Final ISE 364

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Introduction

The objective is to create a model with data from data.csv and be used to predict target value with new.csv.

Summary

The data from data.csv was first explored and then used to create a neural network, which was then used to predict the target (column 11) with data from new.csv. Several neural network design, with different activation functions, and other techniques were explored. The final model is a 3-layer model, 1 hidden layer of 25 nodes, using sigmoid as activation functions.

Experimental Details

- Load the data.csv as df
- Conduct Exploratory Data Analysis for project_data.csv
- Use OneHotEncoder to transform categorical columns into multiple numeric columns
- Apply Train Test Split to df
- Train Test sets are scaled
- Construct the neural network as the base model
- Train the neural network, and test it with test data
- Evaluate the model with accuracy score
- Retrain and valuate the model with different variations
    - Variations includes, using sgd as the optimizer instead of adam, reduce data dimensions from 2-50 using Principal Component Analysis (PCA), use standard scaler instead of MinMax scaler, use different activation functions like tanh, sigmoid, softmax, in addition to relu.
- Load the new.csv as df_new
- Use OneHotEncoder to transform categorical columns into multiple numeric columns
- Scale and transform the data df_new for prediction
- Predict and save the target column (11) to predictions.csv

Base Model

```
model = Sequential()
model.add(Dense(units=50, activation='relu'))
model.add(Dropout(0.5))

model.add(Dense(units=25, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(units=1, activation='sigmoid'))
# loss for binary
model.compile(loss='binary_crossentropy',
```

```
        optimizer='adam', metrics=['accuracy'],)

# fit
model.fit(x=X_train, y=y_train, epochs=1000, validation_data=(
    X_test, y_test), verbose=0, callbacks=early_stop)
```

Base model consists of 1 input layer with nodes equal to the total feature, 50, one hidden layer with nodes half of the input layer, and one node for the out put layer. The first and second layer has a Dropout of 0.5 and uses relu activation function, and the output layer uses sigmoid as the activation function. The model is also being validated with the test data. Callbacks are set with a patience of 50 base on loss, epochs at 1000, and accuracy are displayed.

Results and discussions

The following chart is the accuracy of the base model and model with different variations.

Model	Accuracy Score	Model compared to base model
Base	0.8267	
Base SGD	0.8247	Use sgd optimizer instead of adam
PCA 50 SGD	0.8260	Applied PCA with n=50 to data, trained with sgd optimizer instead of adam
Base Underbalance	0.7427	Resample data for underbalanced case with imblearn.under_sampling
Base Overbalance	0.7890	Resample data for overbalanced case with from imblearn.over_sampling
Standard Scaler	0.8263	Used standard scaler instead of MinMax scaler
Complex 1	0.8253	Introduce a hidden layer of 11 nodes and 0.5 Dropout after 2nd layer
Complex 2	0.8293	2nd layer is 11 nodes instead of 25
Tanh	0.8267	Used tanh as activation function for the first 2 layer
sigmoid	0.8297	Used sigmoid as activation function for the first 2 layer
complex 1 sigmoid	0.8263	Introduce a hidden layer of 11 nodes and 0.5 Dropout after 2nd layer, and used sigmoid as activation function for the first 2 layer
softmax	0.8190	Used softmax as activation function for the first 2 layer
PCA n=1	0.7560	Applied PCA with n=1 to data
PCA n=2	0.7630	Applied PCA with n=2 to data
PCA n=3	0.7793	Applied PCA with n=3 to data
PCA n=4	0.7560	Applied PCA with n=4 to data
PCA n=5	0.7720	Applied PCA with n=5 to data
PCA n=6	0.7750	Applied PCA with n=6 to data
PCA n=7	0.7860	Applied PCA with n=7 to data

