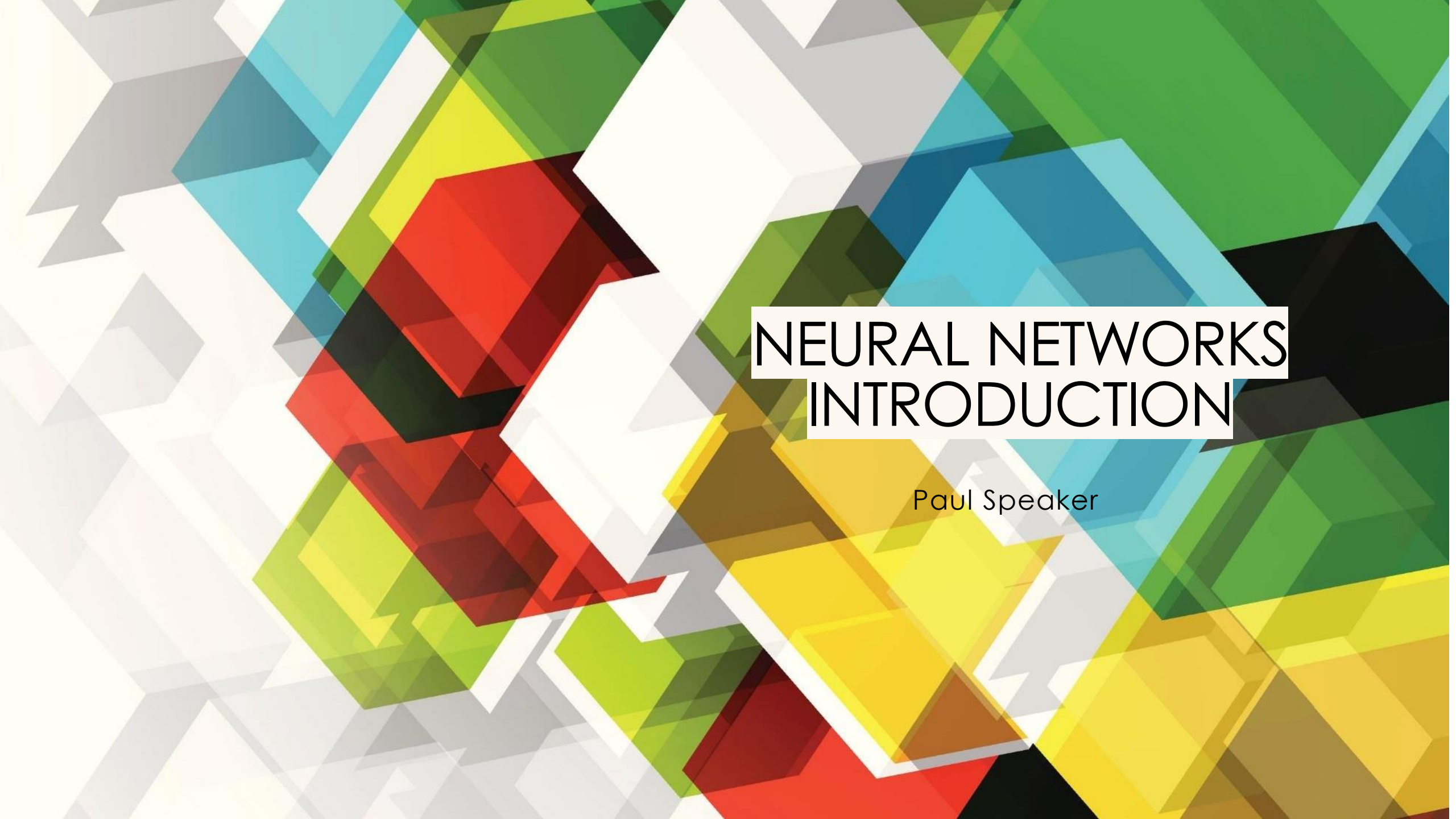

NEURAL NETWORKS
INTRODUCTION
Paul Speaker

Convolutional Neural Networks

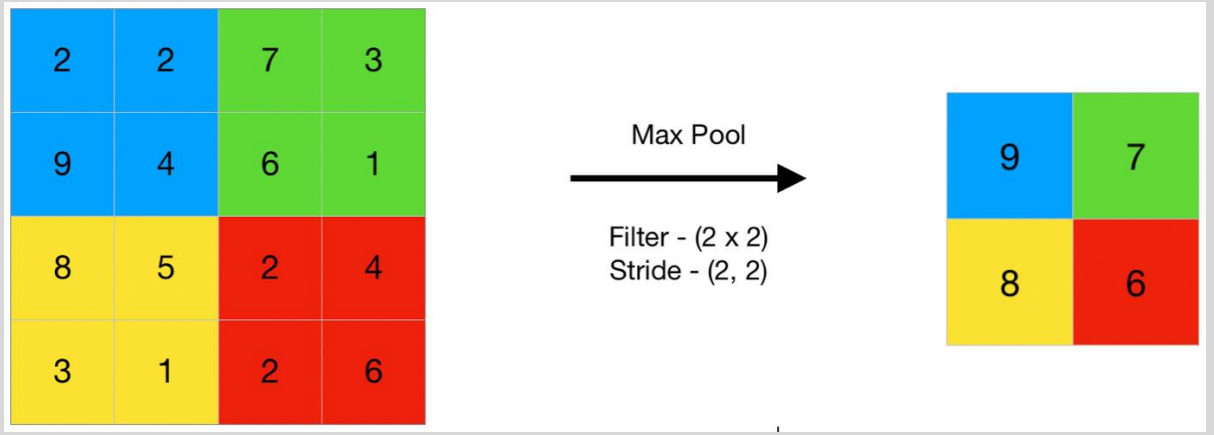
- Convolutional Neural Networks (CNN's) are the most common type of neural networks used in deep learning
  - Recurrent Neural Networks are catching up though!
- Oldest form for deep learning (over 20 years old)
- Efficient way to capture features in image processing
- Original purpose: automatic check processing
  - Digit recognition
- Now used for image identification in general with more levels of target
- Lots of ongoing research

