Final Report

By: Lauren Simms and Joshua Eli Swick

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1. Choose and describe the problem you are trying to solve. Clarity is important in your answer.

We are attempting to predict the income, over $50,000 per year or under $50,000 per year, for a person based on census data as accurately as possible. This data includes age, race, education, marital status, income, sex, relationship status and country of origin. We are approaching this problem using Binary Classification.

```
38, Private, 215646, HS-grad, 9, Divorced, Handlers-cleaners, Not-in-family, White, Male, 0, 0, 40, United-States, <=50K
53, Private, 234721, 11th, 7, Married-civ-spouse, Handlers-cleaners, Husband, Black, Male, 0, 0, 40, United-States, <=50K
28, Private, 338409, Bachelors, 13, Married-civ-spouse, Prof-specialty, Wife, Black, Female, 0, 0, 40, Cuba, <=50K
37, Private, 284582, Masters, 14, Married-civ-spouse, Exec-managerial, Wife, White, Female, 0, 0, 40, United-States, <=50K
49, Private, 160187, 9th, 5, Married-spouse-absent, Other-service, Not-in-family, Black, Female, 0, 0, 16, Jamaica, <=50K
52, Self-emp-not-inc, 209642, HS-grad, 9, Married-civ-spouse, Exec-managerial, Husband, White, Male, 0, 0, 45, United-States, >50K
31, Private, 45781, Masters, 14, Never-married, Prof-specialty, Not-in-family, White, Female, 14084, 0, 50, United-States, >50K
42, Private, 159449, Bachelors, 13, Married-civ-spouse, Exec-managerial, Husband, White, Male, 5178, 0, 40, United-States, >50K
37, Private, 280464, Some-college, 10, Married-civ-spouse, Exec-managerial, Husband, Black, Male, 0, 0, 80, United-States, >50K
30, State-gov, 141297, Bachelors, 13, Married-civ-spouse, Prof-specialty, Husband, Asian-Pac-Islander, Male, 0, 0, 40, India, >50K
```

2. Describe your approach in detail, considering all the feedback you have received (and any additional research you have performed). Make sure you answer the following adequately:

a. What kind of problem are you trying to solve? Regression? Classification? Clustering?

b. If classification, what classes are your outputs?

c. Why did you take this approach?

We are trying to solve a classification problem, with the potential for it to be a clustering problem. Our outputs are above $50,000 and under $50,000.

We left out the 'fnlwgt' column as this value is related to the sample size in the census and not a feature of an individual person represented in the data set.

The ' <=50k' and ' >50k' target features were converted to a 0 and 1 respectively in order for them to be represented numerically.

```
In [11]: dataset['income'].unique()
Out[11]: array([' <=50K', ' >50K'], dtype=object)

In [12]: list=[]
         for income in dataset['income']:
             if income == ' <=50K':
                 list.append(0)
             if income == ' >50K':
                 list.append(1)

         dataset['income'] = list
```

We also had to normalize the numeric features and encode the categorical features.

```
In [86]: training_data.head()
```

Out[86]:

	age	workclass	fnlwgt	education	education-num	marital-status	occupation	relationship	race	sex	capital-gain	capital-loss	hours-per-week	native-country	native-country
24645	0.150685	2	162298	1	0.533333	0	6	3	0	0	0.0	0.000000	0.397959	0	0
19112	0.739726	1	130436	13	0.066667	2	6	0	0	1	0.0	0.000000	0.275510	0	0
11592	0.260274	2	181721	12	0.333333	0	8	3	1	0	0.0	0.000000	0.602041	0	0
5755	0.534247	2	182460	1	0.533333	1	2	1	0	0	0.0	0.000000	0.397959	0	0
31139	0.136986	2	215504	0	0.800000	1	5	1	0	0	0.0	0.424242	0.551020	0	0

Classification analysis is appropriate for this problem and dataset as predicting if an individual's income is above or below $50,000 per year can be represented as two categories. Additionally, as identified throughout our work this semester, the SoftMax activation function works well as the activation function layer in classification models.

3. Describe the state-of-the-art solutions by others on the same dataset.

a. What are the differences with your approach with theirs?

b. What are the differences according to your metrics?

