BRENTON MALLEN

MACHINE LEARNING AS A MICROSERVICE

BIO

Masters in Ocean Engineering

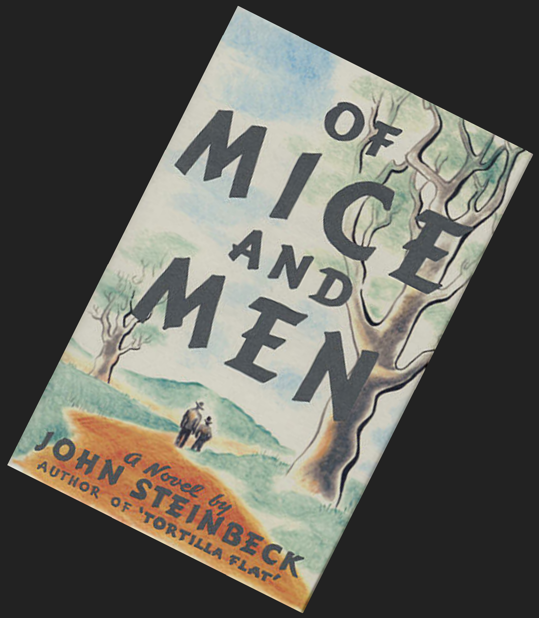
Underwater mine detection and classification using sonar image processing

Data Scientist in Cyber Security

Performing R&D, ad hoc analyses and building production ML systems for internet bot detection and mitigation

INTENT

Illustrate an approach to a product development cycle of getting data, building a machine learning model and turning it into something that can be used by others.



AGENDA

Problem Background

Build a Machine Learning Model

Build a Web App/API (Microservice)

Demo

Code Snippets along the way!

Source Code: https://github.com/brentonmallen1/titanic_survival

LANGUAGES & TECH

Python

sklearn, pandas, flask, zappa

HTML

Javascript

Amazon Web Services (AWS)

Lambda, API Gateway

THE PROBLEM BACKGROUND

THE TITANIC PROBLEM

Objective:

Predict if a passenger would have survived the titanic

https://www.kaggle.com/c/titanic

THE DATA

Training Set

891 records

Label: Survival

Test Set

418 records

Data Variables
Survival
Ticket class
Sex
Age in years
# of siblings / spouses aboard
# of parents / children aboard
Ticket number
Passenger fare
Cabin number
Port of Embarkation

BUILD A MODEL

https://github.com/brentonmallen1/titanic_survival/blob/master/notebooks/titanic.ipynb

What does every ML model need?

CHOOSING & ENGINEERING FEATURES

Removed ship location related features

Not particularly useful without knowledge of the ship layout

New features:

Age and Fare groups

Is Alone

Data Variables
Ticket class
Sex
Age in years
# of siblings / spouses aboard
# of parents / children aboard
Ticket number
Passenger fare
Cabin number
Port of Embarkation

FEATURE CHALLENGES

Small Set

891 Train Records

418 Test Records

Categorical Data

Missing Data

PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...	female	38.0	1	0	PC 17599	71.2833	C85	C
3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S
4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S
5	0	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S

MISSING DATA

Selecting Most Common

```
most_common_embark = df['Embarked'].mode()[0]
df['Embarked'] = df['Embarked'].fillna(most_common_embark)
```

Selecting Median Value

```
test_data['Fare'] = test_data['Fare'].fillna(test_data['Fare'].median())
test_data['Fare'] = test_data['Fare'].apply(fare_groups)
```

MISSING DATA

Predict Using a Classifier*

```
# Fill missing ages and encode them into age groups
age_features = [f for f in _utils.FEATURES if f != 'Age']
age_clf = _utils.missing_clf(train_data,
                             age_features,
                             'Age'
                             )
train_data['Age'] = (train_data.
    apply(
    lambda x: _utils.predict_encode_age(
        x,
        features=age_features,
        clf=age_clf
    ),
    axis=1
)
)
```

```
def missing_clf(df: pd.DataFrame, features: List,
                label: str) -> RandomForestClassifier:
    """
    This function will train a classifier
    on the data with missing values. This
    classifier is can be used to fill in
    missing data.
    :param df:
    :param features:
    :param label:
    :return:
    """

    train_data = df[~df[label].isna()]
    label = train_data[label].astype(int)  # train on
    clf = RandomForestClassifier(n_estimators=250,
                                 max_depth=3,
                                 bootstrap=False,
                                 oob_score=False
                                 )
    clf.fit(train_data[features], label)
    return clf
```

```
def predict_encode_age(row: pd.Series,
                       features: List = [],
                       clf: RandomForestClassifier = None) -> int:
    """
    This function will predict a passenger's age
    :param row:
    :param features:
    :param clf:
    :return:
    """
    if pd.isnull(row['Age']):
        return age_groups(clf.predict(row[features].values.reshape(1, -1))[0])
    else:
        return age_groups(row['Age'])
```

