Neural Network Regularization
Data Augmentation and Dropout

CS109B Data Science 2

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Outline

Regularization of NN

- Norm Penalties
- Early Stopping
- **Data Augmentation**
- Dropout

Keys

Using the functional API

DataGenerator

Custom Loss

Custom Layer

Gradient Tape

TF Data

TF Records


When you move on to Deep Learning
Thanks guys
@datascienceinfo
Decision Tree
Linear Regression
K-Means
SVM
Random Forest
Naive Bayes
kNN
Logistic Regression
XGBoost
So long, partner

Data Augmentation

Data Augmentation: dos and don'ts

We use ImageDataGenerator to augment the dataset

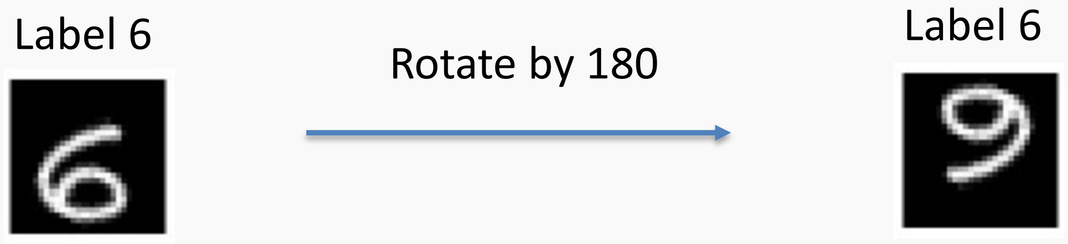
```
def get_generator():
    # create duplicate images
    BATCHES_PER_EPOCH = 300//BATCH_SIZE
    classes = ['pavlos', 'not-pavlos']
    for img_class in classes:
        img = Image.open((f'{DATA_DIR}/{img_class}.jpeg'))
        for i in range(1, BATCH_SIZE*BATCHES_PER_EPOCH//2+1):
            img.thumbnail(TARGET_SIZE, Image.ANTIALIAS)
            img.save(f'{DATA_DIR}/{img_class}/{img_class}{i:0>3}.jpeg', "JPEG")

    data_gen = ImageDataGenerator(
            rescale=1./255,
            height_shift_range=0.5,
            width_shift_range=0.5)

    img_generator = data_gen.flow_from_directory(
            DATA_DIR,
            target_size=(TARGET_SIZE),
            batch_size=BATCH_SIZE,
            classes=classes,
            class_mode='binary')
    return img_generator
```

Data Augmentation: dos and don'ts

Carefully choose your transformations. Not all transformations are valid.



Data Augmentation does not work for tabular data and not as nicely for time series.

