Prediction and Analysis of Visa Application Acceptance using Deep Learning

Pranav Bhandari, Dushyant Singh Udawat, Krzysztof Dutka, Leo Franco Soto

Team Name: Bond (Group Number 2)

December 8th, 2022

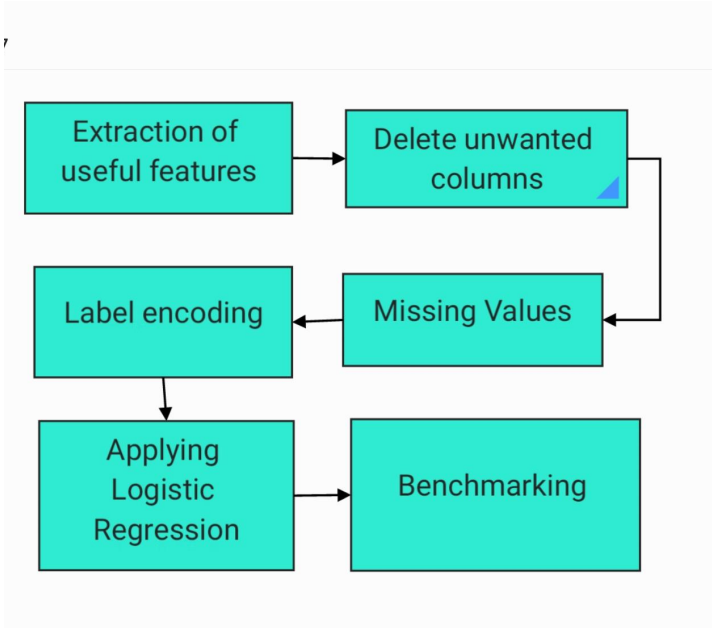
Problem Statement

1. Predict the result of an application (Approved / Denied / Withdrawn)
2. Find out if the dataset is self-exciting?
    a. Self-exciting describe random sequences of events where the occurrence of an event increases the likelihood that subsequent events occur nearby in time and space
3. Make various models to predict the percentage of applications getting Approved / Denied / Withdrawn
    a. Logistic Regression
    b. **C**onvolutional **N**eural **N**etwork (CNN)
    c. **L**ong **S**hort-**T**erm **M**emory (LSTM)

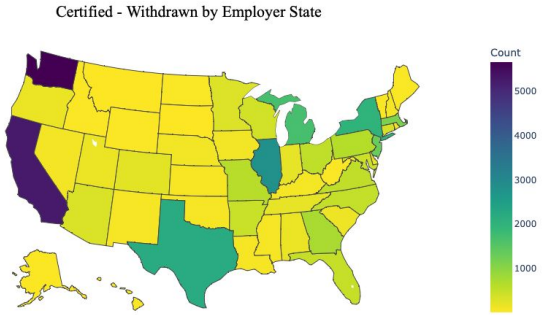
Image Source: https://www.istockphoto.com/photos/h1b-visa

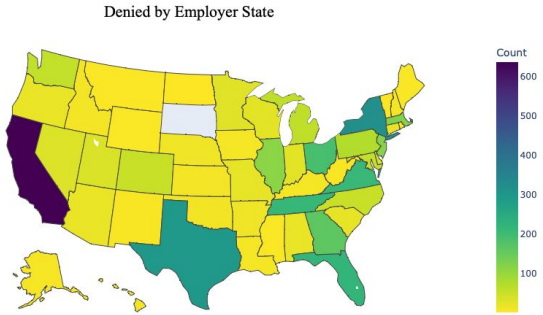
Data preprocessing

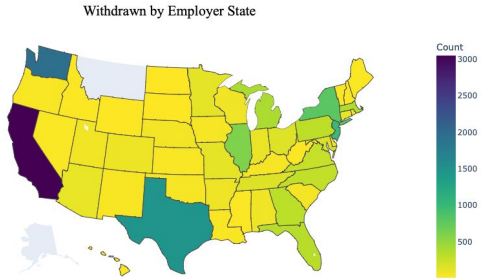
Inputs
Employer City
Employer State
Worksite City
Worksite State
No. of Employees in Worksite
Application Date
Outputs
Status of Application



Data Visualization Maps by Employer State



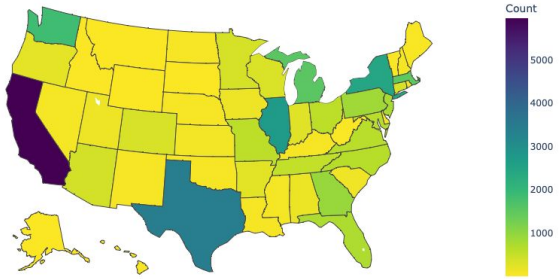




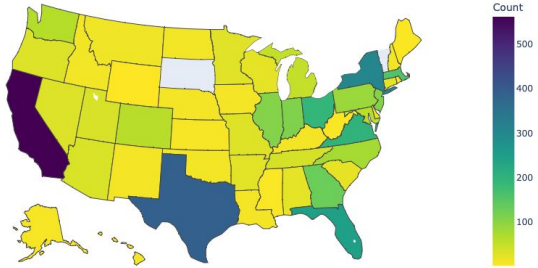
Slide and Code by: Pranav Bhandari (ppb4)