*Using the output of a classifier as features for another classifier can lead to latent interactions and increased tuning complexity

ENCODING CATEGORICAL FEATURES

Sex Encoding

```
SEX_MAPPING = {'female': 0, 'male': 1}
```

```
# encode the sex data
train_data['Sex'] = train_data['Sex'].map(_utils.SEX_MAPPING)
```

Embarked Encoding

```
encoding = {f: i for i, f in enumerate(df['Embarked'].unique())}
df['Embarked'] = df['Embarked'].map(encoding)
```

ENGINEERED FEATURES

Fare Encoding

```python
def fare_groups(fare: float):
    """
    This function puts Fares into groups based of
    a defined interval
    :param fare:
    :return:
    """
    if fare < 7.78:
        return 0
    elif 7.78 <= fare < 8.66:
        return 1
    elif 8.66 <= fare < 14.45:
        return 2
    elif 14.45 <= fare < 26.0:
        return 3
    elif 26.0 <= fare < 52.37:
        return 4
    elif 52.37 <= fare < 512.33:
        return 5
    else:
        return 6
```

Age Encoding

```python
def age_groups(age):
    """
    This function creates age groups
    """
    if age < 10:
        return 0
    elif 10 <= age < 18:
        return 1
    elif 18 <= age < 26:
        return 2
    elif 26 <= age < 36:
        return 3
    elif 36 <= age < 48:
        return 4
    elif 48 <= age < 56:
        return 5
    else:
        return 6
```

ENGINEERED FEATURES

Is Alone

```python
def is_alone(row: pd.Series):
    """
    This function is used to determine if a passenger was not traveling with
    anyone else
    :param row: row of titanic data
    :return: binary output of whether and passenger was traveling alone
    """
    family_size = row['SibSp'] + row['Parch']
    if family_size == 0:
        return 1
    else:
        return 0
```

If the passenger has no spouse, sibling, parent or child

FINAL FEATURE SET

Pclass	Sex	Age	SibSp	Parch	Fare	Embarked	Alone
3	1	2	1	0	0	0	1
1	0	4	1	0	5	1	1
3	0	3	0	0	1	0	0
1	0	3	1	0	5	0	1
3	1	3	0	0	1	0	0

TRAIN A MODEL

```python
def train() -> RandomForestClassifier:
    """
    Train a random forest classifier on some training data
    :return: trained classifier
    """
    train_data = process_data(_utils.TRAIN_FILE)
    clf = RandomForestClassifier(n_estimators=300,
                                 min_samples_leaf=7,
                                 min_samples_split=5,
                                 max_features=0.5,
                                 oob_score=True,
                                 n_jobs=-1,
                                 random_state=42
                                 )
    clf.fit(train_data[_utils.CLASS_FEATURES], train_data[_utils.LABEL])
    return clf
```

An attempt to mitigate overfitting due to small sample size

MODEL INSPECTION

Cross Validation

```
from sklearn.model_selection import cross_val_score
```

```
scores = cross_val_score(survival_clf,
                         encoded_train[CLASS_FEATURES],
                         encoded_train[LABEL],
                         cv=10,
                         scoring='accuracy'
                        )

print(f"""
    Accuracy (95% CI):
{round(scores.mean(), 3)} (+/- {round(scores.std() * 2, 3)})
"""
)
```

Accuracy* (95% CI): 0.823 (+/- 0.076)

*This is classification accuracy, which is the performance metric used for the Kaggle competition

MODEL INSPECTION

Women and Children First
by: Fortunino Matania

Feature Importance

Feature	Importance
Sex	0.51589
Ticket Class	0.15865
Fare	0.11274
Age	0.09403
# of siblings / spouses aboard	0.04831
Embarked	0.03169
# of parents / children aboard	0.02158
Alone	0.01799

MODEL PERFORMANCE

Gather Features on Test Data

```
# Embarked fill and encoding
test_data = raw_test.copy()  # retain original since changes are in place
fill_encode_embark(test_data)
# Sex encoding
test_data['Sex'] = test_data['Sex'].map(sex_mapping)
# Age prediction
test_data['Age'] = test_data.apply(
    lambda x: predict_encode_age(x,
                                 features=age_features,
                                 clf=age_clf
                                 ),
    axis=1
)
test_data['Fare'] = test_data['Fare'].fillna(test_data['Fare'].median())
test_data['Fare'] = test_data['Fare'].apply(fare_groups)
test_data['Alone'] = test_data.apply(is_alone, axis=1)
test_data['Survived'] = survival_clf.predict(test_data[CLASS_FEATURES])
```