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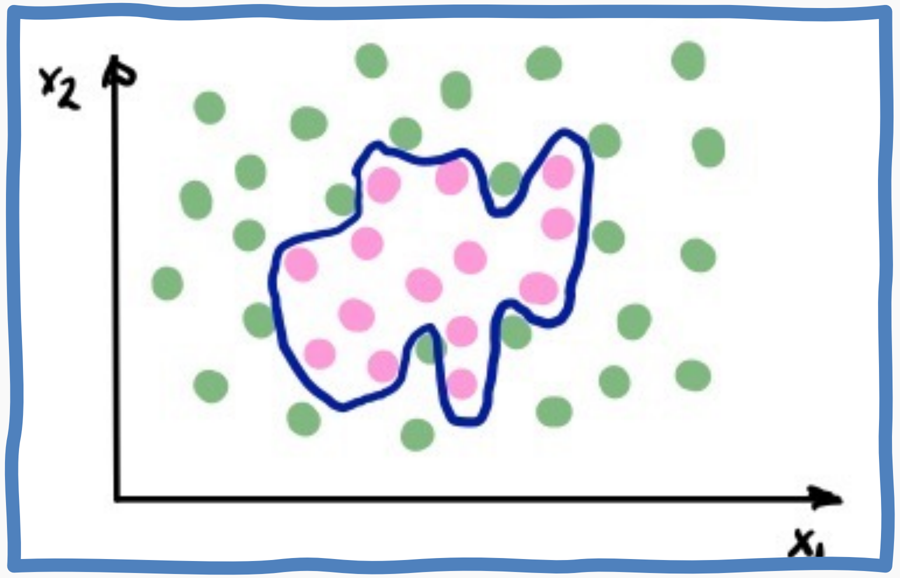
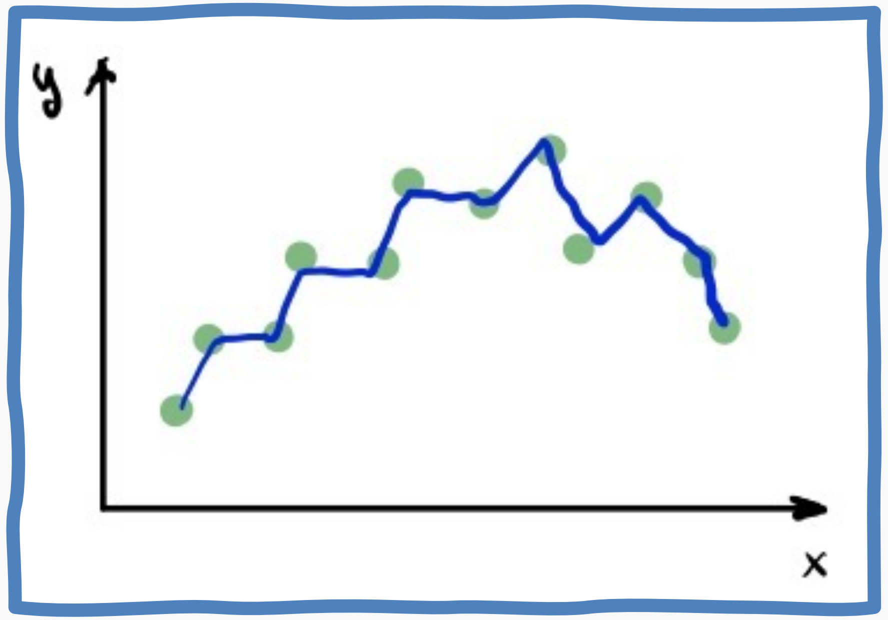
Co-adaptation

Overfitting occurs when the model is sensitive to slight variations on the input and therefore it fits the noise.

L1 and L2 regularizations 'shrink' the weights to avoid this problem.

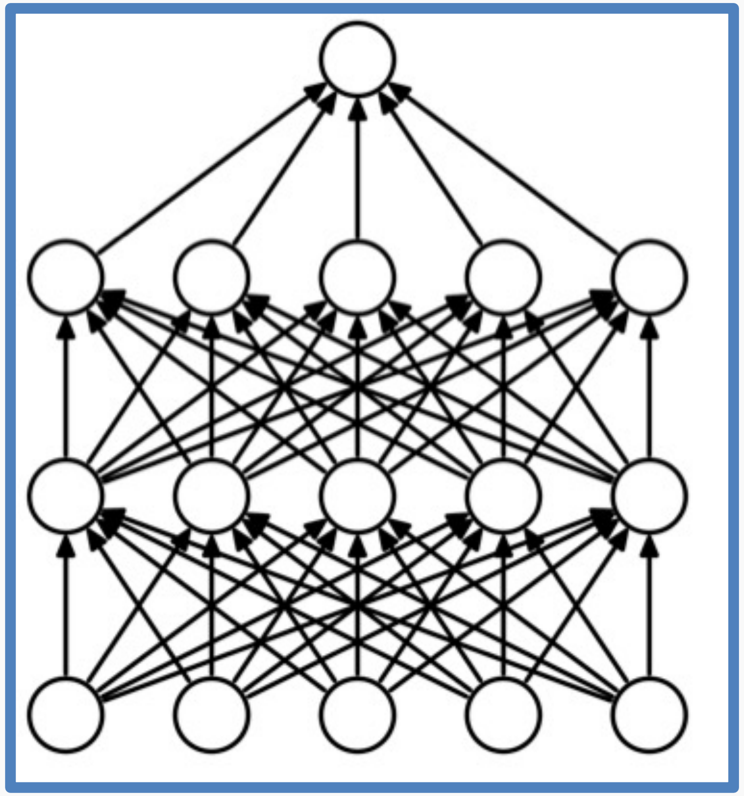
However in a large network many units can collaborate to respond to the input while the weights can remain relatively small. This is called co-adaptation.



