CSE 691
Machine Intelligence w. Deep Learning

Lecture 01: Introduction

General Information

- **Instructor**
  - Professor Qinru Qiu, Room CST 4-133,
  - Tel: (315)443-1836, email: qiqiu@syr.edu
  - Office Hours: Wednesday 10:00 am– 12:00 pm
    Thursday 2:00 ~ 3:30 pm
- **Class Location and Times**
  - CST 1-019
  - Tuesday & Thursday 12:30 pm ~ 1:50 pm
- **TA**
  - Ziyi Zhao
  - Office hours: TBD
  - Location: TBD
- **Acknowledgement**
  - This course is supported by Google Cloud Education Grant and Intel

Objectives

- Understand the basic training and inference techniques and performance criteria of a neural network
- Explain the structure and neuron functions in a deep convolutional neural network
- Implement the basic training and inference of a simple neural network in Python
- Implement a deep convolutional neural network in Intel Neon framework
- Explain the fundamentals of the GPU acceleration
- Understand the recent advances in deep learning and machine intelligence
- Get familiar with other types of neural networks such as LSTM, RBM, etc. (if time allows.)

Topics

- 1. Introductions
- 2. Classification problem, basic machine learning models
- 3. Training and inference techniques
- 4. Image classification problem
- 5. Python implementation of training and inference
- 6. Structure of deep convolutional neural networks (DCNN)
- 7. Neon
- 8. Using GPU to accelerate learning and inference
- 9. Other deep learning models beyond DCNN
- 10. Other interesting applications

Prerequisites

- Python, or C/C++ programming
- College calculus, linear algebra, comfortable with derivatives, matrix vector operations and notations
- Basic probability and statistics

Homework Assignments

- 5-6 homework assignments
  - Some of them will be team work, read the instruction carefully
- 1 final project
  - Research, coding, presentation….
- Only 1 exam
- Grading policy
  - Quizzes: 20%
  - Final Project: 20%
  - Homework: 25%
  - Midterm Exam: 30%
  - Others 5%

Policies

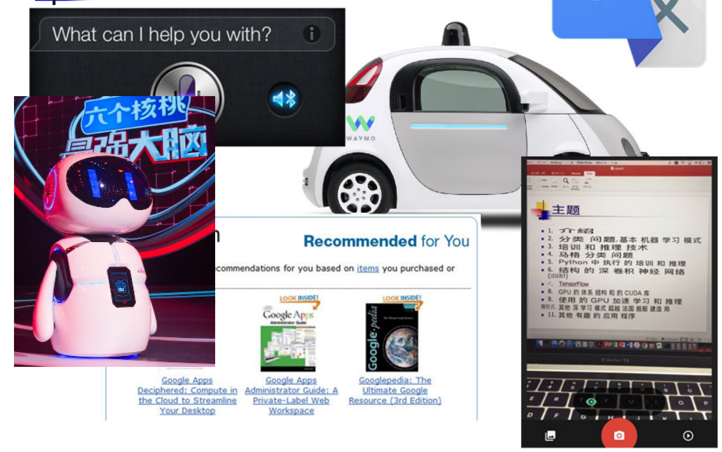
- Homework
  - Submit the correct file/design
  - Submit assignment in time
  - Late submission will have penalty
  - 10 points for each day of delay
- Pop up quizzes
  - By default open book/notes
  - Prepare a binder to keep all your notes and bring them with you to class
  - Discussion and exchange of notes are not allowed
  - A form of attendance check, 60 points for just writing down your name
- Exams
  - By default close book

Academic Honesty

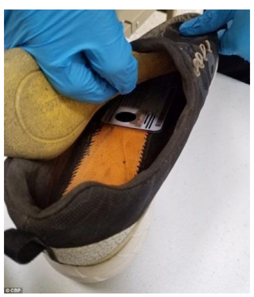
- Cheating in any form is not tolerated, nor is assisting another person to cheat.
- The submission of any work by a student is taken as a guarantee that the thoughts and expressions in it are the students own except when properly credited to another.
- Violations of this principle will result in a failing grade "F" and a letter of reprimand in your department student file.

