Introduction

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Outline

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- Me
- Class
- Logistics
- Expectations
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Motivation

Motivation

- Welcome to the special topics in computer science convolutional neural networks course
- The goal of this lecture is to create a framework for understanding the design of the whole class and how the semester will progress
- So this introduction lecture will be a little different than the normal lectures (next class we'll start the more traditional lecture format)
  - More words
  - More stories
  - Less math

Me

Basic Info

- Grew up a little south of Richmond, Virginia
- BS in EE from University of Virginia
  - Started in chemical engineering
  - Moved to electrical engineering
  - Specialized in signal processing
- PhD in ECE from Georgia Tech
  - Thesis on Volterra systems, nonlinear generalization of convolution

Basic Info

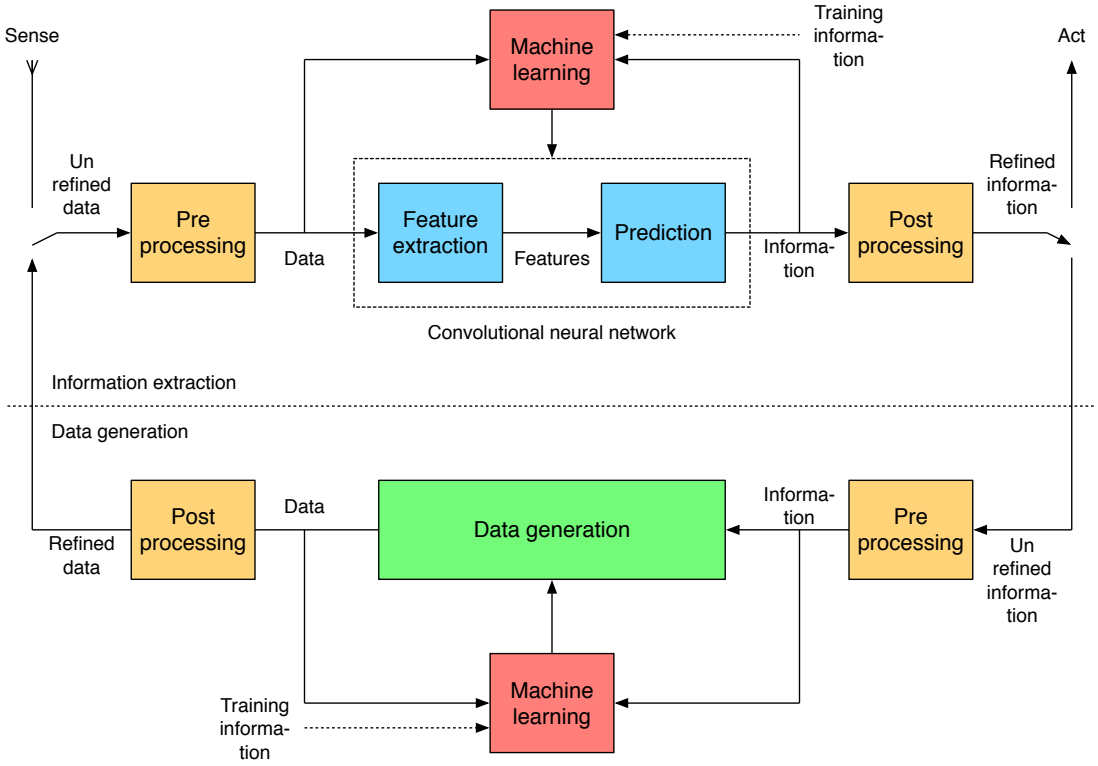
- Moved to Dallas, Texas to work at Texas Instruments
  - Physical layer communication system design
  - Signal processing for analog systems
  - Machine learning
- Currently I manage a machine learning lab in the TI Embedded Processors organization
  - Work on algorithms, software and hardware for different applications
  - This class will cover much of the same (that's not an accident)
- Live in Plano, Texas