Predict Survival on Test Data

Test Accuracy: 0.78947*

*Baseline classifier (sex as label) score: 0.76555

BUILD A WEB APP / API SERVICE

API

Flask App

Resource

Method

```
@app.route('/', methods=['GET'])
def index(name=None):
    """
    Main landing page
    :param name:
    :return:
    """
    return render_template('titanic.html', name=name)


@app.route('/titanic', methods=['POST'])
def predict_survival() -> Response:
    """
    Perform survival prediction based off form input
    :return: flask response with prediction output and status code 200
    """
    clf = _utils.load_model(_utils.MODEL_LOC,
                            _utils.MODEL_NAME
                            )
    prediction = clf.predict(get_features())[0]
    return Response(
        format_prediction(prediction),
        200
    )
```

⋮

Return Prediction

WEB APP

Javascript

Form & Action

User Input

Result

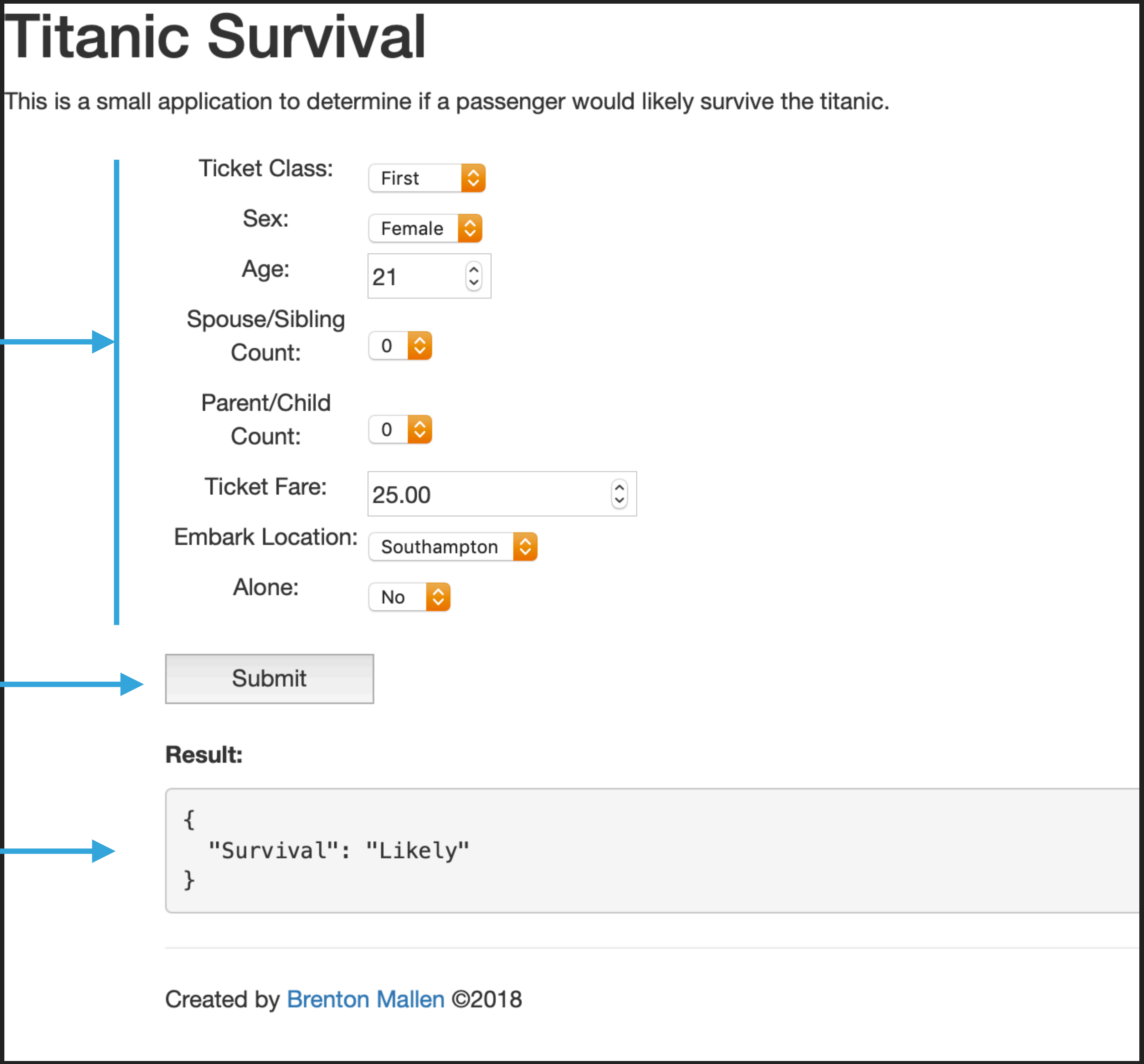
```
<html lang="en">
<head>
    <meta charset="UTF-8">
    <script src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>
    <script src="static/js/script.js"></script>
    <link rel="stylesheet"
          href="https://maxcdn.bootstrapcdn.com/bootstrap/3.3.7/css/bootstrap.min.css">
    <title>Titanic Survival</title>
</head>
<body>
<h1>Titanic Survival</h1>
This is a small application to determine if a passenger would likely survive
the titanic.
<br>
<br>
<div class="container">
    <form action="/dev/titanic" method="POST" enctype="multipart/form-data">
        <table style="width:30%">
            <tr>
                <td><p align="center">Ticket Class:</p></td>
                <td>
                    <select name="Pclass">
                        <option value="1">First</option>
                        <option value="2">Second</option>
                        <option value="3">Third</option>
                    </select>
                </td>
            </tr>
⋮
        </table>
        <br>
        <input id="submit" type="submit" name="submit"
               style="height:30px;width:125px"/>
        <br>
        <br>
        <p><strong>Result:</strong></p>
        <pre class="output"></pre>
    </form>
```

