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WALT DISNEY ANIMATION STUDIOS

JUNE 2020 WEBINAR

Hands-on Workshop: Machine Learning and Neural Networks

SIGGRAPHNOW

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Today

- Quick Recap: Intro & Housing data
- First Neural Network - Regression
- Visualization
- Second Neural Network - Classification

Recap

Given some data:

Q: How do we approximate a function that represents the data?

A: By minimizing prediction error

Recap - Terminology

- *Given: <u>Features</u> (X, Attributes), Output (Y, <u>Labels</u>, Ground Truth): Y=f(X)*
- *Network (<u>Model</u>)*
- *Loss Function (Metric, <u>Cost</u>)*
- *<u>Activation</u> Function (adds non-linearity, Ex: sigmoid, ReLU)*
- *<u>Training</u> (<u>fit</u>, Optimization to minimize Loss Function)*
- *Evaluate (performance, correctness)*
- *Predict (<u>Inference</u>, on new data)*

Recap - Questions

For example, if I want my machine learning to classify 1000 images for me, what percentage of correct classification should I expect, as I assume it won't ever be 100% correct.

Quick question, what would you recommend for someone to do if they are interested in this subject but are fairly lost before next class? Like things I should study or such

What if you do not have the ground truth to compare against to estimate the loss ?

Could you please explain the diagonal of the plot?

Why is the sigmoid and the RLU functions picked to model non-linearity?

Is there a way to know if you've found a local minimum, or the global minimum?

Going from linear to non linear with an activation function, do we usually have one activation function per model? or do we usually use more, one for each group of inputs/weights?

How do you go about selecting the initial weights?

Are you going to cover the bias-variance tradeoff?

What determines the number of outputs in relation to the number of inputs?

The fit is easy to see with 2-dimensional data. But how do you recognize over- or under-fitting for multi-dimensional data?

Hands-on

- ★ *Log in to your google drive*
- ★ Find the shared folder ‘Disney Machine Learning Webinar’
- ★ Make a copy of:
  - HousingRegression.ipynb,
  - FlowerClassification.ipynb
  - *Let’s take a look at the HousingRegression.ipynb*
    - *Simple Neural Network for predicting home prices*

How

- FRAMING: What is observed & what answer you want to predict
- DATA COLLECTION: Collect, clean, and prepare data
- DATA ANALYSIS: Visualize & analyze the data
- FEATURE PROCESSING: Transform raw data for better predictive input
- MODEL BUILDING: Design and build the learning algorithm
- TRAINING: Feed data to the model and evaluate the quality of the models
- PREDICTION: Use model to generate predictions for new data instances

ML project - process - apply to housing problem 1/7

- *FRAMING*: what is observed & what answer you want to predict

Observed: parameters related to homes for a census block

Predict: Median home-price for the block

Housing project steps - 2/7

- *DATA COLLECTION*: Collect, clean, and prepare data

Already given in a csv file: `housing.csv`

`isna(), np.where(), dropna()`

Housing project steps - 3/7

- *DATA ANALYSIS*: Visualize & analyze the data
  - `sns.pairplot(...)`
  - `data.describe()`

Housing project steps - 4/7

- *FEATURE PROCESSING*: Transform raw data for better predictive input

-- Normalize `(x-x.min())/(x.max()-x.min())` : brings data between 0 and 1

-- Standardize `(x-x.mean())/x.std()`: remaps to mean of 0, and std_dev of 1

-- Keep 20% for testing:

```
train=data.sample(frac=0.8)

test=data.drop(train.index)
```

