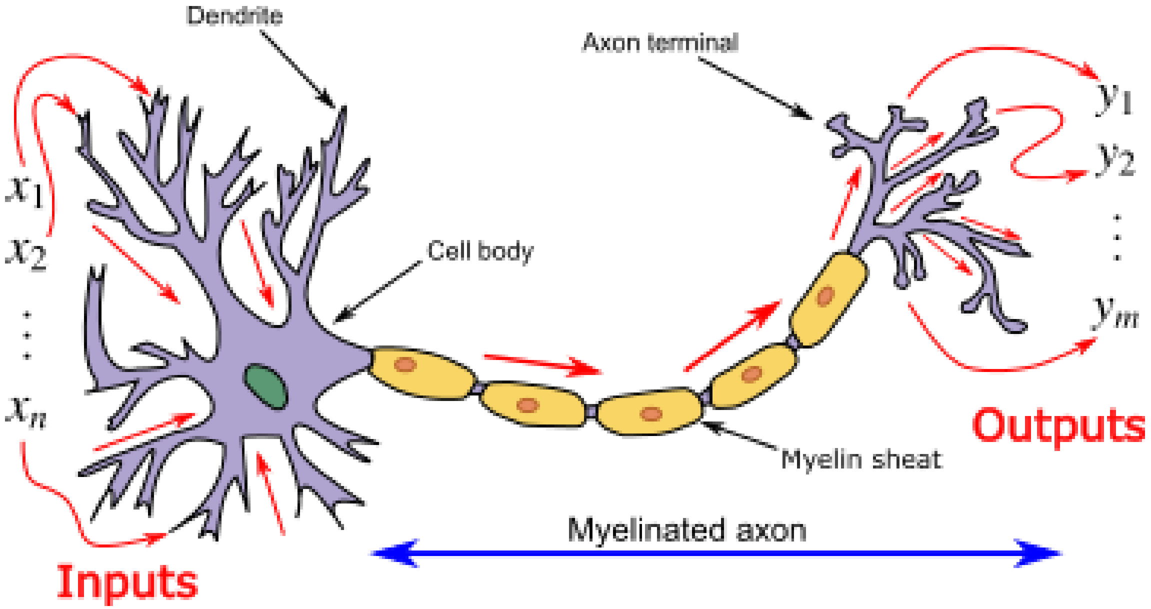
What is Deep Learning?: DL vs ML

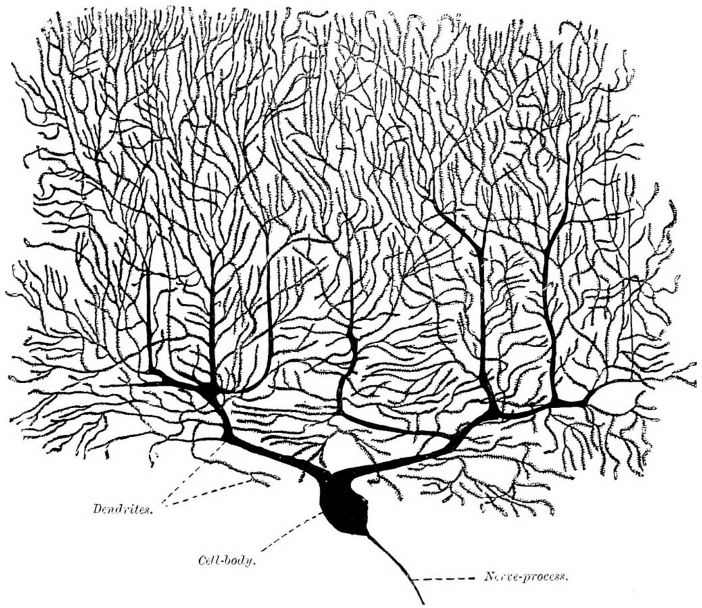
- **Traditional Machine Learning**

- **Deep Learning**

adapted from LeCun's ISSCC 2019 talk

What is Artificial Neural Networks?





- **A mathematical model** inspried by biological brains which responds to stimuli from its sensory inputs [McCulloch and Pitts, 1943].
- ANNs can **learn** the relationship between a set of input signals and output signals.
- It is just a (very) flexible mathematical model.