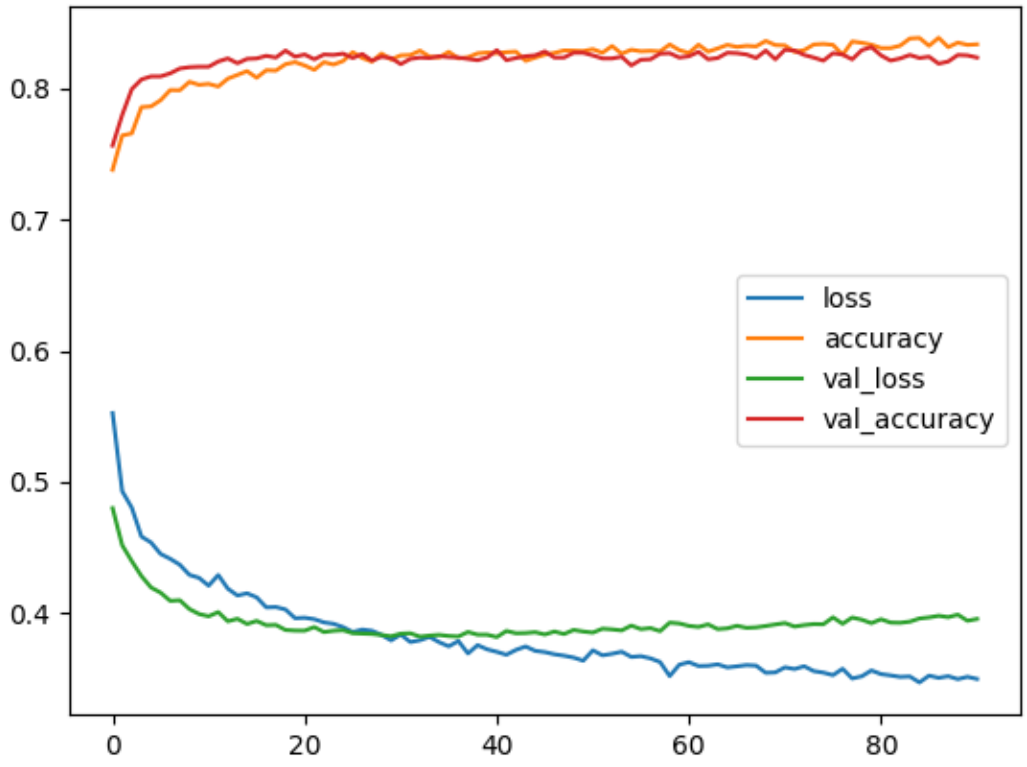
PCA n=8	0.7957	Applied PCA with n=8 to data
PCA n=9	0.8020	Applied PCA with n=9 to data
PCA n=10	0.8037	Applied PCA with n=10 to data
PCA n=11	0.8057	Applied PCA with n=11 to data
PCA n=12	0.8023	Applied PCA with n=12 to data
PCA n=13	0.7910	Applied PCA with n=13 to data
PCA n=14	0.8067	Applied PCA with n=14 to data
PCA n=15	0.8137	Applied PCA with n=15 to data
PCA n=16	0.8177	Applied PCA with n=16 to data
PCA n=17	0.8100	Applied PCA with n=17 to data
PCA n=18	0.8113	Applied PCA with n=18 to data
PCA n=19	0.8073	Applied PCA with n=19 to data
PCA n=20	0.8167	Applied PCA with n=20 to data
PCA n=21	0.8120	Applied PCA with n=21 to data
PCA n=22	0.8123	Applied PCA with n=22 to data
PCA n=23	0.8213	Applied PCA with n=23 to data
PCA n=24	0.8103	Applied PCA with n=24 to data
PCA n=25	0.8123	Applied PCA with n=25 to data
PCA n=26	0.8157	Applied PCA with n=26 to data
PCA n=27	0.8240	Applied PCA with n=27 to data
PCA n=28	0.8177	Applied PCA with n=28 to data
PCA n=29	0.8253	Applied PCA with n=29 to data
PCA n=30	0.8270	Applied PCA with n=30 to data
PCA n=31	0.8263	Applied PCA with n=31 to data
PCA n=32	0.8187	Applied PCA with n=32 to data
PCA n=33	0.8213	Applied PCA with n=33 to data
PCA n=34	0.8260	Applied PCA with n=34 to data
PCA n=35	0.8240	Applied PCA with n=35 to data
PCA n=36	0.8177	Applied PCA with n=36 to data
PCA n=37	0.8200	Applied PCA with n=37 to data
PCA n=38	0.8197	Applied PCA with n=38 to data
PCA n=39	0.8187	Applied PCA with n=39 to data
PCA n=40	0.8230	Applied PCA with n=40 to data
PCA n=41	0.8253	Applied PCA with n=41 to data
PCA n=42	0.8270	Applied PCA with n=42 to data
PCA n=43	0.8230	Applied PCA with n=43 to data
PCA n=44	0.8263	Applied PCA with n=44 to data
PCA n=45	0.8263	Applied PCA with n=45 to data
PCA n=46	0.8193	Applied PCA with n=46 to data