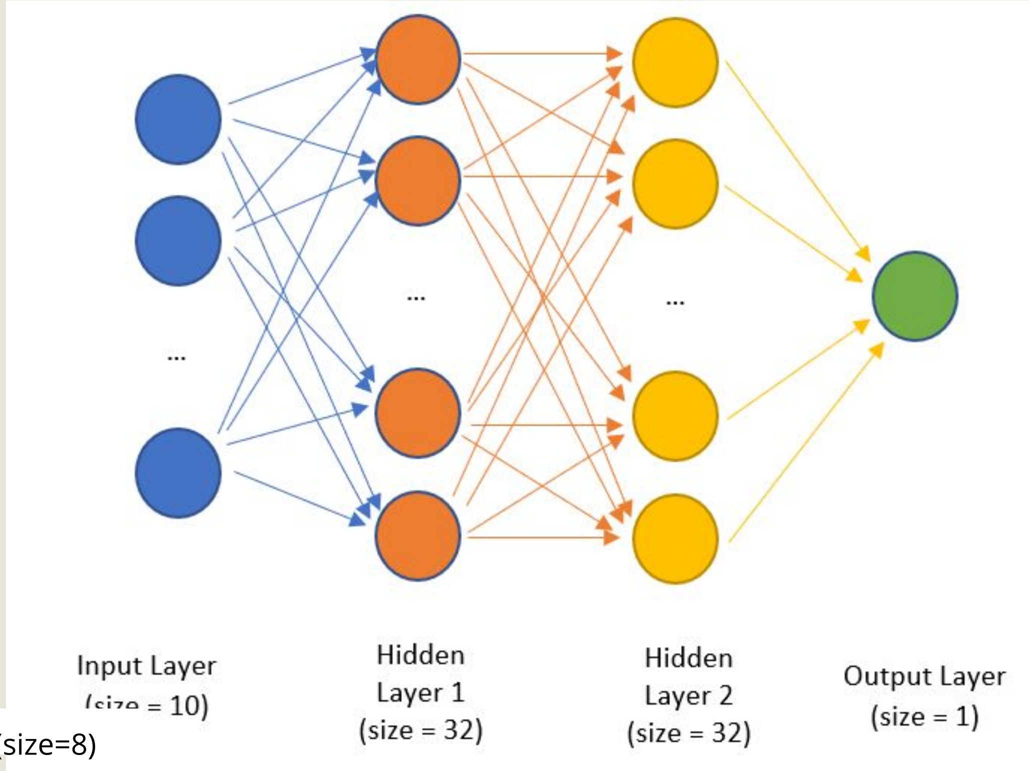
-- Separate features (x) from labels (y):

```
X_train = train.drop('median_house_value', axis=1)

Y_train = train[‘median_house_value’]
```

Housing project steps - 5/7

- *MODEL BUILDING*: Feed features to learning algorithm to build models



(size=8)

Housing project steps - 5/7

- *MODEL BUILDING*: Feed features to learning algorithm to build models

```
import tensorflow as tf

INPUT_SHAPE=[9]

model = tf.keras.Sequential([
    tf.keras.layers.InputLayer(INPUT_SHAPE, name="Input_Layer"),
    tf.keras.layers.Dense(32, activation='relu', name="dense_01"),
    tf.keras.layers.Dense(32, activation='relu', name="dense_02"),
    tf.keras.layers.Dense(1, name="Output_Layer")
  ])

model.compile(loss='mse',
              optimizer=tf.keras.optimizers.RMSprop(0.001),
              metrics=['mae', 'mse'])

print(model.summary())
```

Housing project steps - 6/7

- *TRAINING*: compute weights and Evaluate the quality of the models

```
example_batch = x_train[:10]
example_result = model.predict(example_batch)
print(example_result)

history = model.fit(x_train, y_train,
                    batch_size=32,
                    epochs=10,
                    validation_split=0.2,
                    verbose=1)

# Plot training & validation loss values
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validate'], loc='upper left')
plt.show()

loss, mae, mse = model.evaluate(x_test, y_test, verbose=2)
print("Loss:", loss, " mae:", mae, " mse:", mse)
```

Housing project steps - 7/7

- *PREDICTION*: Use model to generate predictions for new data instances

```
p_test = model.predict(x_test)
print(p_test, y_test)

a = plt.axes(aspect='equal')
plt.scatter(y_test, p_test)
plt.xlabel('True Values')
plt.ylabel('Predictions')
lims = [0, 1]
plt.xlim(lims)
plt.ylim(lims)
plt.plot(lims, lims)
plt.show()

error = p_test.flatten() - y_test
print(error)
plt.hist(error, bins = 25)
plt.xlabel("Prediction Error")
plt.ylabel("Count")
plt.show()
```

Housing project steps - Homework

- *Improve results*, tune hyperparameters
  - Increase/Decrease # of epochs
  - Try different batch sizes: 16 (observe time to train, accuracy etc)
  - Try different learning rates (0.01, 0.000001)
  - Try different optimizers (‘adam’)
  - Try different loss functions (‘mse’, ‘mae’)
  - Make the network deeper (more layers) or denser (more nodes/layer)