WEB APP

User Input Form

Send Input to API

Display Model Output



WEB APP

JavaScript

Link to Submit Button

Take Form Input

Make AJAX Call to API

Return Result (or Error)

```
$(function() {
    $('input[type="submit"]').click(function(event) {
        var $form = $(this).parent();
        $form.find('.output').text("")
        $.ajax({
            url: $form.attr('action'),
            data: $form.serialize(),
            type: 'POST',
            success: function(response) {
                $form.find('.output').text(JSON.stringify(JSON.parse(response), null, 2))
                console.log(response);
            },
            error: function(error) {
                $form.find('.output').text(error.responseText)
                console.log(error);
            }
        });
        event.preventDefault()
    });
});
```

DEPLOYMENT

Zappa Commands*

Deploy → Update → Destroy → Inspect

```
# ---------------
#   ZAPPA
# ---------------
.PHONY: deploy
deploy:
	(source $(VENV)/activate && zappa deploy $(ZAPPA_ENV))

.PHONY: redeploy
redeploy:
	(source $(VENV)/activate && zappa update $(ZAPPA_ENV))

.PHONY: remove
remove:
	(source $(VENV)/activate && zappa undeploy $(ZAPPA_ENV))

.PHONY: logs
logs:
	(source $(VENV)/activate && zappa tail $(ENV))
```

* Commands shown have been compiled into a Makefile for convenience

DEPLOYMENT

Zappa config*

Application →

Environment →

IAM Role →

Regions →

```
{
  "dev": {
    "app_function": "titanic.app",
    "aws_region": "us-east-1",
    "profile_name": "default",
    "project_name": "titanic-survival",
    "runtime": "python3.6",
    "s3_bucket": "titanic-survival",
    "lambda_description": "Function to determine if an passenger would survive the titanic",
    "manage_roles": false,
    "role_name": "titanic-survival-dev-ZappaLambdaExecutionRole",
    "role_arn": "",
    "slim_handler": true
  },
  "dev_ap_northeast_1": {
    "aws_region": "ap-northeast-1",
    "extends": "dev"
  },
  "dev_ap_south_1": {
    "aws_region": "ap-south-1",
    "extends": "dev"
  },
  "dev_ap_southeast_1": {
    "aws_region": "ap-southeast-1",
    "extends": "dev"
```

⋮

* Zappa requires an AWS account as well as an IAM role and policy

DEMO TIME

PRODUCTION NEXT STEPS

Continuous Integration / Deployment

AWS CodePipeline/CodeBuild, Jenkins, etc.

Monitoring / Dashboards

AWS Cloudwatch, DataDog, etc.

POSSIBLE TWEAKS

Classifier Model

Perform grid search on hyper-parameters

Try a different model or feature set

App / API

Improve app styling using CSS

Add DNS to make it more approachable

Add caching for performance

ANOTHER APPLICATION

Using this methodology we can make other apps as well

http://www.bg-similarity.com

Source Code: https://github.com/brentonmallen1/boardgame_similarities

QUESTIONS?