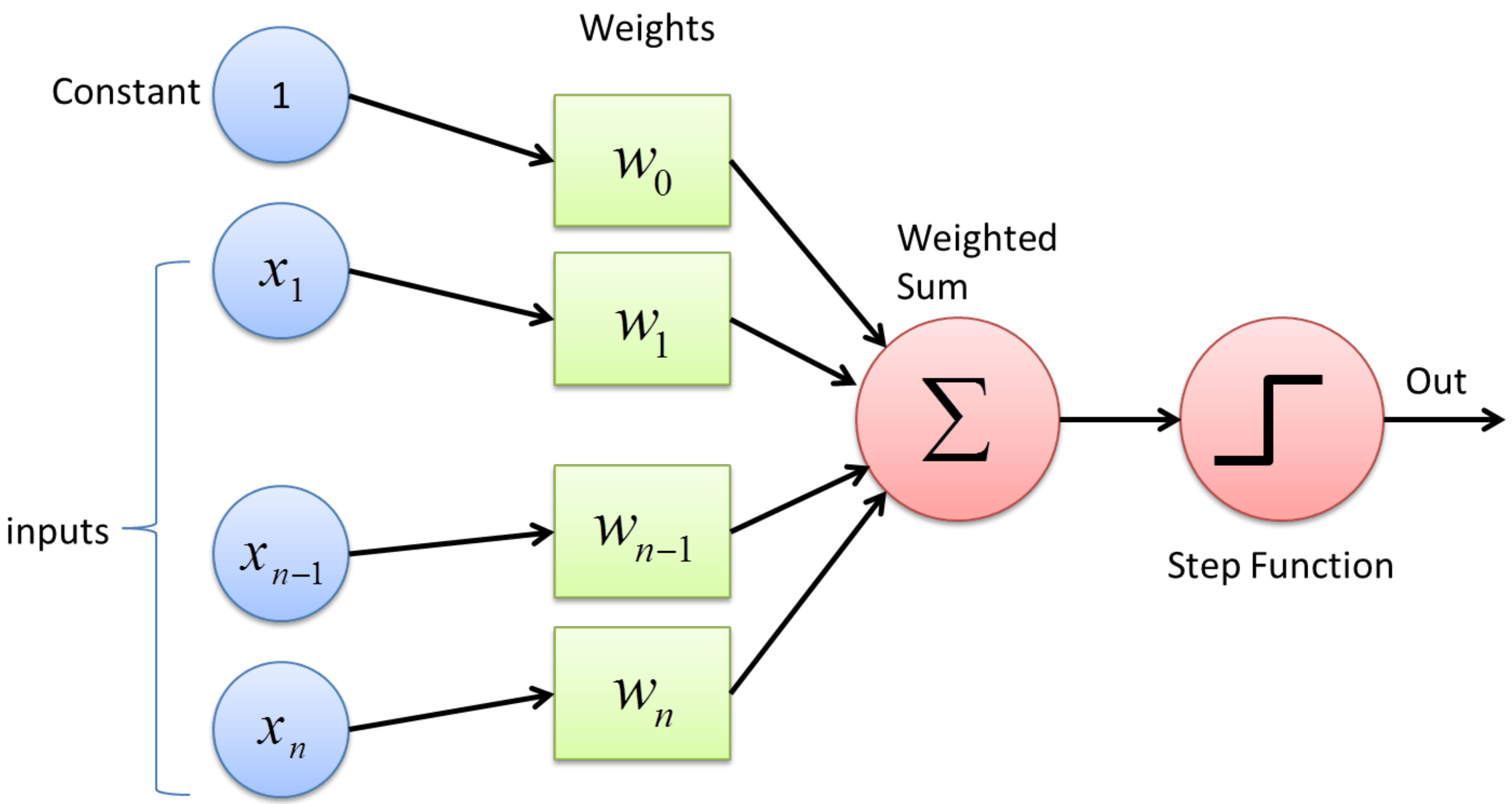
sources: wikipedia, flicker

McCulloch, Warren; Walter Pitts (1943). "A Logical Calculus of Ideas Immanent in Nervous Activity". Bulletin of Mathematical Biophysics. 5 (4): 115–133.

Why Deep Learning Becomes Powerful

1. ANN model can describe very complex relationships/functions (universality theorem).
2. Advances in (big) data acquisition.
3. Advances in computer hardware.
4. Public-domain software.