Flower Project - Classification

- *FRAMING*: what is observed & what answer you want to predict
  - Given data: about 3 species of iris flowers
- *DATA COLLECTION*: Collect, clean, and prepare data
- *DATA ANALYSIS*: Visualize & analyze the data
- *FEATURE PROCESSING*: Transform raw data for better predictive input:
- *MODEL BUILDING*: Feed features to learning algorithm to build models
- *TRAINING*: Evaluate the quality of the models
- *PREDICTION*: Use model to generate predictions for new data instances

Flower Classification: get data ready

120	4	setosa	versicolor	virginica	
0	6.4	2.8	5.6	2.2	2
1	5.0	2.3	3.3	1.0	1
2	4.9	2.5	4.5	1.7	2
3	4.9	3.1	1.5	0.1	0
4	5.7	3.8	1.7	0.3	0

Given: Features about Iris: sepal length, sepal width, petal length, petal width
Task: Classify into kind of Iris: setosa (0), versicolor (1), or virginica (2)

- Plot data
- Split data for training and testing
- Normalize training data

Flowers - Classification - get data ready

```
    #----------DATA READING
filename = 'https://storage.googleapis.com/download.tensorflow.org/data/iris_training.csv'
# read file
csv_data = pd.read_csv(filename, sep=',')
print(csv_data.head())

column_names = ['sepal_length', 'sepal_width', 'petal_length', 'petal_width', 'species']
class_names = ['Iris setosa', 'Iris versicolor', 'Iris virginica']

#----------DATA CLEANUP
csv_data.columns = column_names # new_header --set the header row as the data header
print(csv_data.head())
# look at simple data statistics
print(csv_data.describe().transpose())
# plot of all features against each other
sns.pairplot(csv_data)
```

Flowers - Classification - get data ready

```
#----------TRAIN/TEST SPLIT
train_data = csv_data.sample(frac=0.8) # take 80% randomly from the data for training
test_data = csv_data.drop(train_data.index) # reserve the rest for testing

# separate out the y (results) from x (features) for training
x_train = train_data.drop('species', axis=1)
y_train = train_data['species']
# normalize the training data
x_train = (x_train-x_train.min())/(x_train.max()-x_train.min())

# separate out the y (results) from x (features) testing
x_test = test_data.drop('species', axis=1)
y_test = test_data['species']
# normalize the test data
x_test = (x_test-x_test.min())/(x_test.max()-x_test.min())

print('Training Data\n', x_train.describe().transpose())
print('Test Data\n', x_test.describe().transpose())
```

Flowers - Classification steps - model

```
#--------MODEL BUILDING
num_params = len(x_train.keys())
print(num_params)
model = tf.keras.Sequential([
   tf.keras.layers.InputLayer([num_params], name="Input_Layer"),
   tf.keras.layers.Dense(32, activation='relu', name="dense_01"),
   tf.keras.layers.Dense(32, activation='relu', name="dense_02"),
   # 1 node in the output for the median_house_vale
   tf.keras.layers.Dense(3, name="Output_Layer")
 ])

model.compile(optimizer=tf.keras.optimizers.RMSprop(0.001),
              # loss function to minimize
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              # list of metrics to monitor
              metrics=['acc',])

model.summary()
```

Flowers - Classification Log Likelihood

```
Note:

Loss Function: SparseCategoricalCrossentropy(from_logits=True)
```

- Instead of a value, it returns a 'LOG LIKELIHOOD' for each output class
- Which we convert into a probability for each output class
- We take the class with the highest probability as the predicted class

Log Likelihood:

```
     class-A       class-B     class-C
 [ 0.02669345  0.03092438 -0.01683718 ]
```

Convert to probabilites (using *softmax* function)

```
 [ 0.13765042   0.739082   0.12326758 ]
```

Output class: B (class with the maximum probability)