Introduction

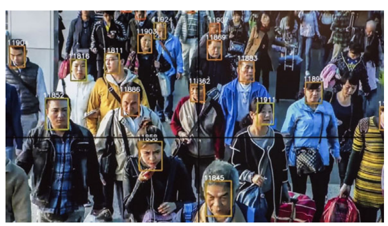
Machine Intelligence

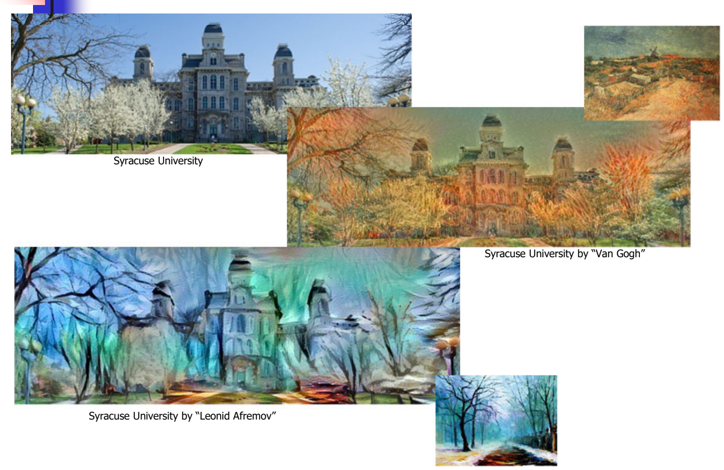


Customs officers use new facial recognition technology to bust a man trying to enter the US illegally on someone else's French passport



Facial recognition technology spots wanted man in crowd of 60,000 Chinese concert-goers





Syracuse University

Syracuse University by "Van Gogh"

Syracuse University by "Leonid Afremov"

DeepDream

Why Machine Learning

- Cognition, easy for human brain, hard for computers
  - Hard to program because we don't know how it works
  - Even if we do, the program will be very complicated
  - Need to consider all kinds of input, application environment, for a new task a new program must be written
- Human brain relies on memory and pattern matching
  - Learn from past experiences
  - Adapt to new environment and new tasks
- The machine learning approach
  - We collect a lot of examples that specify the correct output for a given input
  - A machine learning algorithm learns from these examples and produces a program (model) that does the job
    - If the learning is right, the program also works for new inputs that are not in the training set but share some similarity
    - For a new task, a new set of training data is needed and a new model will be learned

Machine Learning is Good At…

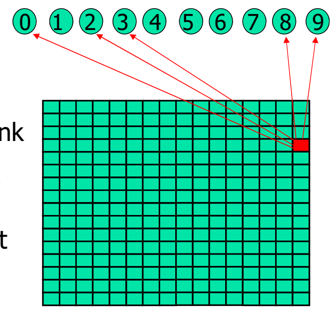
- Recognizing patterns
  - Objects in real scenes
  - Facial identifies or facial expressions
  - Spoken words
- Recognizing anomalies
  - Unusual sequences of credit card transactions
  - Unusual patterns of sensor readings in a nuclear power plant
- Prediction
  - Future stock prices or currency exchange rates
  - Which movies will a person like?

What Enables Machine Learning

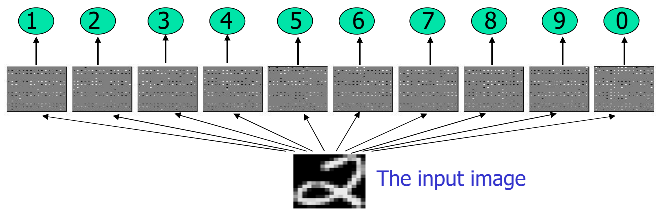
- Fast computers
  - GPU, TPU, BrainWave, …
    - NVIDIA Volta – 640 TensorCores, 100 TFLOPS
    - NVIDIA Titan X Pascal – 3840 Cuda core, 12 TFLOPS
    - Google TPU 2 – 256x256 8-bit MAC unit at 45 TFLOPS
- Abundant training data
  - ImageNet
    - Over ten million URLs of images have been hand-annotated to indicate objects; at least one million of the images, bounding boxes are also provided.
  - MS Coco
    - 328K Images of everyday scenes containing 91 types of common objects labeled using per-instance segmentations. With a total of 2.5 million labeled instances.
  - Flikr, Pascal VOC, etc.
- Better model and training techniques

An Example of Learning System

- A learning system to recognize hand written digits
  - A neural network with two layers of neurons.
  - Neurons in the top layer represent known shapes.
  - Neurons in the bottom layer represent pixel intensities.
  - A pixel gets to vote if it has ink on it.
  - Each inked pixel can vote for several different shapes.
  - The shape that gets the most votes wins.