PCA n=47	0.8213	Applied PCA with n=47 to data
PCA n=48	0.8210	Applied PCA with n=48 to data
PCA n=49	0.8280	Applied PCA with n=49 to data
PCA n=50	0.8279	Applied PCA with n=50 to data

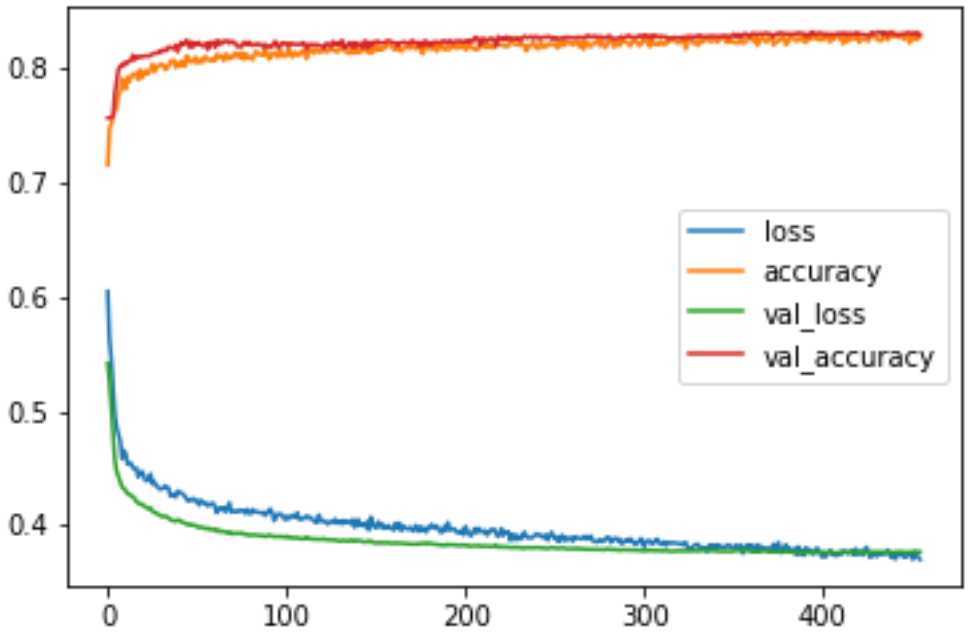
Changing the dimensions of the input data down did not improve the accuracy, and the graphs (can be found inside the folder PCA_1000) for each of the PCA showed that as n increases, the validation losses also increase. Each of the PCA n from 1 to 50 are ran to 1000 epoch with no call backs.

Using sigmoid as activation function for the first 2 layers provided the greatest accuracy with consistency. Although it is only a 0.07 increase in accuracy compared to the base model, unlike the more complex model, it consistently results in a 0.07 increase. Therefore, a model using sigmoid as activation function for the first 2 layers was used to train the data.