Flowers - Classification - train and test

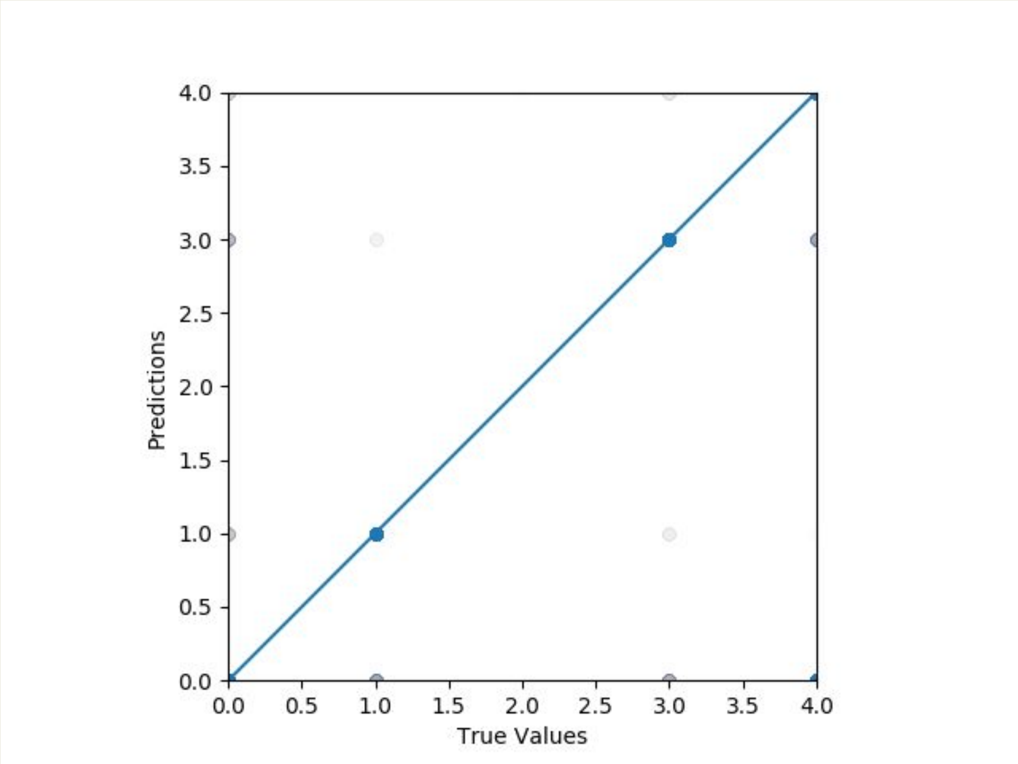
```
# Fit/TRAIN model on training data
history = model.fit(x_train, y_train,
                    batch_size=4,
                    epochs=10,
                    validation_split=0.2,
                    verbose=1)
#--------MONITOR
# Plot training & validation loss values
fig = plt.figure(figsize=(12,9))
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model loss')
plt.ylabel('Loss')
plt.xlabel('Epoch')
plt.legend(['Train', 'Validate'], loc='upper left')
plt.show()
```