Data Visualization Maps by Worksite

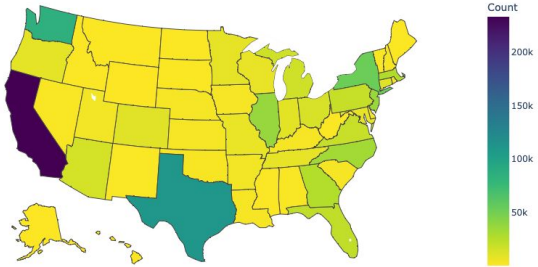
Certified - Withdrawn by Worksite State



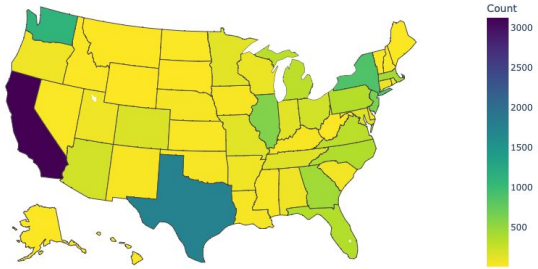
Denied by Worksite State



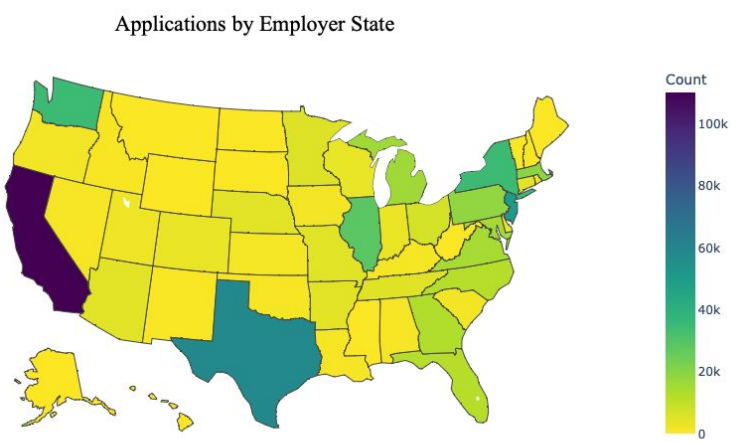
Certified by Worksite State

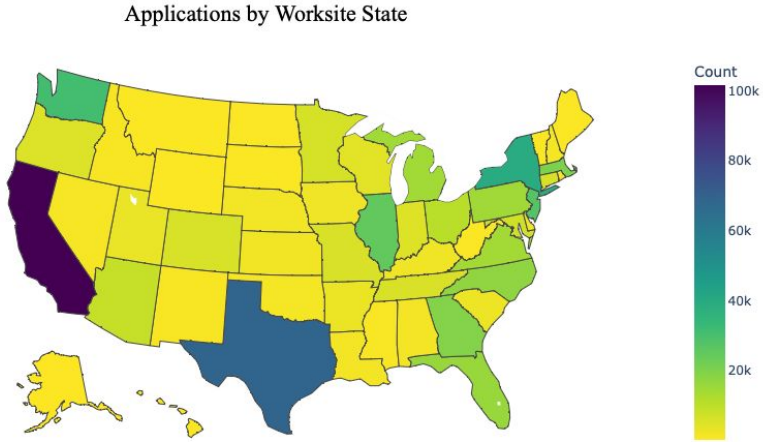


Withdrawn by Worksite State



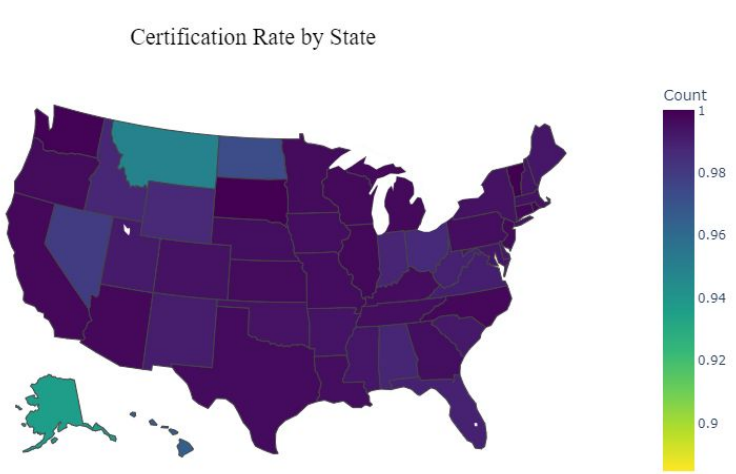
Data Visualization by Number of Applications