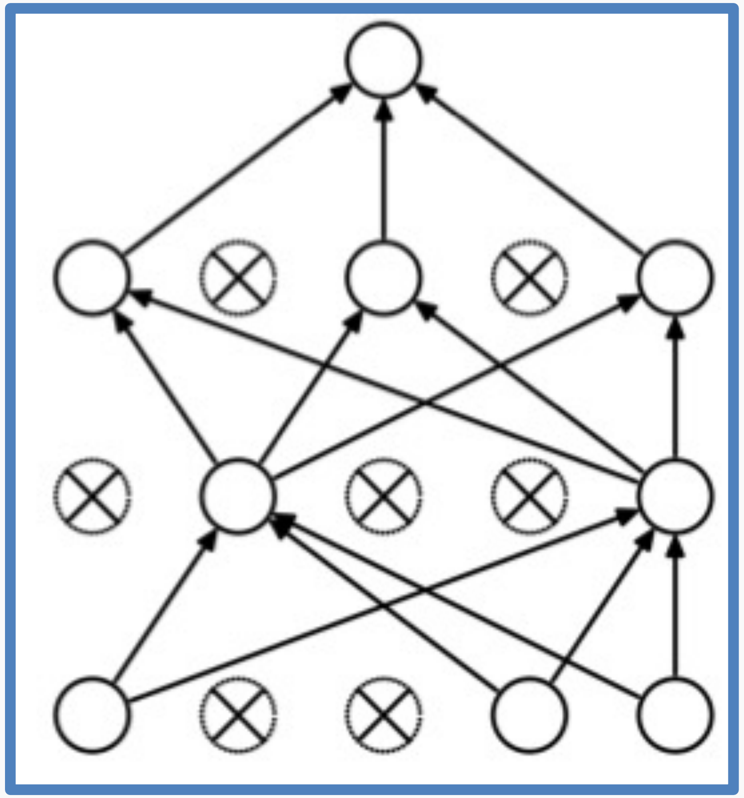


Dropout

- Randomly set some neurons and their connections to zero (i.e. “dropped”)
- Prevent overfitting by reducing co-adaptation of neurons
- Like training many random sub-networks



Standard Neural Network



After applying dropout

https://arxiv.org/pdf/1207.0580.pdf

Dropout: Training

For each new example in a mini-batch (could be for one mini-batch depending on the implementation):