Classification - Evaluation

- Problem with Prediction vs True Value
- Truth Table
- Confusion Matrix

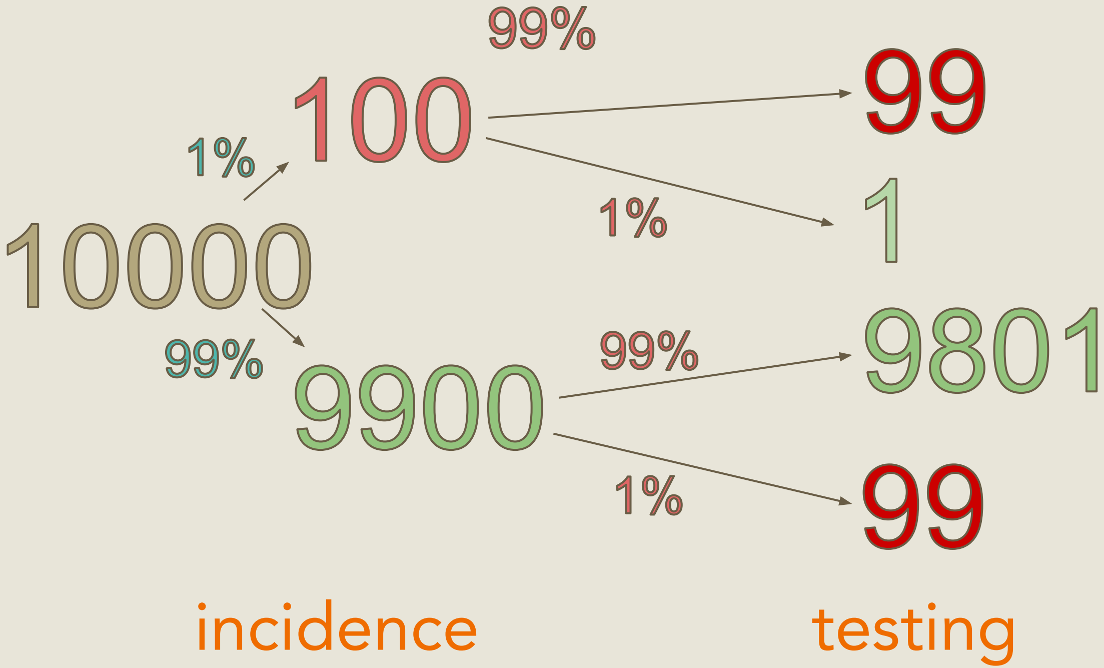
Classification - Evaluation

- Problem with Prediction vs True Value



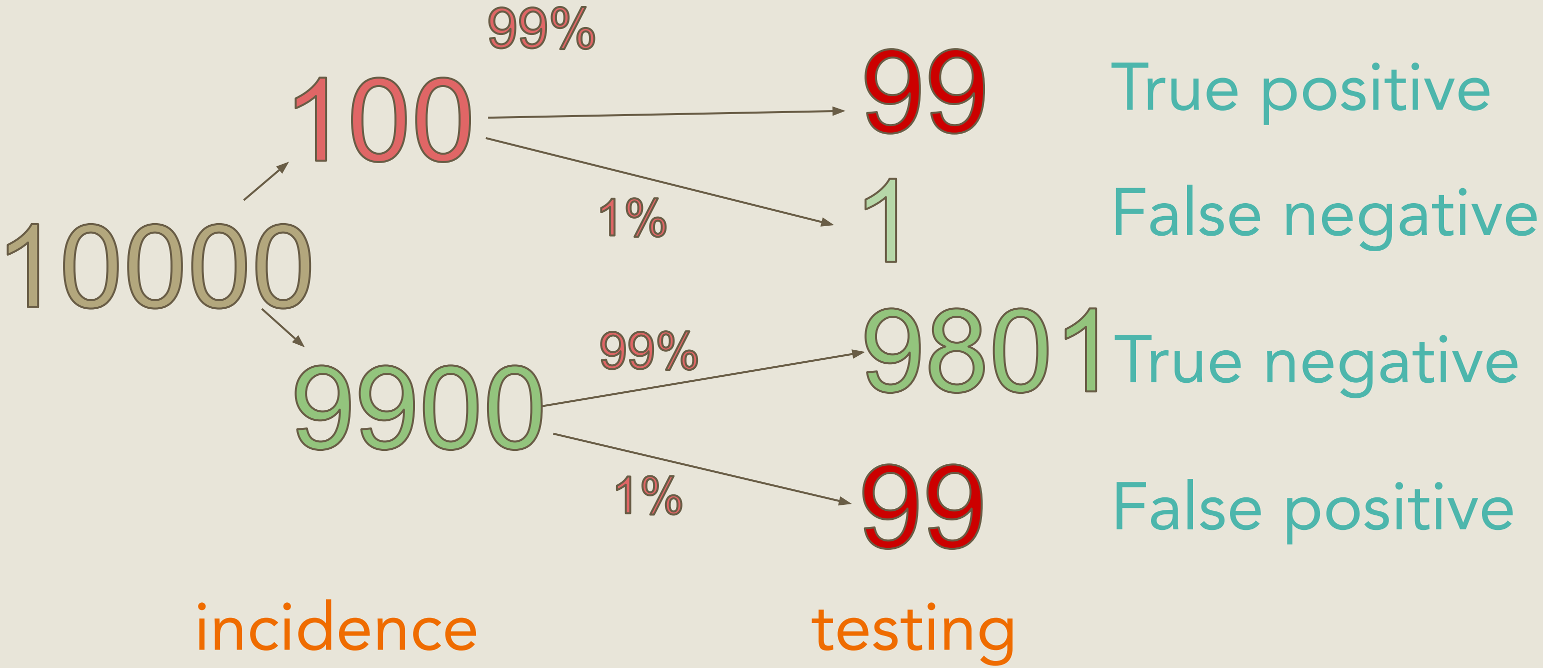
Classification - Evaluation

- Fallacy of accurate tests:
- Ex: 1% incidence, test is: 99% accurate