The Convolution in CNN's

- Convolution is a general process which involves a combination of data across domains
- Example: take a sequence of data: 1, 3, 5, 2, 3, 6, 6, 10, 4, 6
- Some convolutions of this one dimensional data
  - Moving average: taking average of last, current, and next:
    - 3, 3.3, 3.3, 3.7, 5, 7.3, 6.7, 6.7
    - In image resolution, this is called **blurring**
  - **Sharpening**: $x_n' = -1x_{n-1} + 4x_n - x_{n+1}$
- Other types of convolutions can find edges in images or other types of features
- The above example is 1-dimensional, but can carry over to 2-dimensional images
- Color can add further features for the data

Pooling for Images

- Pooling is another common way of feature extraction for images
- Method of dimension reduction
- Steps in pooling:
  - Pool Pixels into grid
  - Make calculation for each grid
    - Max Pooling
    - Average Pooling
- Filter = size of grid
- Stride Length = shift in data on grid

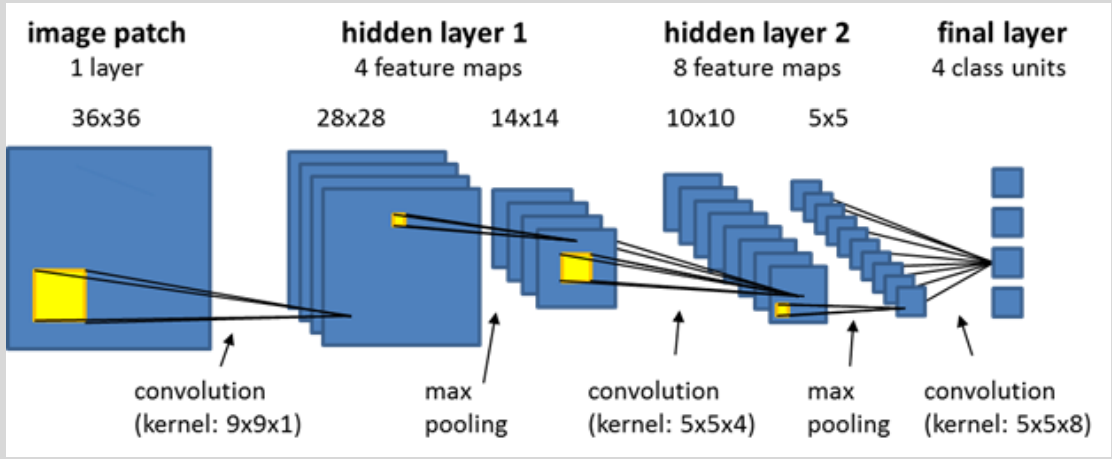


Data Augmentation for Image Recognition

- There are some simple transformations that can make the dataset richer for modeling with CNN's
  - Artificially increasing the dataset size so that models are better
- Suppose we have dataset which contains labeled targets (such as images of digits, where target has 10 levels: 0-9). We can
  - Translate the digits (move up/down/left/right)
  - Expand/shrink the digits
  - Rotate the digits
  - Any combination of the above
- The transformed data can be added to the original dataset for a larger set of data
  - Adding data to make modeling better is called **data augmentation**

Structure of Modeling with CNN

- Steps
  - Convolution
  - Pooling
  - Neural Network
- Convolution and Pooling are described as layers
  - no fitting happens in these layers
- Often are multiple layers at each level
- Hidden layers in neural network are usually fully connected
  - ReLU is most common activation function



Regularization in Neural Networks

- Our structure has a crazy number of parameters
- We will need to clamp down on parameter explosion by regularization process
- Types of regularization for neural networks
  - Penalty regularization
    - Penalize for parameter sizes
    - Can be L_1 or L_2 just like with lasso/ridge regression
  - Dropout regularization
    - A random set of nodes are "turned off"
    - The dropout rate is a hyperparameter which gives the probability of any individual neuron to be turned off

Convolutional Neural Networks in R

- We will use keras for processing CNN's
- Lots of things to do in keras
- Let's jump straight to sample code