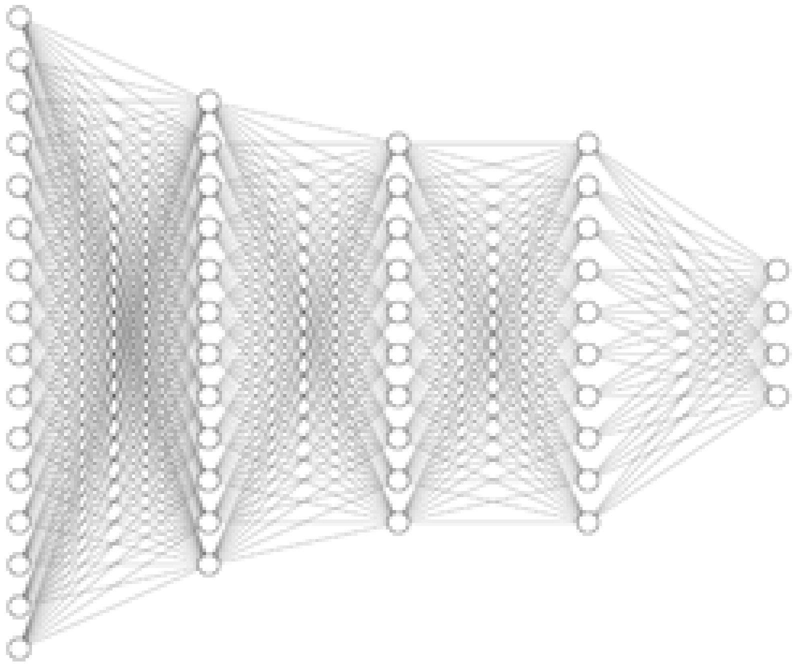
(1) Artificial Neural Networks

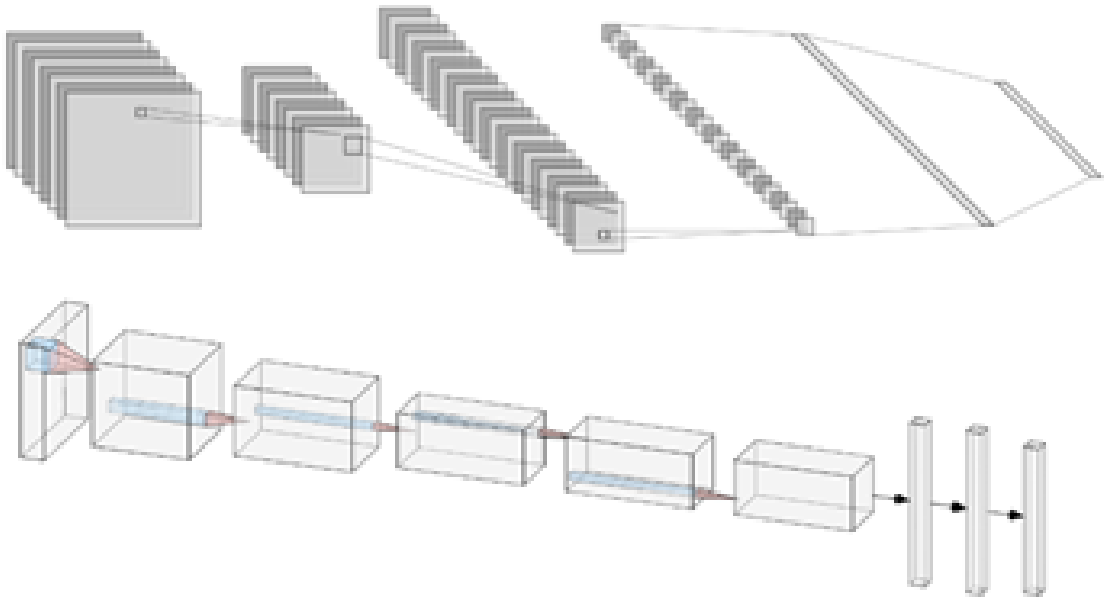


$$y = \sigma_N(W_N \cdots \sigma_2(W_2(\sigma_1(W_1 x))$$

- Repeated Matrix-vector multiplications and nonlinear operations.

(1) Artificial Neural Networks





Fully Connected NN, LeNet, and AlexNet architectures.

http://alexlenail.me/NN-SVG/

(2) Data Acquisition

TRILLION SENSORS IN 10 YEARS[1]

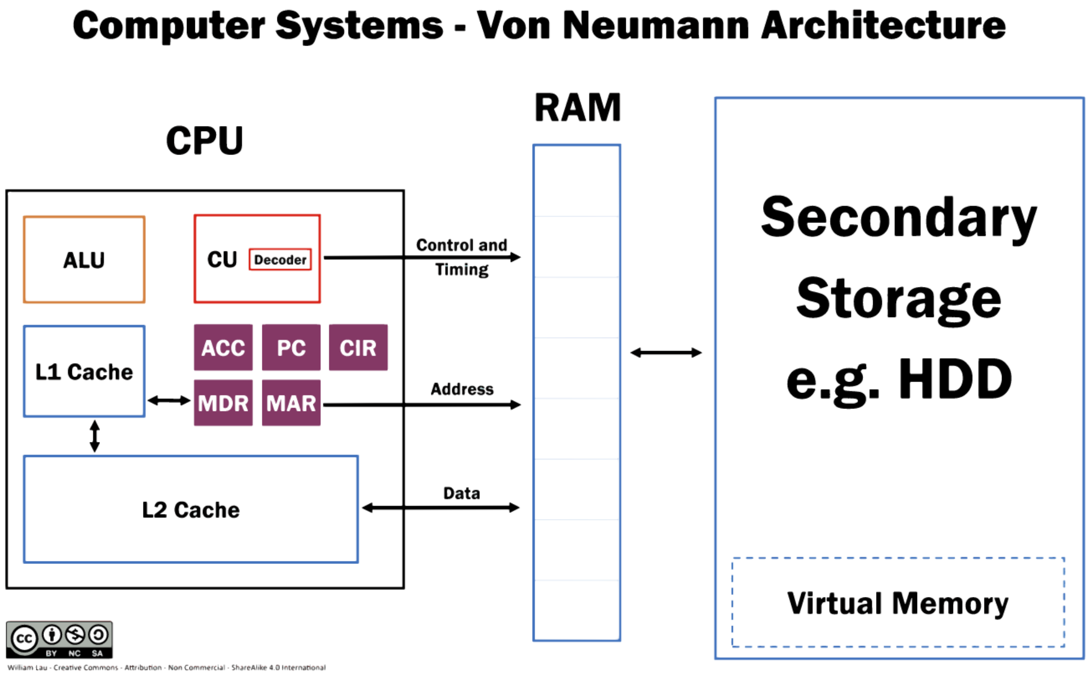
Year	Unit Price	Units Sold
2005	30.000	46,666,667
2010	15.000	466,666,667
2015	1.800	8,333,333,333
2020	0.216	138,888,888,889
2025	0.026	1,388,888,888,889