We found one instance where another data scientist used this dataset for income classification. This model used the Python package 'sklearn' and had an accuracy of 82.5%.

4. What is/are the metric(s) you are using? Justify their use. If you are using data from a competition, it may be that others are using that metric, so you want to compare your answer against theirs.

This model focuses on accuracy, as we want the model to accurately predict an individual's income category.

More specifically, accuracy is the number of incomes predicted correctly divided by the total number of rows in the test dataset.

5. What is/are the activation functions used in your model? Where are they used? Show a few variations and how this affects your results.

We used the SoftMax and Relu activation functions.

We were asked during our presentation if sigmoid would have been a better activation function to use because of the nature of the function. We then ran our model using the sigmoid function and it retuned 24% accuracy which was considerably less than the 76% accuracy we got when we ran it with the SoftMax function.

6. After choosing the best activation functions, what is/are the loss functions used in your model?

The loss function used in this model is Binary Cross-Entropy. The loss function set during the configuration of the model in preparation for training using the model's compile method. The loss function is related to the error value that will be minimized by the model.

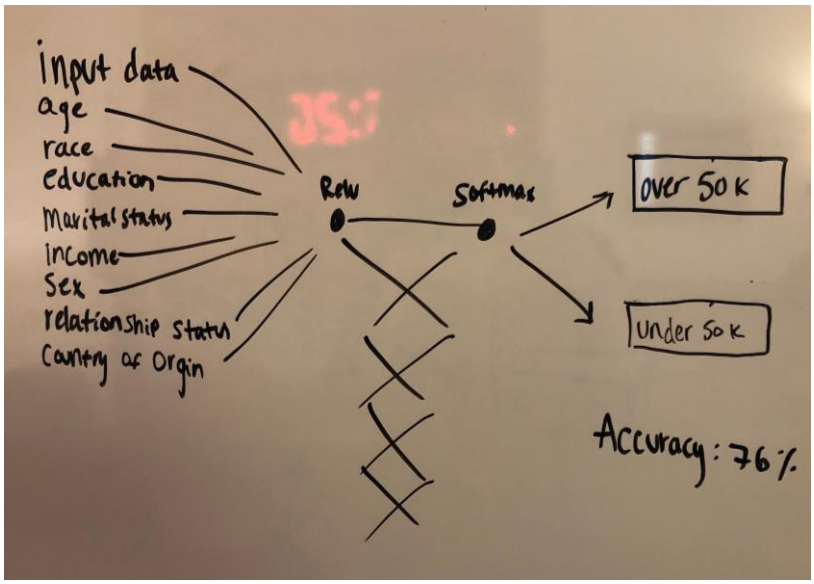
```
In [103]:
model = keras.Sequential([
    keras.layers.Dense(16, input_shape=(15,), activation=tf.nn.relu),
    keras.layers.Dense(2, activation=tf.nn.softmax)
])
```

```
In [104]:
model.compile(
    optimizer='rmsprop',
    loss='binary_crossentropy',
    metrics=['accuracy']
)
```

```
In [106]:
model.fit(
    training_data,
    to_categorical(training_labels),
    epochs=3
)
```

```
Epoch 1/3
26048/26048 [==============================] - 1s 28us/sample - loss: 3.8223 - acc: 0.7616
Epoch 2/3
26048/26048 [==============================] - 1s 31us/sample - loss: 3.8223 - acc: 0.7616
Epoch 3/3
26048/26048 [==============================] - 1s 28us/sample - loss: 3.8223 - acc: 0.7616
Out[106]: <tensorflow.python.keras.callbacks.History at 0x7f8249420c88>
```

7. Draw a general picture of your model, including the layers and inputs/outputs. There are lots of examples online and, depending on your model, can be refined based on your needs.



8. A general idea of the lessons learned doing the project (this can be an expanded version of what you had provided in your presentation).

Datasets that include numerical data, text labels, and inconsistent values need thoughtful preparation for TensorFlow to interpret the values properly.

Deep learning is still an ever-changing field and the tools and techniques are constantly evolving.