Class

Official Objectives

- Ability to understand, design and train convolutional neural networks
- Ability to create software for mapping convolutional neural network designs to hardware
- Ability to specify hardware for convolutional neural network optimized data movement and compute
- Ability to evaluate convolutional neural network performance
- Ability to apply convolutional neural networks to applications including vision, speech, language and games

Theory And Application



Problem 1: Information Extraction

- Transformation from un refined data space to data space to feature space to information space to refined information space

- Pre processing
  - Make feature extraction easier
  - Data cleaning, dimensionality reduction, …
  - Frequently uses application specific side information

- Feature extraction
  - Make prediction easier
  - Hand engineered or learned

Information Extraction

- Prediction
  - Classification (discrete)
  - Regression (continuous)

- Post processing
  - Clean up predictions
  - Frequently uses application specific side information

Definitions (Not Webster Quality)

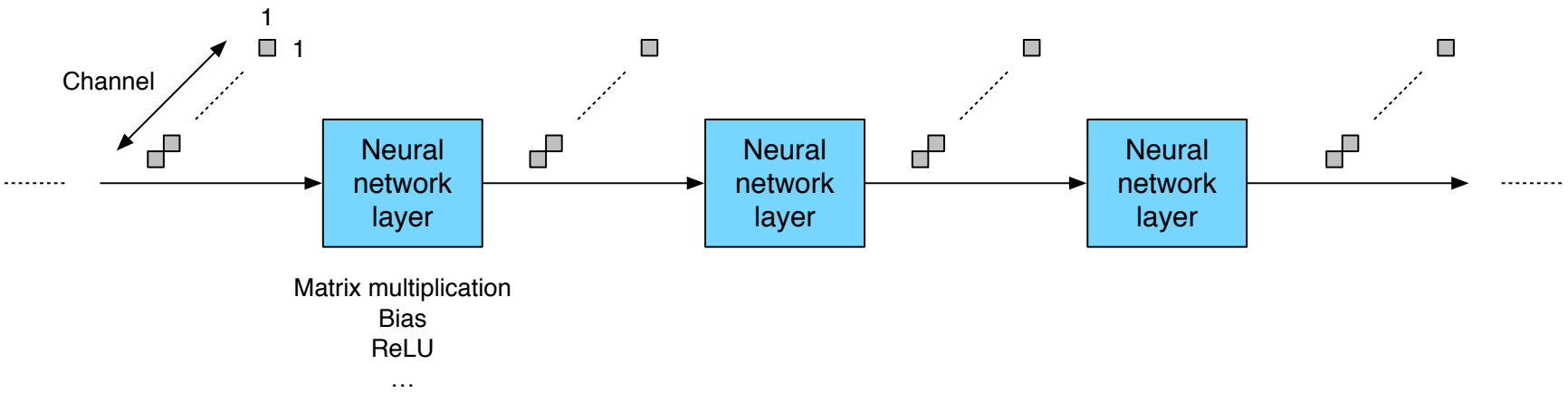
- Intelligence is the ability to acquire and apply knowledge
  - Artificial intelligence is intelligence exhibited by algorithms

- Learning is the acquisition of knowledge from experience
  - Machine learning is learning from data (experience) applied to an algorithm such that it exhibits artificial intelligence
  - Deep learning is machine learning applied to a deep structure