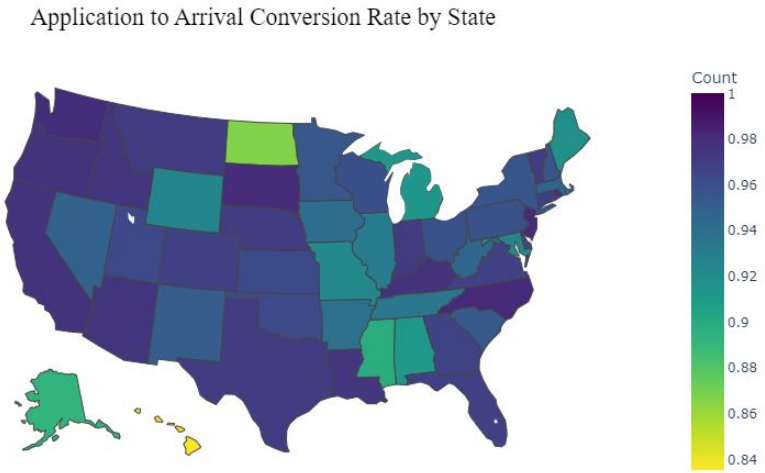




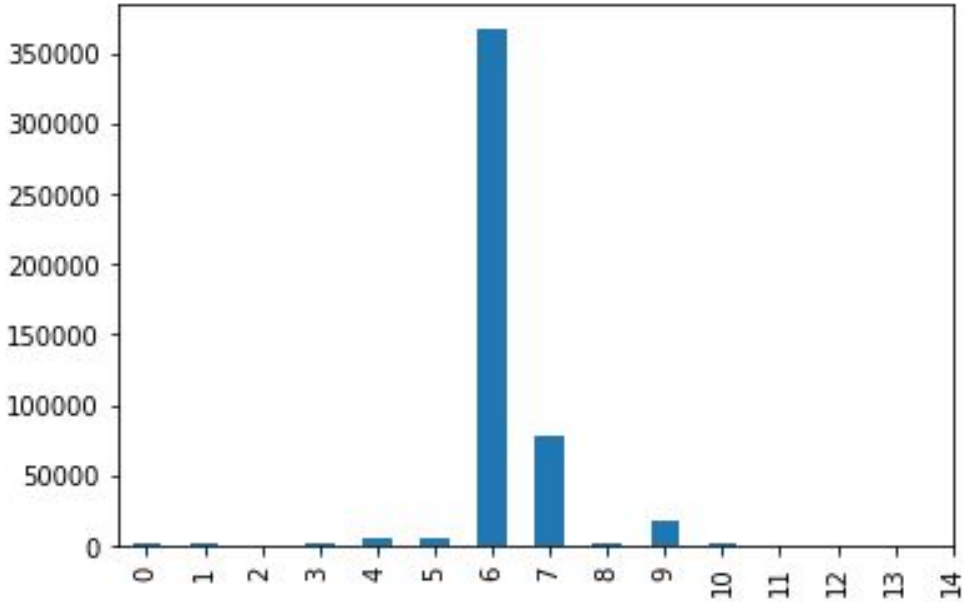
Slide and Code by: Pranav Bhandari (ppb4)