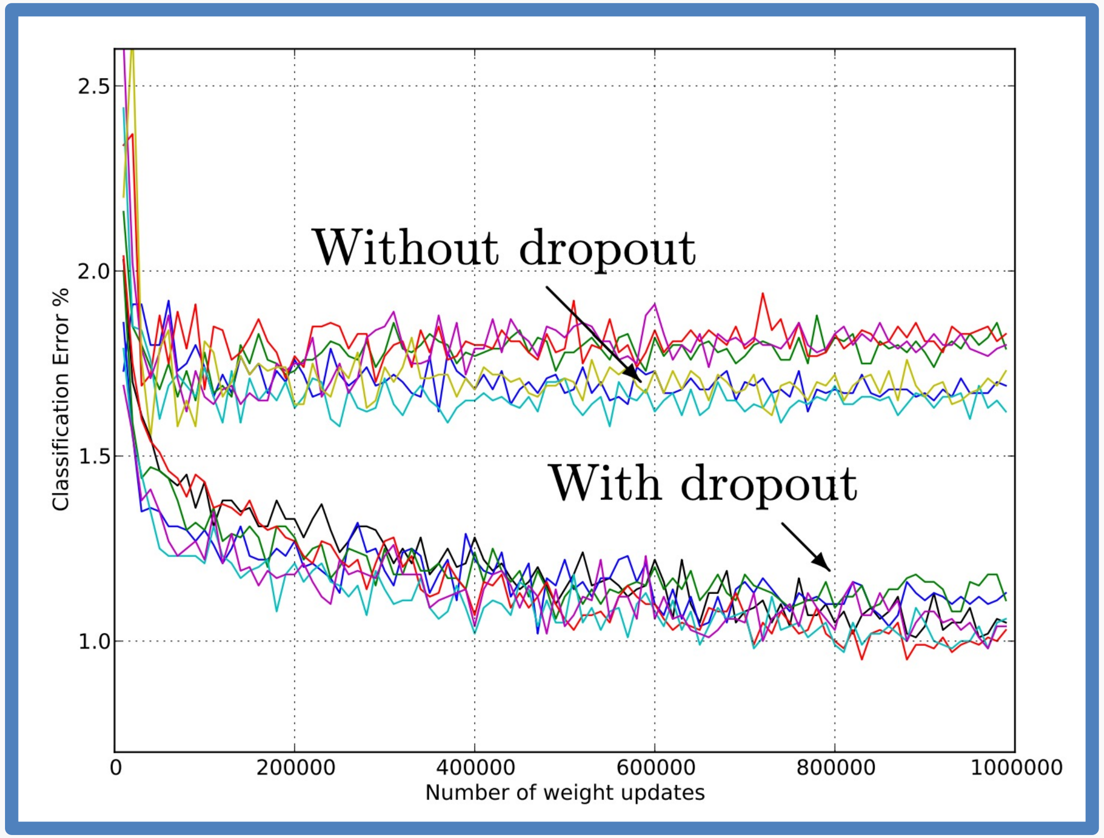
- Randomly sample a binary mask μ independently, where μ_i indicates if input/hidden node i is included
- Multiply output of node i with μ_i, and perform gradient update

Typically:

- Input nodes are <u>included</u> with prob=0.8 (as per original paper, but rarely used)
- Hidden nodes are <u>included</u> with prob=0.5

Dropout

- Widely used and highly effective



Test error for different architectures with and without dropout.

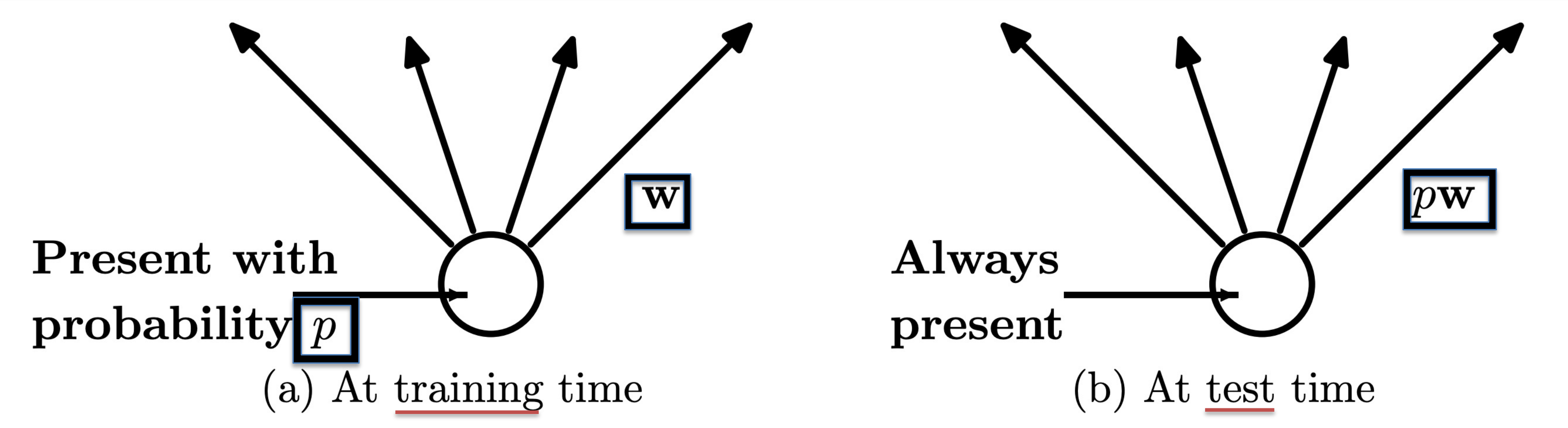
The networks have 2 to 4 hidden layers each with 1024 to 2048 units.