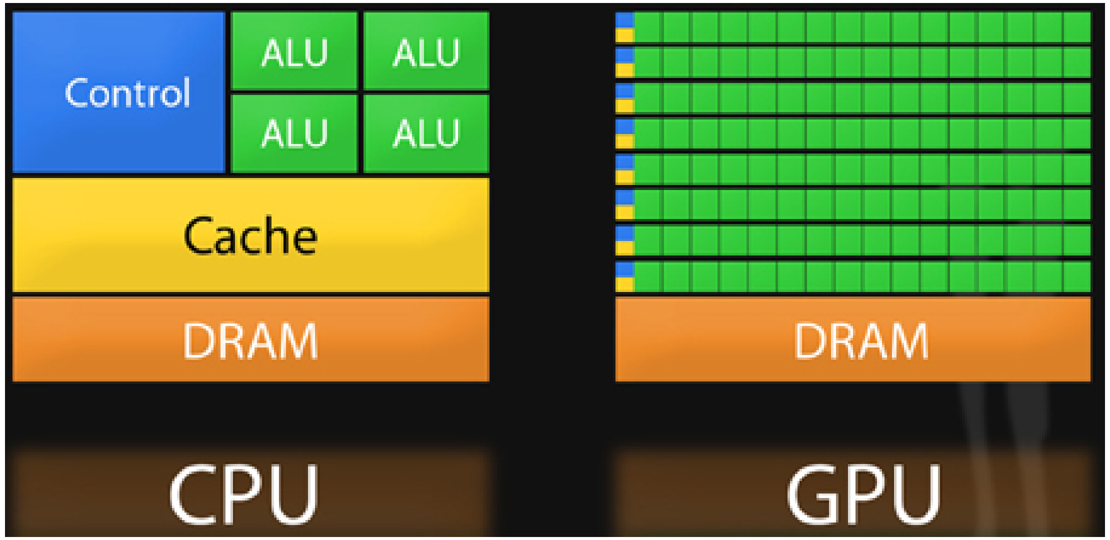
[1] Chris Wasden at 2014 MEMS executive congress

SkyTEM : Airborne electromagnetic surveys

What if you don't have many data? - Use your physics model (Physics-informed Learning).

(3) Hardware: Graphical Processing Unit (GPU)





- NN is *embarassingly* parallel.
- Bottleneck in CPUs: communication between computation (ALU) and memory (RAM/HDD/SSD).
- GPU is a specialized hardware for independent parallel computations.

https://nyu-cds.github.io/python-gpu/01-introduction/

(4) Public Domain Software: TensorFlow and PyTorch

TensorFlow is an open-source machine learning library for research and production. TensorFlow offers APIs for beginners and experts to develop for desktop, mobile, web, and cloud. See the sections below to get started.

Learn and use ML

The high-level Keras API provides building blocks to create and train deep learning models. Start with these beginner-friendly notebook examples, then read the TensorFlow Keras guide.