Data Visualization by Number of Applications



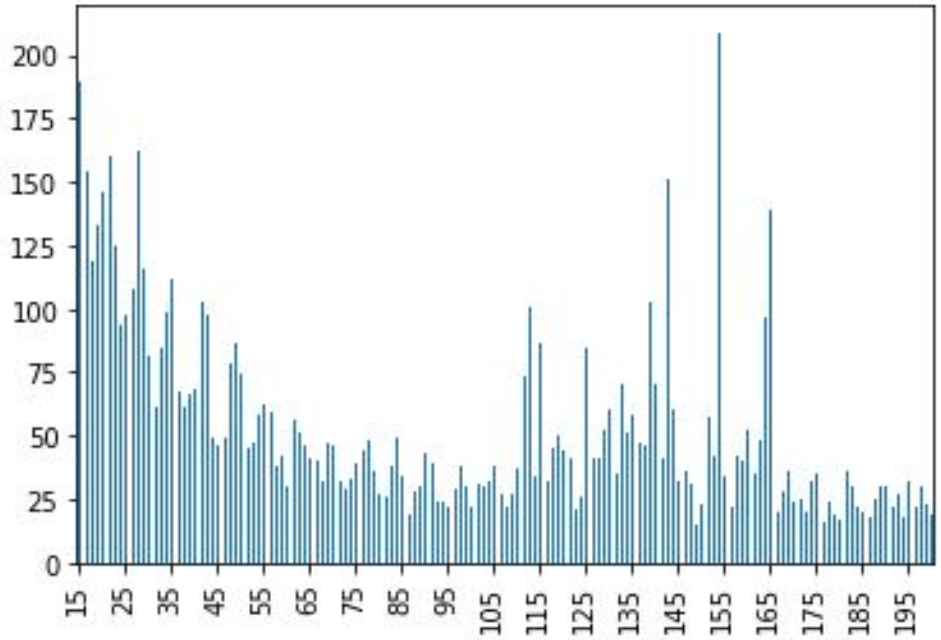


Number of Results per day within 2 weeks



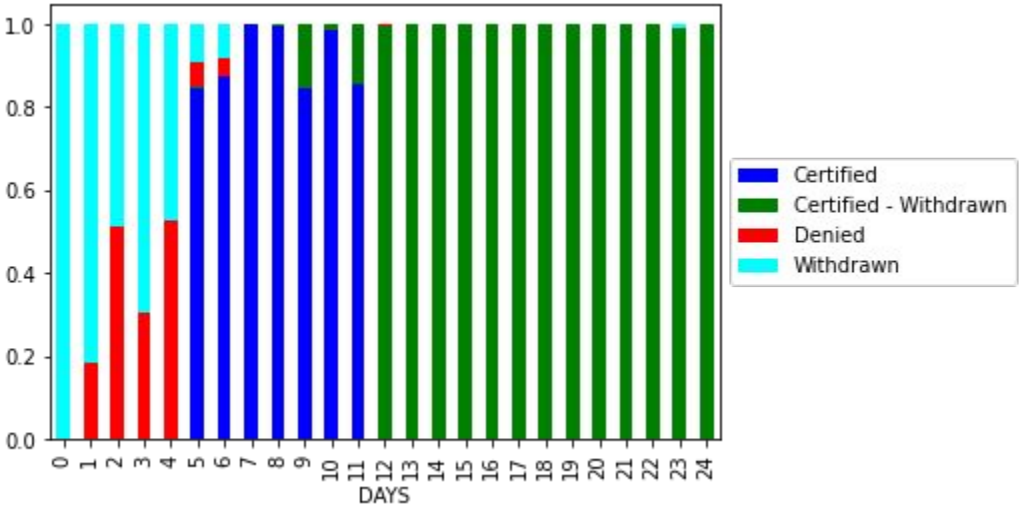
- Day 6 is the greatest in terms of replies
- With a total of 350000+ all landing on day 6

Number of Results per day 2+ weeks



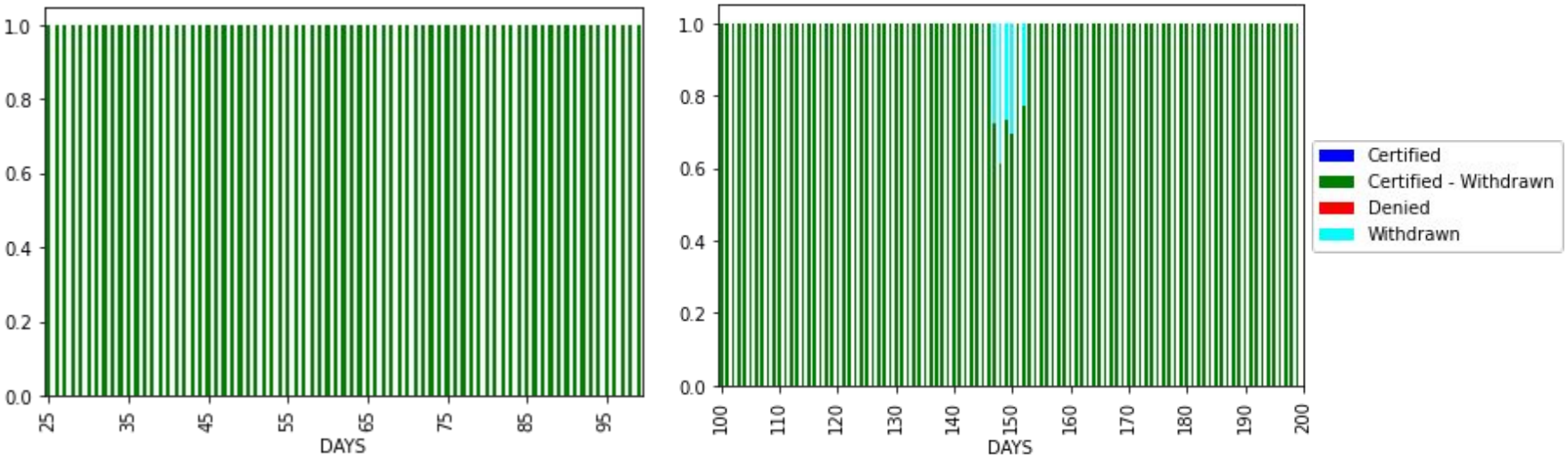
- Anything past the first two weeks usually gets very little replies.
- This is possibly due to the number of withdrawn and denied applications in the first two weeks

Breakdown of results per day within 4 weeks



- Most applicants get accepted with two weeks
- Past two weeks, mostly withdrawals

Breakdown of results per day past 4 weeks



Benchmarking using Logistic Regression

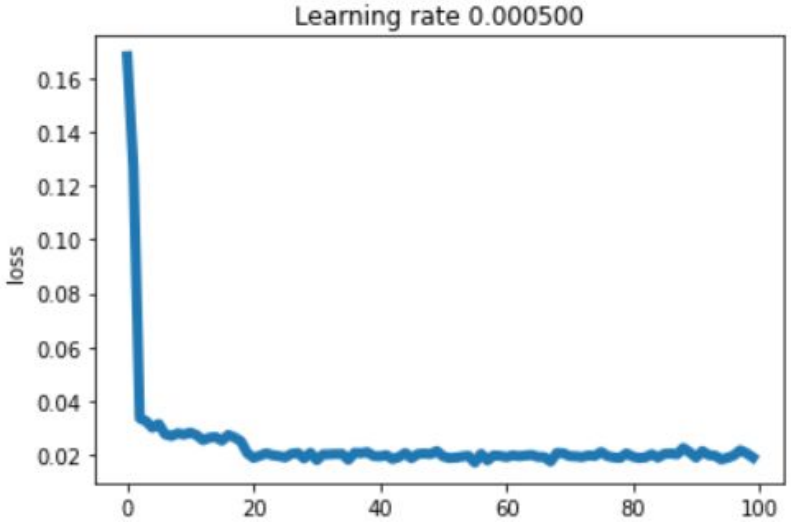
```
PERFORMANCE_OF_LOGISTIC_REGRESSION_TRAINING =  0.9558854230093422
PERFORMANCE_OF_LOGISTIC_REGRESSION_TESTING =   0.9563949505822488

              precision    recall  f1-score   support

           C       0.96      1.00      0.98     47503
          CW       1.00      0.57      0.72      2402
           W       0.00      0.00      0.00       233
           D       0.00      0.00      0.00       957

    accuracy                           0.96     51095
   macro avg       0.49      0.39      0.43     51095
weighted avg       0.94      0.96      0.94     51095
```