- Proposed as an alternative to ensemble methods, which is too expensive for neural nets

http://jmlr.org/papers/volume15/srivastava14a/srivastava14a.pdf

Dropout: Prediction

- We can think of dropout as training many of sub-networks
- At **test time**, we can “aggregate” over these sub-networks by **reducing connection weights in proportion to dropout probability, *p***



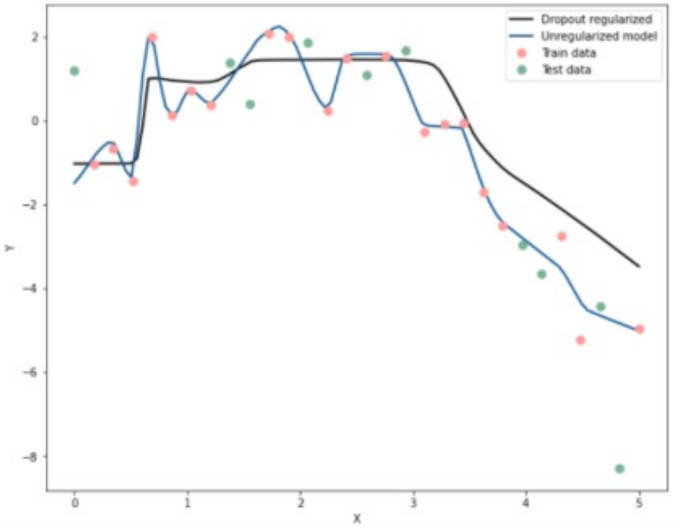
NOTE: Dropouts can be used for **neural network inference** by dropping during predictions and predicting multiple times to get a distribution

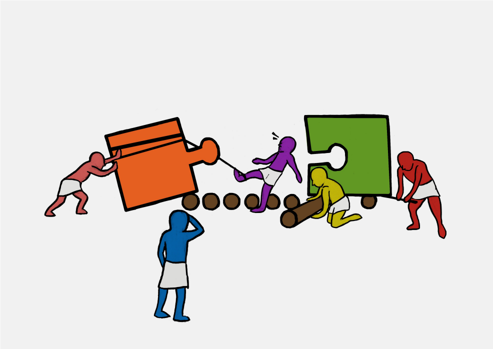
Exercise: Dropout

The goal of this exercise is to understand and use **dropouts** for neural network regularization.

This method avoids overfitting by briefly *switching off* certain weights during training.

NOTE: This graph is only a sample.





Instructions:

- Use the helper function `unregularized_model` to:
  - Generate the predictor and response data using the helper code given.
  - Build a simple neural network with 5 hidden layers with 100 neurons each and display the trace plot. This network has no regularization.
- For the same model architecture implement dropout by adding appropriate dropout layers.
- Compile the model with MSE as the loss. Fit the model on the training data.
- Use the helper code to visualise the MSE of the train and test data with respect to the epochs.
- Predict on the entire data.
- Use the helper code to plot the predictions along with the generated data.
- This plot will consist of the predictions of both the neural networks. The graph will look similar to the one given above.