1. Basic classification
2. Text classification
3. Regression
4. Overfitting and underfitting
5. Save and load

Read the Keras guide

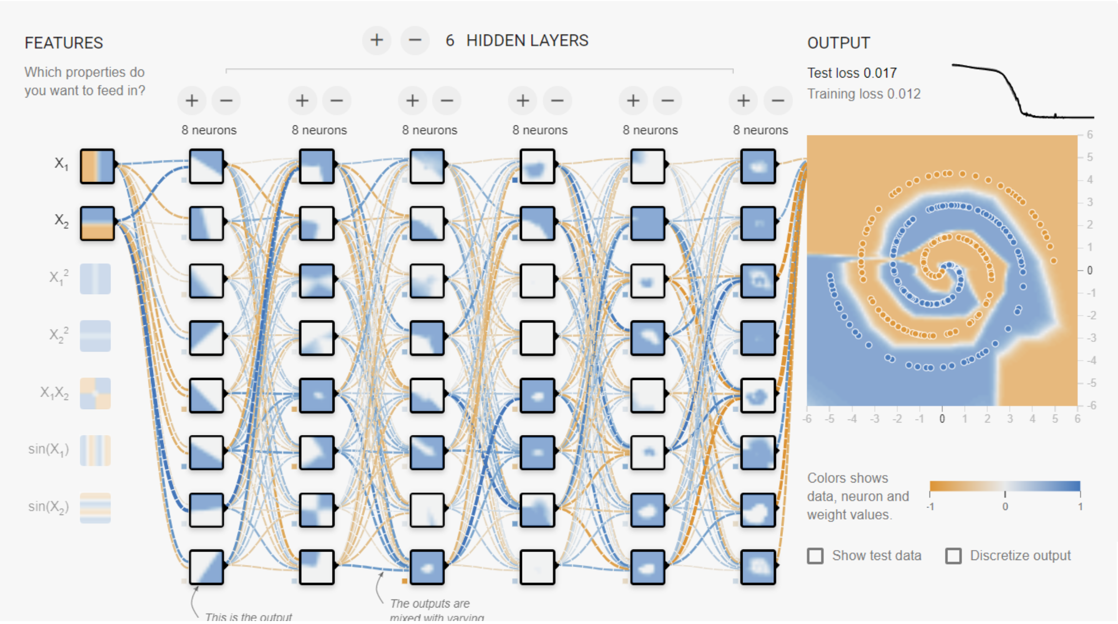
```
import tensorflow as tf
mnist = tf.keras.datasets.mnist

(x_train, y_train),(x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)
model.evaluate(x_test, y_test)
```

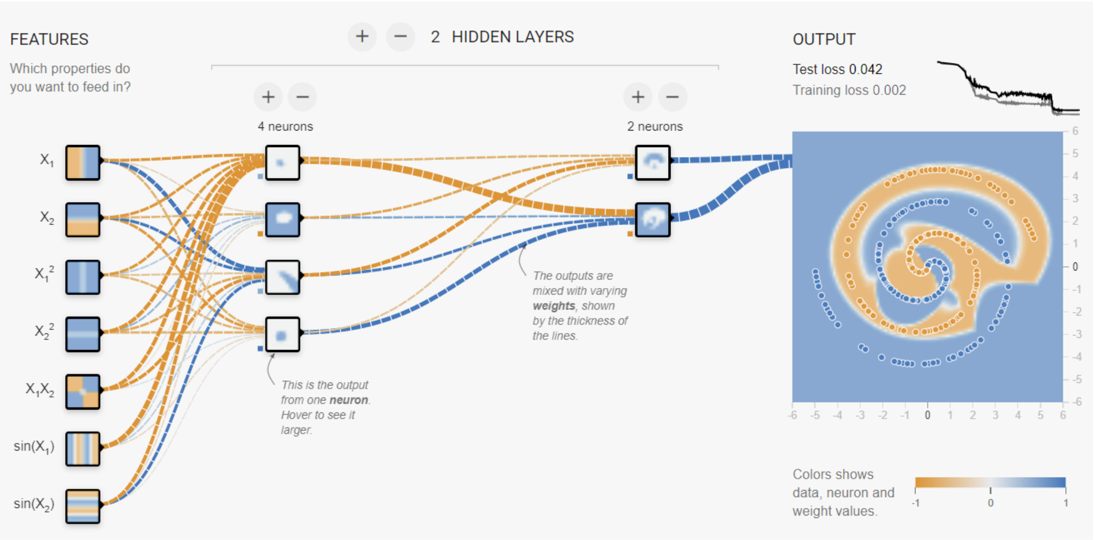
Run code now   Try in Google's interactive notebook

With ~10 line scripting you can do quite good classification tasks!

(https://www.tensorflow.org/tutorials)