Classification - Evaluation

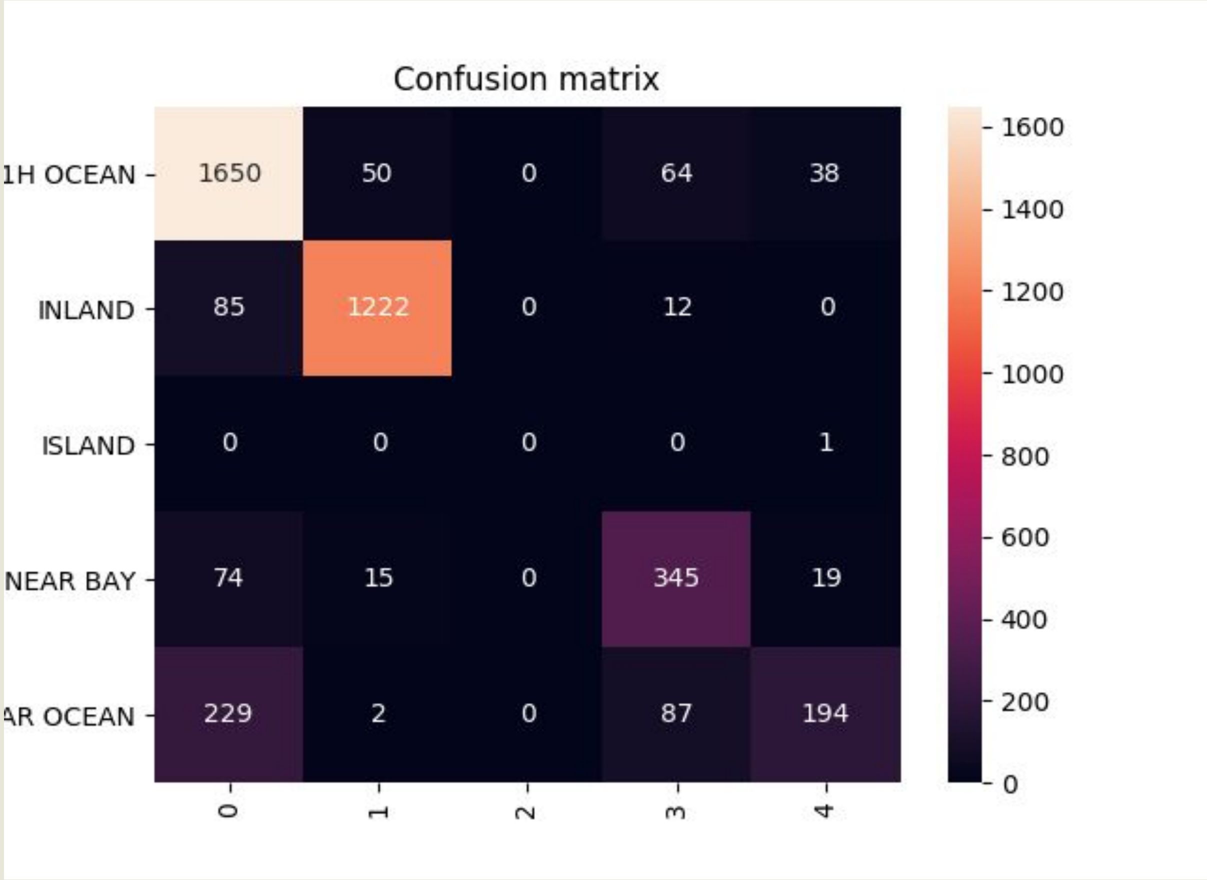
- Fallacy of accurate tests:
- Ex: 1% incidence, test is: 99% accurate



Classification - Evaluation - Confusion Matrix

		Actual Value	
		positives	negatives
Predicted Value	positives	TRUE POSITIVE	FALSE POSITIVE
	negatives	FALSE NEGATIVE	TRUE NEGATIVE

