[MIT 6.S094: Deep Learning for Self-Driving Cars](https://selfdrivingcars.mit.edu/" \o "MIT 6.S094: Deep Learning for Self-Driving Cars)

Lecture 1 Notes

* Why self-driving cars?
  + Quite possibly, the first wide reaching and profound integration of personal robots in society
    - Wide reaching: 1 billion cars on the road
    - Profound: Human give control of his/her life to robot
    - Personal: one on one relationship of communication, collaboration, understanding and trust
* We have to design systems that can transfer control to human when the system can’t handle a problem
* Artificial General Intelligence Course MIT 6.S029
* Artificial Intelligence
  + Machine Learning
    - Representation Learning
      * Deep Learning
        + Deep Learning is able to create hierarchical representations of the raw information to be able to do something interesting with it
        + Forming representations with data and its able to find structure within the data
* Think about the problem that we are trying to solve with a Cartesian Coordinates space and try to separate the points vs a polar coordinate space where you are trying to separate the points (This is representation learning aka feature learning)
  + The learning of the function that separates the points in the polar coordinate space is what we can achieve with deep learning
  + Deep Learning gets better with more data
* Neural Networks
  + We don’t know how human brains works but artificial neural networks use backpropagation to learn
  + The basic element, neuron, is incredibly simple but when you stack up these neurons, they are amazing approximators.
    - They can form feed forward neural networks
      * Computer vision
    - They can form Recurrent Neural Networks
      * Much closer to how our human brain works
  + Combining neurons in hidden layers
    - The ‘Emergent’ Power to approximate
    - Universality: For any arbitrary function f(x), there exists a neural network that closely approximate it for any input x
* Deep Learning Useful Term
  + Basic Terms
    - Deep Learning = Neural Networks
    - Deep Learning is a subset of Machine Learning
  + Terms for neural networks
    - MLP: Multilayer Perceptron
    - DNN: Deep Neural Networks
    - RNN: Recurrent Neural Networks
      * LSTM : Long-Short Term Memory
    - CNN: Convolutional Neural Networks
    - DBN : Deep Belief Networks
  + Neural Network Operations
    - Convolution
    - Pooling
    - Activation Function
    - Backpropagation
* Activation Functions
  + Sigmoid
    - Vanishing gradients
    - Not zero centered
  + Tanh
    - Vanishing gradients
  + Relu
    - Not zero centered but it doesn’t suffer from vanishing gradients
* Backpropagation
  + Update weights and biases to decrease loss function
    - Process is modular so for each individual neuron

1. Forward pass to compute network output and ‘error’
2. Backward pass to compute gradients
3. A fraction of the weights gradient is subtracted from the weight (Learning rate)

* Use stochastic gradient
* Optimization is hard
  + Vanishing gradients
  + Dying ReLU’s
    - Large parts of your network could be dead ReLU’ s
  + Saddle Points
    - Hard to break symmetry
    - Vanilla SGD gets you there but is extremely slow
  + Overfitting
    - Regularization
      * Traditional to validation set in order to handle the computational complexity of training neural networks
      * Dropout
        + Randomly remove some nodes in the network
      * Weight Penalty
        + L2 Penalty
        + L1 Penalty
    - Check playground.tensorflow.org to play around
  + Pose variability, occlusion
* Object Classification
  + Taken an image and classify the most import class int hat image
* Current Challenges in Deep Learning
  + Transfer Learning
    - Unable to transfer representation to most reasonably related domains except in specialized formulations
  + Require big data: inefficient at learning from data
  + Requires supervised data: costly to annotate real-world data
  + Not fully annotated: Needs hyperparameter tuning
  + Reward: Defining a good reward function is difficult
  + Transparency: Neural networks are for the most part black boxes even with tools that visualize various aspects of their operations
  + Edge cases: Deep Learning is not good at dealing with edge cases