Example: Classification/Regression

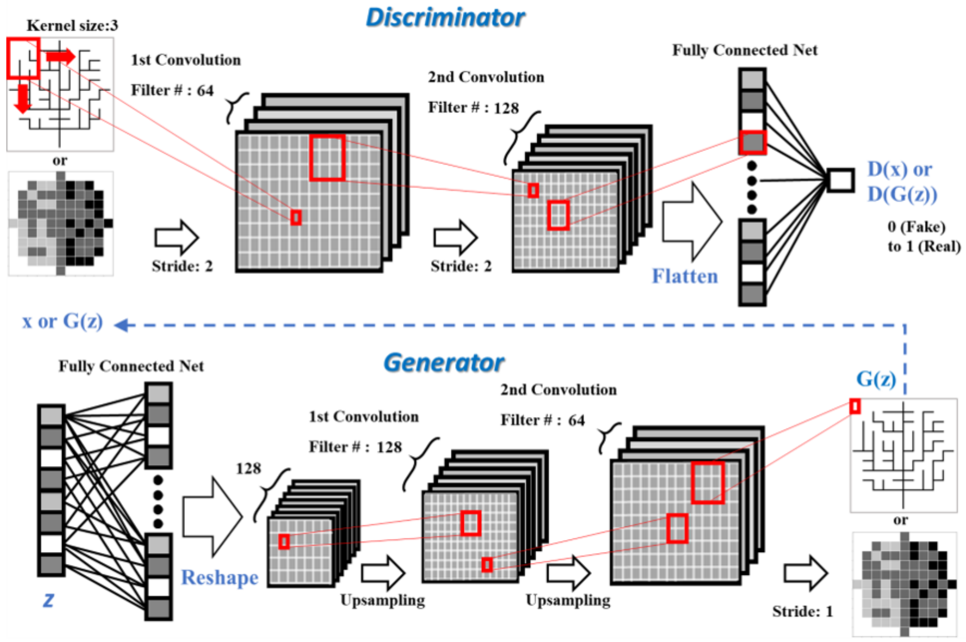




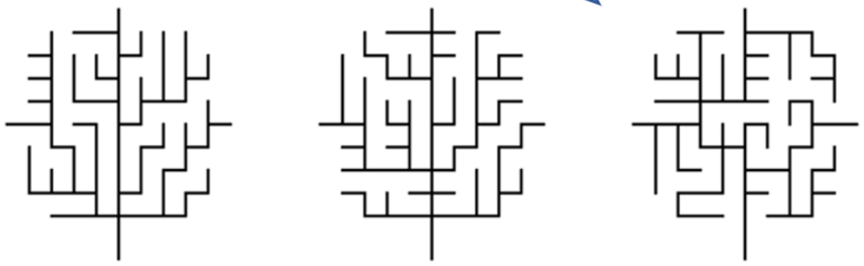
http://playground.tensorflow.org

Applications (1): Flood risk analysis

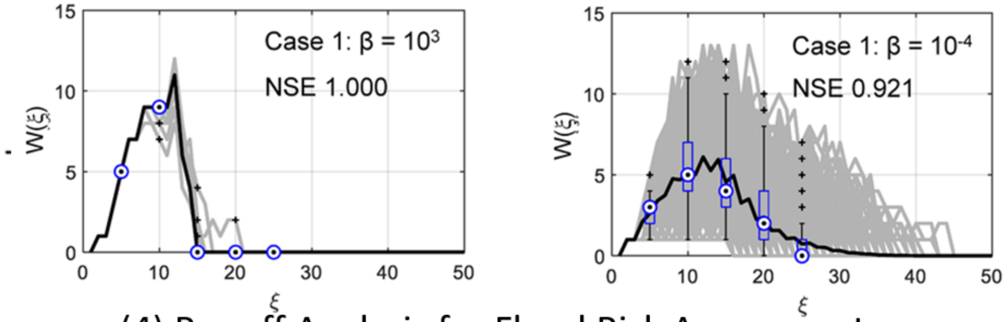
(1) Satellite and Map Data Acquisition



(2) Drainage Network Training using GANs



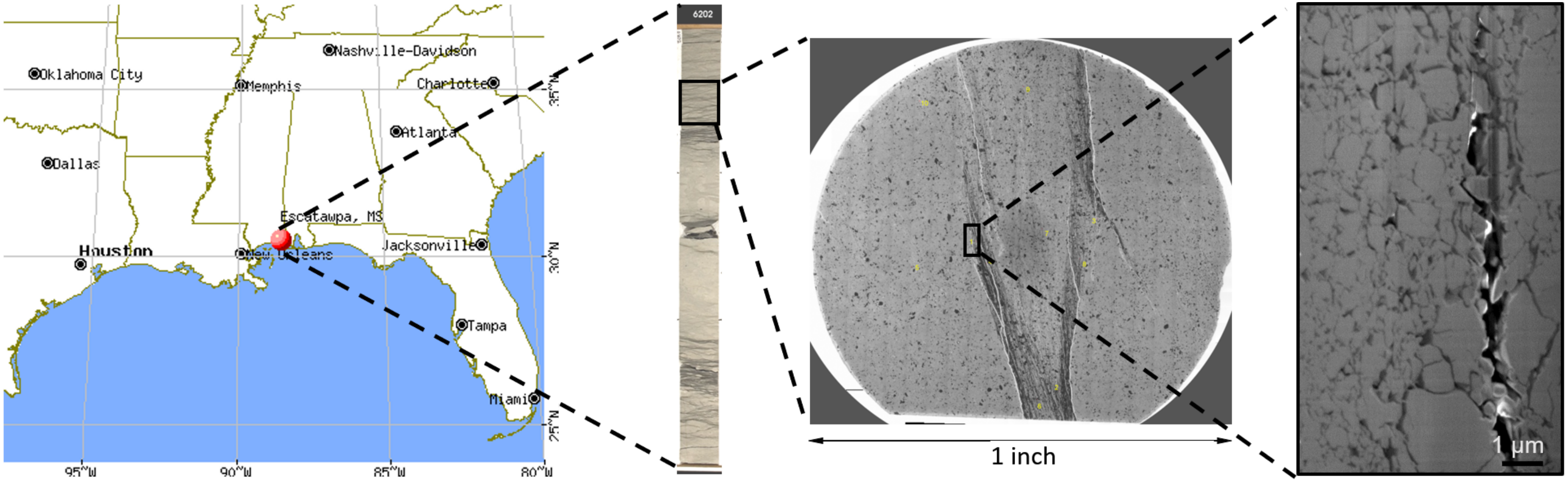
(3) Stochastic Generation of Drainage Network