Good at Classifying Certified and Certified Withdrawn Cases.

In our case, They comprise of 99.5% of the data. Performs horribly bad on W, and D cases.

Accuracy Overall - 95.6 %. (Pretty good)
Avg F-score - 0.43 (Not good)
Avg weighted Fscore - 0.94

CNN



1. No. of Epochs - 100
2. Architecture -
   a. Layersize - 8(input), 16, 16, 8, 8, 8, 4 (output)
   b. ReLU on all layers and Softmax on the last layer.
3. Performance doesn't become better after 20th epoch.

Performance of CNN Model.

```
Accuracy of the model in MSE:  0.2030531363147079
PERFORMANCE_OF_CNN_REGRESSION_TRAINING =  0.9597627911831735
PERFORMANCE_OF_CNN_REGRESSION_TESTING =   0.9601722282023681
```

	precision	recall	f1-score	support
C	0.96	1.00	0.98	47503
CW	0.99	0.65	0.79	2402
W	0.00	0.00	0.00	233
D	0.00	0.00	0.00	957
accuracy			0.96	51095
macro avg	0.49	0.41	0.44	51095
weighted avg	0.94	0.96	0.95	51095

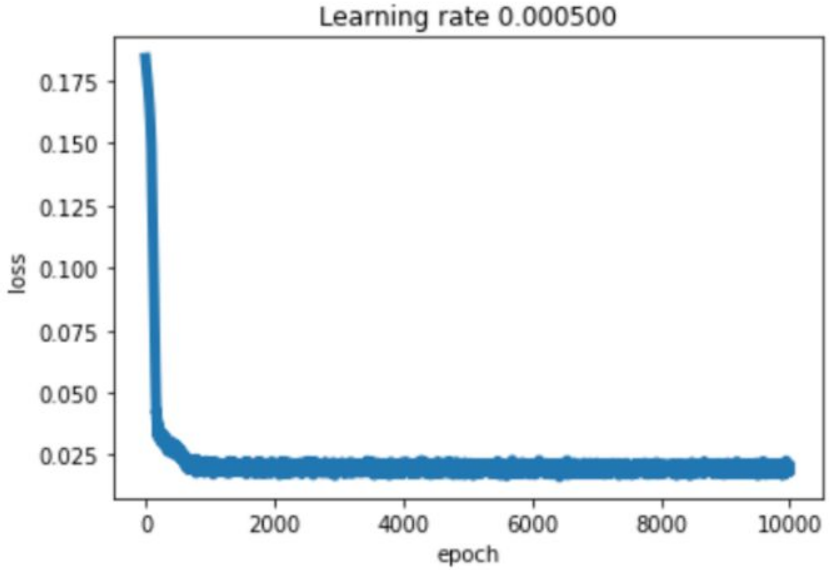
Slightly Better Performance that Logistic Regression.

But since the model isn't interpretable, we shouldn't choose it as best model.

The data is not complex enough to require neural net to predict status.

Accuracy Overall - 96.0 %. (Pretty good) **Avg F-score - 0.44 (Not good)** **Avg weighted F-score - 0.95**
(All slightly better than logistic regression)

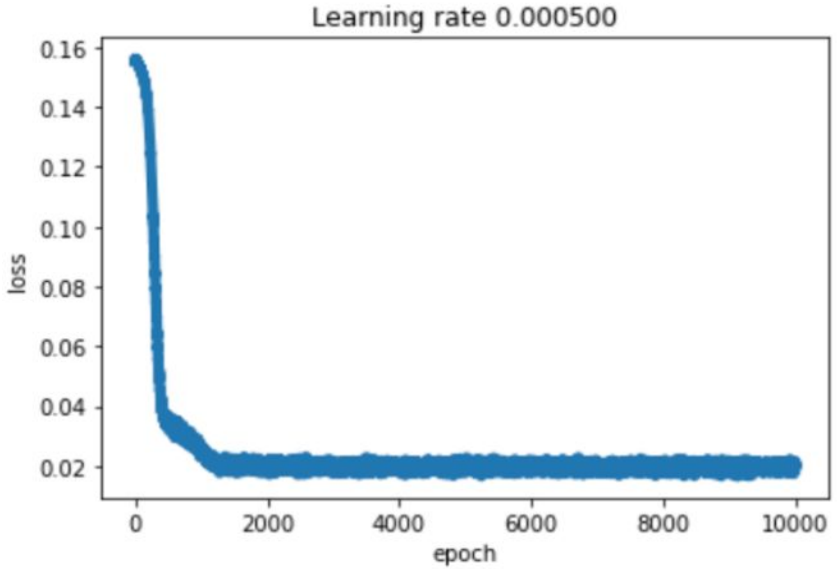
Running CNN with Different Optimizers (AdamW)




```
Accuracy of the model in MSE:  0.20039142773265486
PERFORMANCE_OF_LINEAR_REGRESSION_TRAINING =  0.9598476018162523
PERFORMANCE_OF_LINEAR_REGRESSION_TESTING =   0.959643800763284
```