Here is a loss, accuracy, validation loss, validation accuracy graph of the base model.



Here is a loss, accuracy, validation loss, validation accuracy graph of the model using sigmoid as activation function for the first 2 layers:



While both models are set to stop with call backs patients of 50, the sigmoid model provided better overall consistency and a narrower gap between loss and validation loss.

Body

After the data was loaded into data frames, Exploratory Data Analysis was conducted to attempt to discover trends, to check for nulls, data types, any special relationship between characteristics and targets, etc. The data has 11 different type of characteristics 0-10, and the target column 11 was binary of 1s and 0s. Some characteristics of the data are categorical data, OneHotEncoder was used to transform them, and each unique value in the categorical data got transformed into their own column. As the result, the input data can be categorized to have 50 characteristics. Although it can be reduced by removing 5 columns that from each of the 4 categorical columns, it was left alone.

The data set was then split with 30% for testing after training the model, and then scaled using the MinMax scaler.

Following the data clean up and setting up for training. A base model was set and trained and evaluated for accuracy. A PCA model was constructed and trained after reducing data to 2 dimensions and evaluated for accuracy. Another base model was constructed and trained using sgd as the optimizer. The accuracies for the 3 models that can be found inside the main_eda.ipynb are 0.825 , 0.8, and 0.827.

Next, the goal was to find a model that would be more accurate. The data was then reduced dimensions using PCA to n=2 to n50, total of 49 models. However, as the data for the accuracies for the 49 models did not produce a significantly better results than the base model.

During the exploratory data analysis stage, it was discovered that the ratio of 0s and 1s in the target columns was about 7:0. The set of data was then resampled using oversampling and under sampling techniques, but none of them produced better results.

Two models with additional layers were then tried, they would sometimes produce a better result, but they lack the consistency due to the more complex network.

Lastly, the base model was then reconfigured using different activation functions in the first 2 layers, it includes tanh, sigmoid, and softmax. The results of those were 0.8268, 0.8927, and 0.8190. And the sigmoid has the highest accuracy so far and it was very reproducible due to its simple network. Then predictions were made using the model that uses sigmoid as activation functions.

Conclusions

After comparing the base model and a few variations models, a 3 layers model (50-25-1) using sigmoid as activation functions was then used to predict data from new.csv, and the accuracy is about 0.83.

Recommendations

It would be nice if there is a description of the different features, then each feature can be deeply analyzed and to be used to the advantage. Such as the categorical data, if the relationship between the kinds within a characteristic can be known, different data transformation techniques can the be apply in attempt to create a more accurate model.

Files

main_eda.ipynb
- This files contains the exploratory analysis and explorations of training a few models

predict.ipynb
- This file trains the base model with sigmoid as activation functions and predict and save to the prediction.csv

PCA_1000/
- This is a folder that contains the script that runs PCA from n=2 to n=50, and the results of each run in a consolidated csv files, and each run's graph

base_model.py
- This is a script to run the base model

base_sgd.py
- This is a script to run the base model with sgd optimizer

pca_n50_sdg.py

- This is a script to run the base model with PCA set n=50

base_sigmoid.py

- This is a script to run the base model with sigmoid as activation functions

base_tanh.py

- This is a script to run the base model with tanh as activation functions

base_softmax.py

- This is a script to run the base model with softmax as activation functions

base_under.py

- This is a script to run the base model with under-balancing

base_over.py

- This is a script to run the base model with overbalancing

standard_scaler.py

- This is a script to run the base model with the standard scaler

complex_1_model.py

- This is a script to run the complex 1 model

complex_1_sigmoid.py

- This is a script to run the complex 1 model with sigmoid as activation functions

complex_2.py

- This is a script to run the complex 2 model

result_graph/

- This folder contains the loss, accuracy, validation loss, validation accuracy graphs for each result