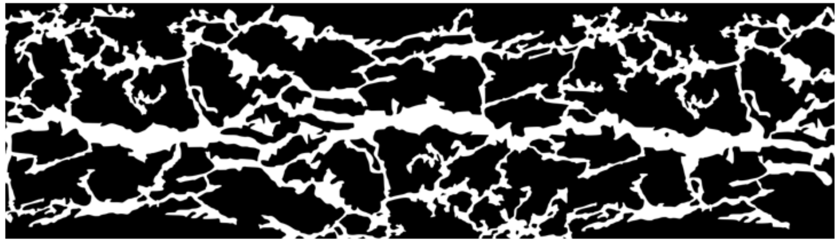
(4) Runoff Analysis for Flood Risk Assessment

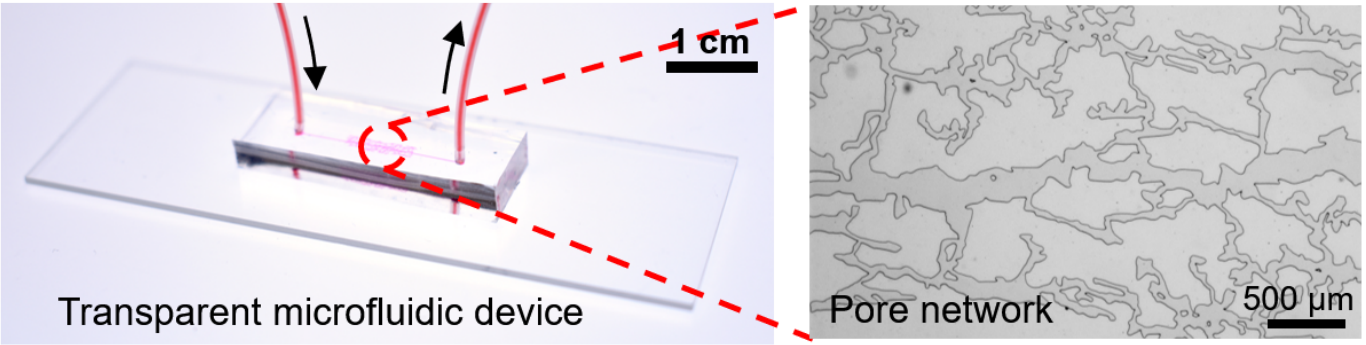
Kim et al., in review. Supported by Sandia National Labs

Applications (2): Earth material reconstruction



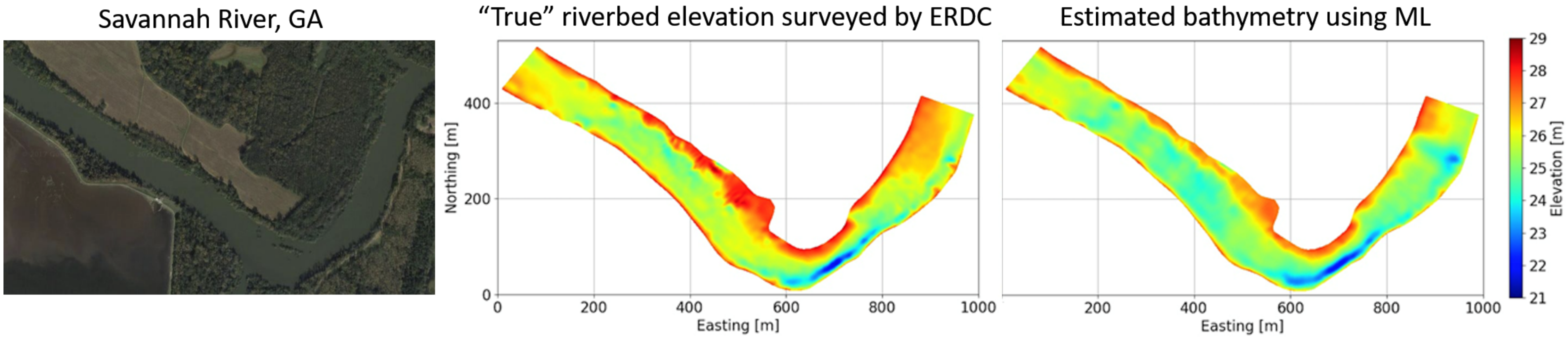
Reconstructed multi-scale porous material





Collaboration with Dr. Sangwoo Shin in Mech. Eng. Supported by Sandia National Labs