Classification - Evaluation - Confusion Matrix*



Classification - Evaluation - Confusion Matrix

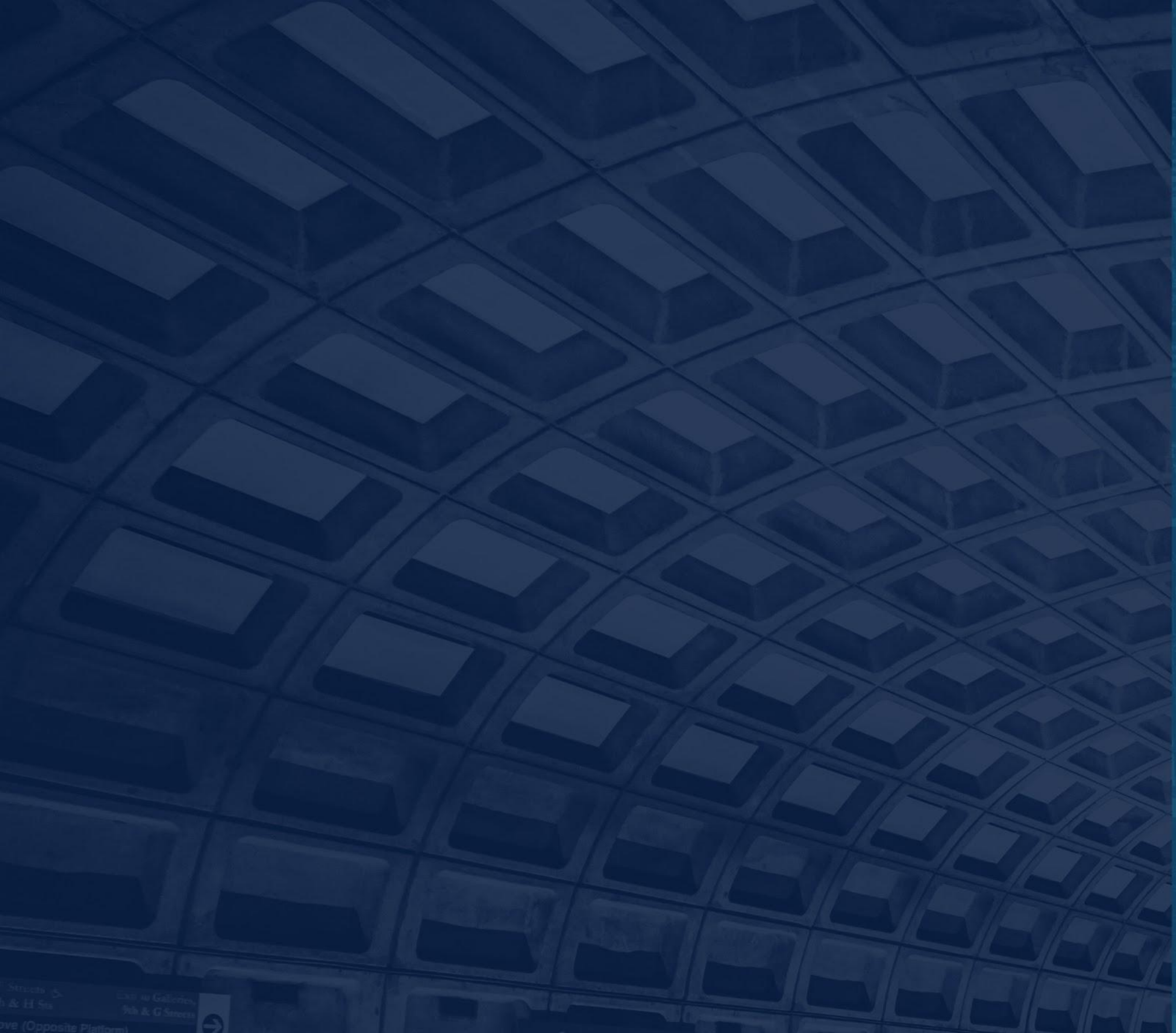
```
# plot the confision matrix as heatmap
sns.heatmap(tf.math.confusion_matrix(y_test,
p_test_class), cmap="Blues", annot=True)
```

Summary

- Regression, Classification
- Optimizer, Loss Function
- Model, training and prediction
- Visualization of progress, results

Next Class

- Data Compression using AutoEncoder
- Tensorflow Data Pipeline
- Homework:
  - Try different hyperparameters
  - Extra credit: Do a regression for sin(x)
- @xarmalarma, #siggraphNOW



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QUESTIONS?

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