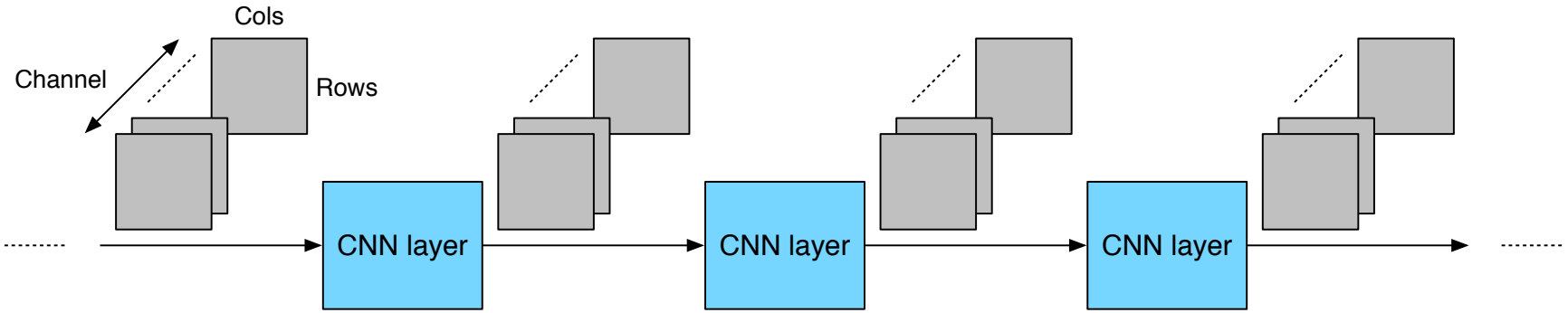
How CNNs Fit In

- CNNs are deep structures trained using deep learning to exhibit artificial intelligence
  - Perform both feature extraction and prediction
- This semester we'll look at design and training CNNs
  - Tail body head approach to design
  - Supervised learning using back propagation and a variant of stochastic gradient descent for training
- Neural networks are universal approximators
  - Can work on all sorts of problems

Generic Neural Network Fragment



Generic CNN Fragment



CNN style 2D convolution
Pooling
Matrix multiplication
Bias
ReLU
…

Why

- Why now
  - Data
  - Compute
  - Better network designs
  - Better training algorithms
  - Snowball of success

- Why this is important in practice
  - Instrumentation of everything (objects, people, spaces)
  - Analysis of data, decision optimization and heuristic replacement
  - Successful applications
  - Vision, speech, language, games, ...

Problem 2: Data Generation

- Mapping of information to data
  - Not the typical focus of a machine learning class (this class is no exception)
  - But we'll talk about it a little
  - Examples: labels to images, words to sounds, …

- Data generation problems are the complement of information extraction problems
  - Can be used as an alternative input to information extraction
  - Synthetic vs natural options
  - Synthetic is helpful when natural is difficult
  - Can use CNNs as a component of data generation

Background And Implementation

- So far
  - What we've talked about will be discussed in the (2) theory and (4) application parts of the course
  - 2 other key parts of the course are (1) background and (3) implementation

Background And Implementation

- How background applies to information extraction and data generation
  - Linear algebra
    - CNN style 2D convolution
    - Fully connected layers
    - Computation strategies later used in hardware, ...
  - Calculus
    - Back propagation and weight update for training
    - Limits and strategy for universal approximation, ...
  - Probability
    - Training extracts knowledge (information) from the training set, testing extracts information from the input given past knowledge (information) extracted from training
    - Initializing coefficients, batch norm, comparing output pdf to target pdf
    - Pdf of the output of a FFT or matrix multiplication, compression, ...

Background And Implementation

- How implementation applies to information extraction and data generation
  - Software
    - High level application specification
    - Low level software runtime
    - Bridge between network specification and hardware implementation
  - Hardware
    - Memory, data movement and compute to run the software that runs the network
    - We'll consider the co design of software and hardware using a low level graph framework to unite them both

This Class In Context

- Not comprehensive of all convolutional neural network information
  - What is presented in lecture is less than what is in the references
  - What is in the references is less than all information on the topic
- A role of a professor is a guide through information and I'll attempt to provide that in this class
  - But realize that there's a lot more useful information out there that could later be critical to you depending on the specifics of your interests
- So an unofficial goal of this class (perhaps more important than any of the official goals) is to help you learn how to learn in this field