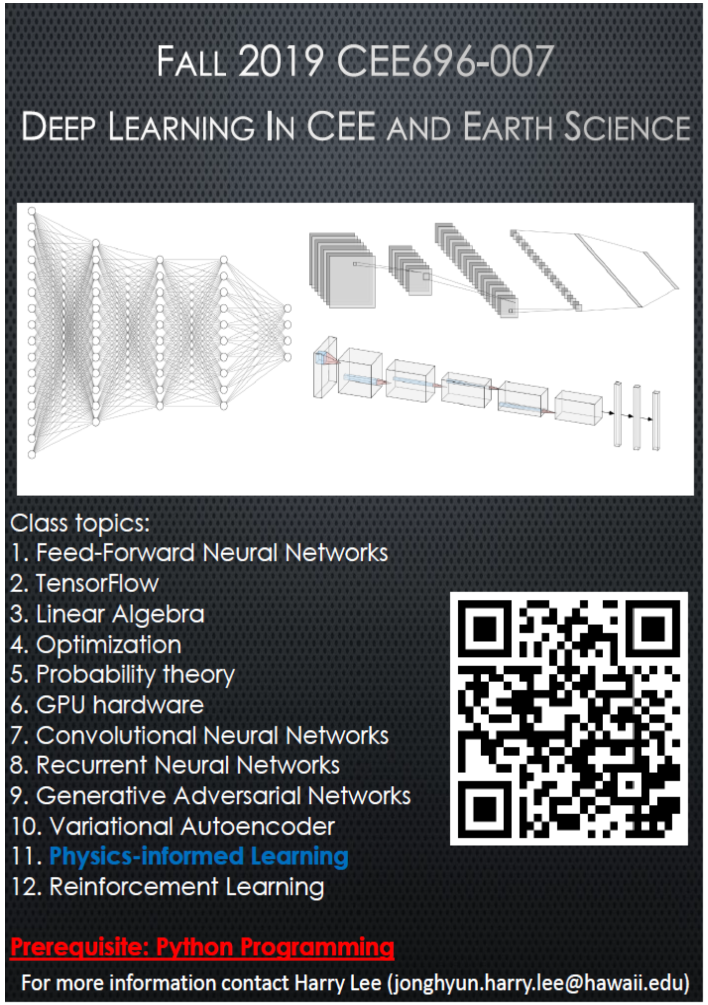
Applications (3): River/Nearshore bathymetry identification



Using river/ocean surface images from UAV/drones, can you identify river/nearshore bathymetry (elevation)? Yes!

and more: 1) data-driven subsurface imaging, 2) proxy model construction using VAE-RNN, 3) anomaly detection, 4) transfer learning, 5) combining PDE with NNs, ….

DL Course will be back in 2020!



CEE 696

- Home
- Lectures
- References
- Final Project

CEE 696: Deep Learning in Civil and Environmental Engineering and Eart

Fall Semester 2019

Schedule

Date	Topic	Reading	Action Items
08/27/2019 T	Intro/Preparation	materials	3B1B
08/29/2019 Th	Feedforward Neural Networks (1) - Architecture/Linear Algebra	materials	HW0 due
09/03/2019 T	Feedforward Neural Networks (2) - Backpropagation/Optimization (1)	materials	
09/05/2019 Th	Feedforward Neural Networks (3) - Backpropagation/Optimization (2)	materials	
09/10/2019 T	Feedforward Neural Networks (4) - Generalization and Validation/Statistical Learning (1)	materials	
09/12/2019 Th	Feedforward Neural Networks (5) - Generalization and Validation/Statistical Learning (2)	materials	
09/17/2019 T	No Class	materials	HW1 due
09/19/2019 Th	No Class	materials	
09/24/2019 T	Autoassociative NNs/History of Deep Learning	materials	HW2 due
09/26/2019 Th	Convolutional Neural Networks (1) - Architecture	materials	project meeting
10/01/2019 T	Convolutional Neural Networks (2) - Learning and Evaluation	materials	project meeting
10/03/2019 Th	Convolutional Neural Networks (3) - Understanding with Visualization	materials	project meeting
10/08/2019 T	Convolutional Neural Networks (4) - Applications	materials	
10/10/2019 Th	GPU Hardware	materials	Watch LeCun
10/15/2019 T	Recurrent Neural Networks (1) - Intro	materials	
10/17/2019 Th	Recurrent Neural Networks (2) - LSTMs	materials	
10/22/2019 T	Recurrent Neural Networks (3) - Applications	materials	
10/24/2019 Th	Autoencoders (1) - Intro/Dimension Reduction/Unsupervised Learning	materials	HW3 due
10/29/2019 T	Autoencoders (2) - Variational Encoding	materials	
10/31/2019 Th	Autoencoders (3) - Applications	materials	
11/05/2019 T	Reinforcement Learning	materials	
11/07/2019 Th	Mid-term		
11/12/2019 T	Generative Adversarial Networks (1) - Intro	materials	
11/14/2019 Th	Generative Adversarial Networks (2) - Applications	materials	
11/19/2019 T	Transfer Learning	materials	
11/21/2019 Th	Physics-informed Learning (1)	materials	
11/26/2019 T	Physics-informed Learning (2)	materials	

https://www2.hawaii.edu/~jonghyun/classes/F19/CEE696/schedule.html

Thank you!

Any Questions?