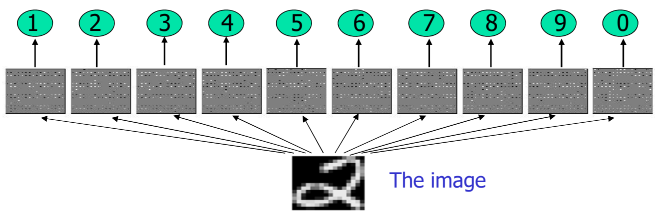


Map of the Weight

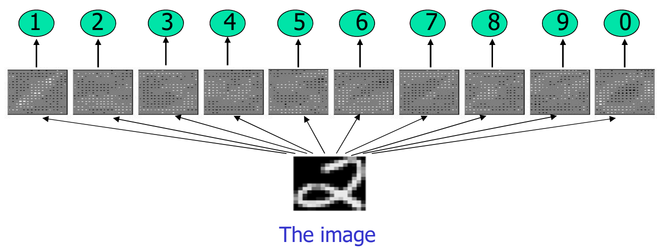


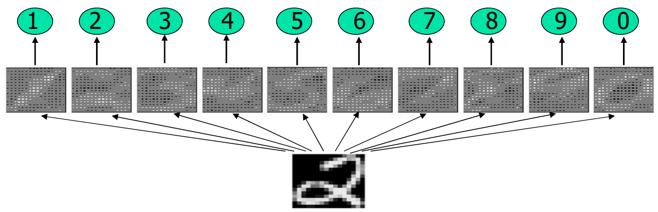
- Each output neuron has 16x16 weights, to scale the vote from 16x16 pixels
- Using grey scale to represent the magnitude and the color to represent the sign gives a 16x16 map of the weight
- The values of the weights are initially random

Weight Update

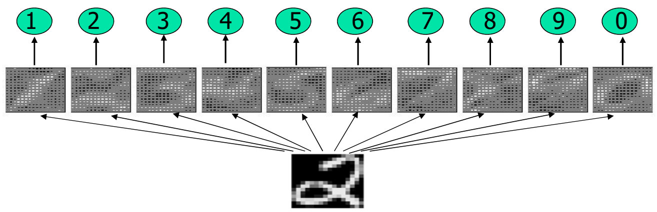


- Show the network an image and increment the weights from active pixels to the correct class.
- Then decrement the weights from active pixels to whatever class the network guesses (but not correct).

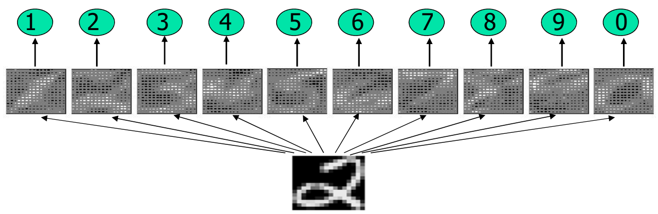




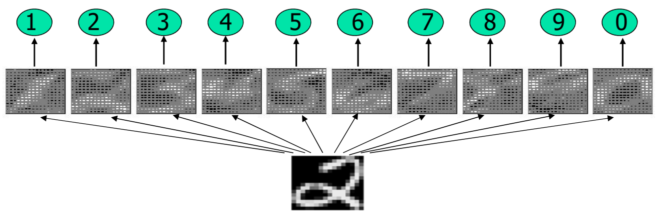
The image



The image

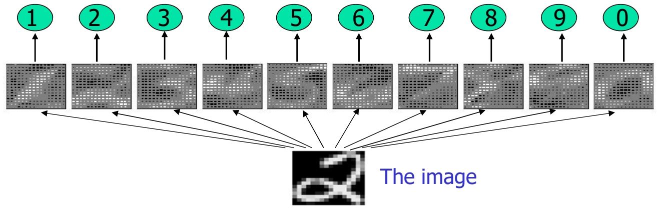


The image



The image

The Learned Weight



- A two layer network with a single winner in the top layer is equivalent to having a rigid template for each shape.
- The winner is the template that has the biggest overlap with the ink.
- This simple 2 layer template based system may not capture all possible variations of hand written digits
  - To capture all the allowable variations of a digit we need to learn the features that it is composed of.