Logistics

Grades

- 4 parts of the semester
  - Background
  - Theory
  - Implementation
  - Application

- 4 components of the grade (no final)
  - 25% background and theory test
  - 25% implementation tool
  - 25% project
  - 25% homework

Background And Theory Test

- Covers
  - Background: linear algebra, calculus and probability
  - Theory: machine learning and convolutional neural networks
- Format
  - In class closed book
  - Pencil and paper only
- Goals
  - Make sure that key concepts are well understood from each chapter

Implementation Tool

- Tools are critical to making practical progress in CNNs

- Examples of tools
  - High level network design
    - Creating networks from building blocks
    - Visualization
  - High level network training
    - Monitoring and optimization
    - Transformation
    - Quantization
  - Low level graph software runtime
    - High level to low level mapping and compilation
    - Performance prediction

Implementation Tool

- Format
  - Designed to complement the implementation part
  - Basic idea is to create a tool and also give a quick ~ 1 min demo in class
  - Details closer to time

Project

- Can be on anything related to the class
  - Theory, implementation or application
- Requirements
  - I approve
- Sources
  - Ideas I provide (I'll give many)
  - Ideas related to your thesis work
  - Ideas related to your hobbies
  - Ideas out of nowhere you find interesting

Project

- Format
  - Work in groups of 1 – 3 (average size 2 for ~ 30 projects)
  - 4 min presentation / demonstration ((4 + 1) x 30 = 150 min so we'll use ~ 2.5 classes at the end)

- Expectations
  - Make it meaningful
  - I want to be impressed

Homework

- Basic strategy is to assign on Wed, due the following Wed
  - Most weeks

- Goal is to make it useful for understanding but not tedious
  - Some overlap of key ideas in class that need quiet time and thought
  - Some new ideas not covered in class
  - Some fun (reading, videos / movies)

Practice And Review Lectures

- I want people to get setup as early as possible with a high level framework
  - Pick 1 (I don't care): PyTorch, TensorFlow, Caffe, …

- More uses of these lectures
  - Review previous material
  - Brainstorm ideas for projects etc.

Class Web Site

- GitHub: https://github.com/arthurredfern/UT-Dallas-CS-6301-CNNs
  - Syllabus — Course syllabus, will update plan as necessary
  - Lectures — Post after class
  - References — Book (early draft form, also see references), links to others
  - Homework — (Usually) post on Wed due next Wed
  - Tests — Will eventually contain theory test
  - Tools — Will eventually contain implementation tool information
  - Projects — Will eventually contain project information
  - Code — Update as necessary

Expectations

Of Me

- My best every class
- My opinions
  - It’s a special topics class
- I speak to adults like adults
  - It's a grad class
  - I want to be precise
  - But I don't want to make things unnecessarily complicated

Of Me

- A logically laid out plan for both the whole course and individual lectures
- A willingness to modify the plan as needed
  - It's a new class
- I don't have perfect knowledge with respect to how long different topics will take
  - If I go short in a lecture we'll figure out a way to make use of the extra time
  - If I run out of time in a lecture we'll make it up in the next lecture or have reading for homework (implementation and applications parts lengths are flexible)

Of Me

- I don't have perfect knowledge of what you do and don't know
  - The course covers a lot
  - It's unlikely that you have a perfect background in everything
  - That's ok
  - Part of the purpose of the course will be to fill in those gaps
  - I'll help via the structuring of the material

Of Students

- Honesty
  - In your work
  - In your interactions with other students
  - In your interactions with me
- Hard work
  - Nothing meaningful in life is easy
  - This won't be an exception
- Correct me if I'm wrong
  - Politely

Of Students

- Friendly environment
  - Great to shine as an individual through individual accomplishments
  - Great to shine by helping others shine
    - Characteristic of a leader
- Be engaged
  - Ask questions freely
- I would like to learn everyone's name
  - Help me out and say it when you ask a question

Questions