	precision	recall	f1-score	support
C	0.96	1.00	0.98	47447
CW	0.99	0.65	0.78	2464
W	0.00	0.00	0.00	255
D	0.00	0.00	0.00	929
accuracy			0.96	51095
macro avg	0.49	0.41	0.44	51095
weighted avg	0.94	0.96	0.95	51095

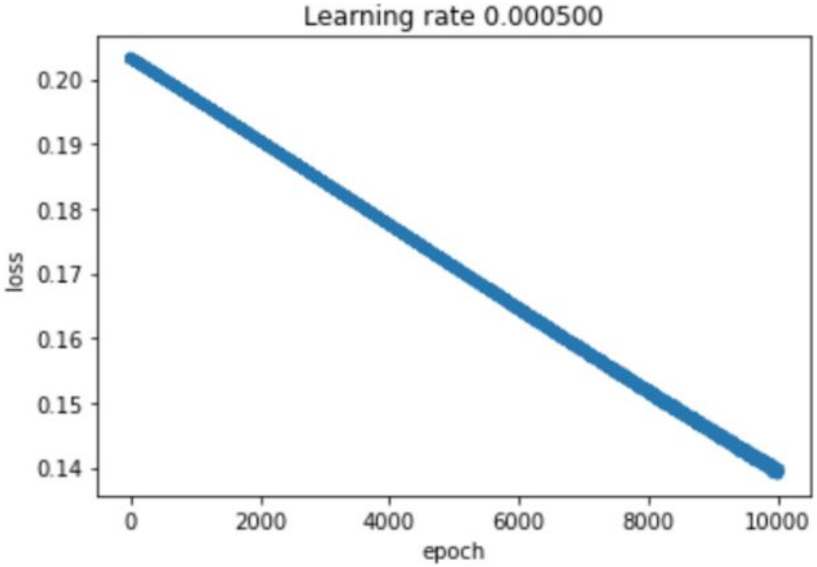
Running CNN with Different Optimizers (RAdam)




```
Accuracy of the model in MSE:  0.20046971327918583
PERFORMANCE_OF_LINEAR_REGRESSION_TRAINING =  0.9597497433934692
PERFORMANCE_OF_LINEAR_REGRESSION_TESTING =   0.9595655152167532
```

	precision	recall	f1-score	support
C	0.96	1.00	0.98	47447
CW	1.00	0.64	0.78	2464
W	0.00	0.00	0.00	255
D	0.00	0.00	0.00	929
accuracy			0.96	51095
macro avg	0.49	0.41	0.44	51095
weighted avg	0.94	0.96	0.95	51095

Running CNN with Different Optimizers (SGD)

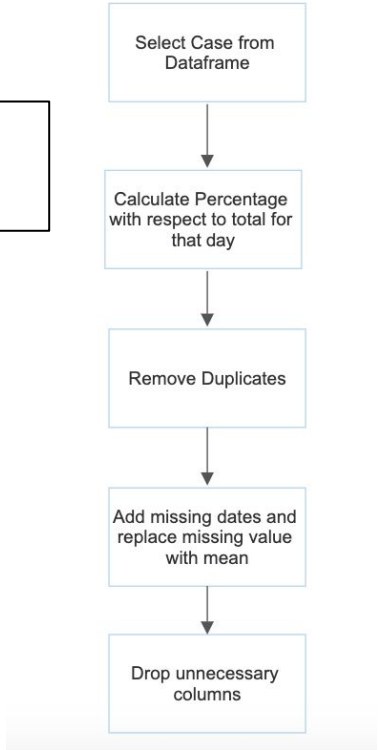


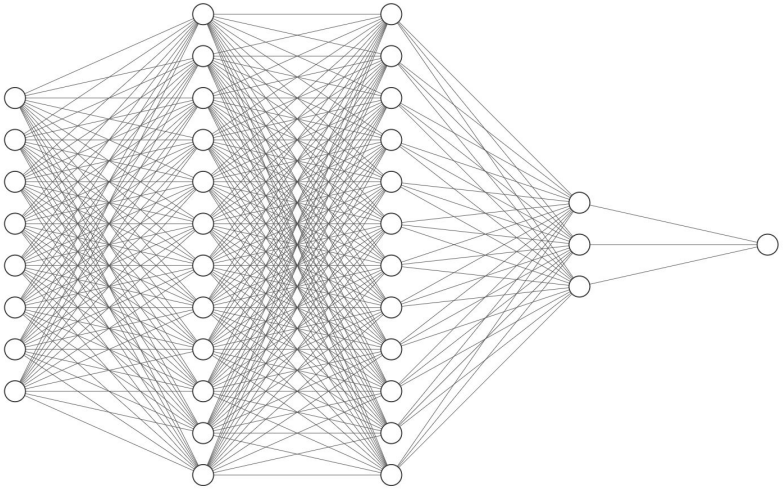

```
Accuracy of the model in MSE:  0.23182307466484
PERFORMANCE_OF_LINEAR_REGRESSION_TRAINING =  0.9287112263182616
PERFORMANCE_OF_LINEAR_REGRESSION_TESTING =   0.9286035815637538
```

	precision	recall	f1-score	support
C	0.93	1.00	0.96	47447
CW	0.00	0.00	0.00	2464
W	0.00	0.00	0.00	255
D	0.00	0.00	0.00	929
accuracy			0.93	51095
macro avg	0.23	0.25	0.24	51095
weighted avg	0.86	0.93	0.89	51095

LSTM Model

Data Preprocessing





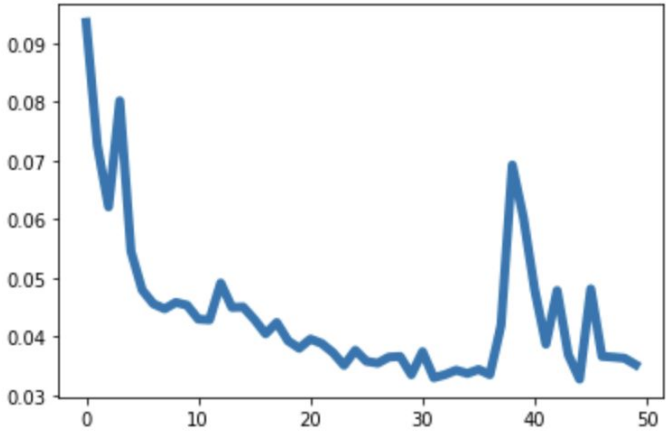
LSTM Architecture

Input Layer
Hidden Layer 1: 100 nodes
Hidden Layer 2: 100 nodes
Dense Layer 1: 25 nodes
Dense Layer 2: 1 node

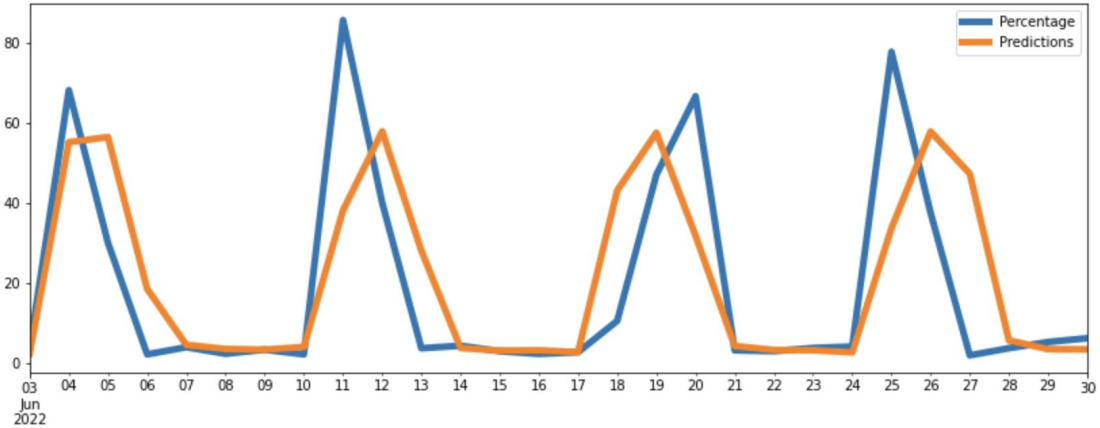
Epochs: 50, Optimizer: Adam, Loss: MSE

LSTM Result - Certified Withdrawn

Loss vs Epoch



Performance on Test Set

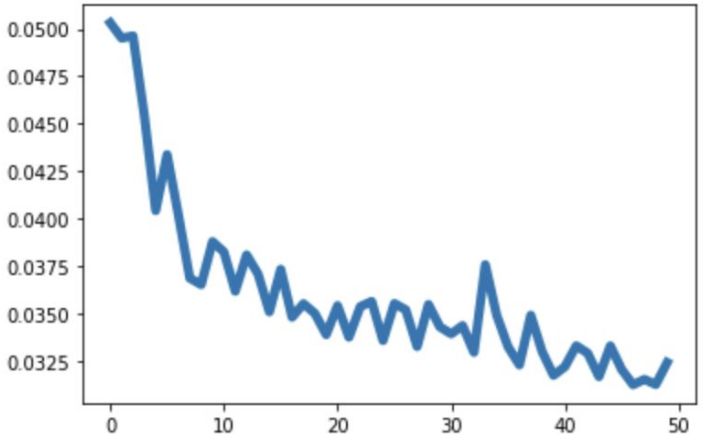


RSME: 19.95

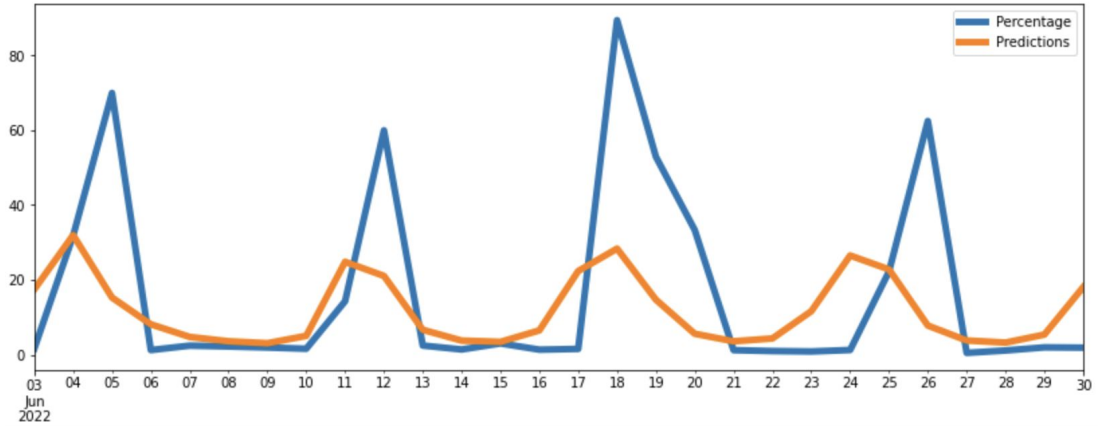
Code and slides by: Pranav Bhandari (ppb4)

LSTM Result - Withdrawn

Loss vs Epoch



Performance on Test Set

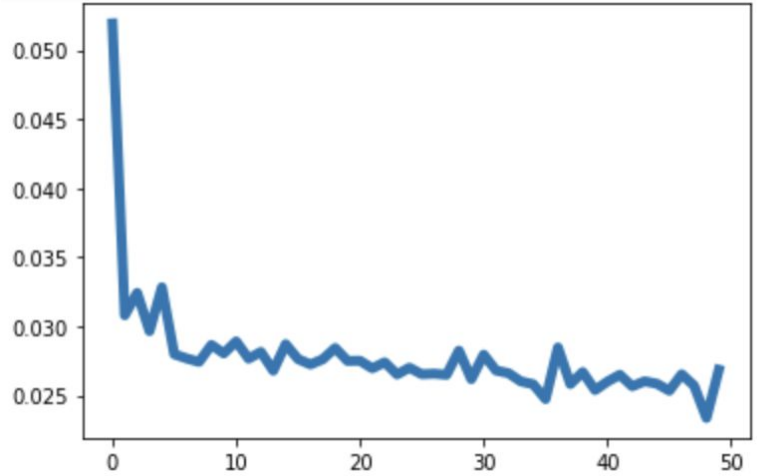


RSME: 23.49

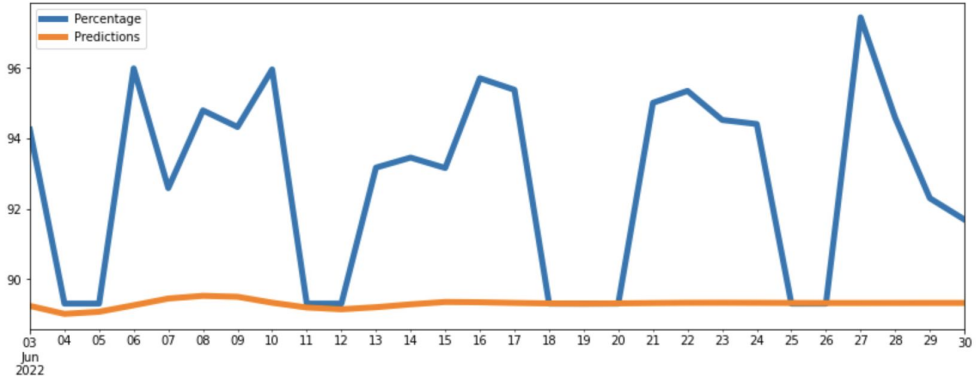
Code and slides by: Pranav Bhandari (ppb4)

LSTM Result - Certified

Loss vs Epoch



Performance on Test Set

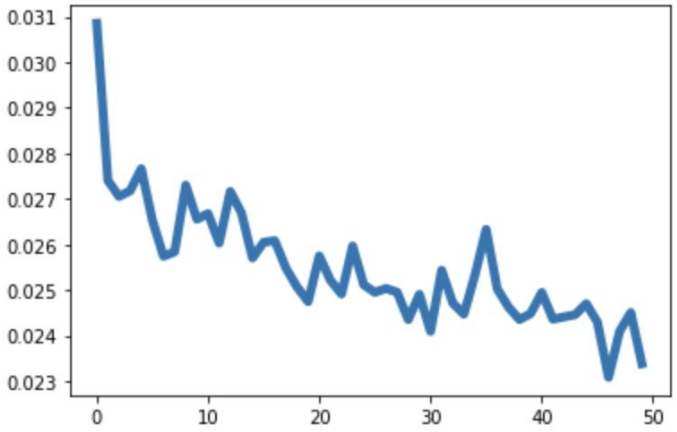


RSME: 4.35

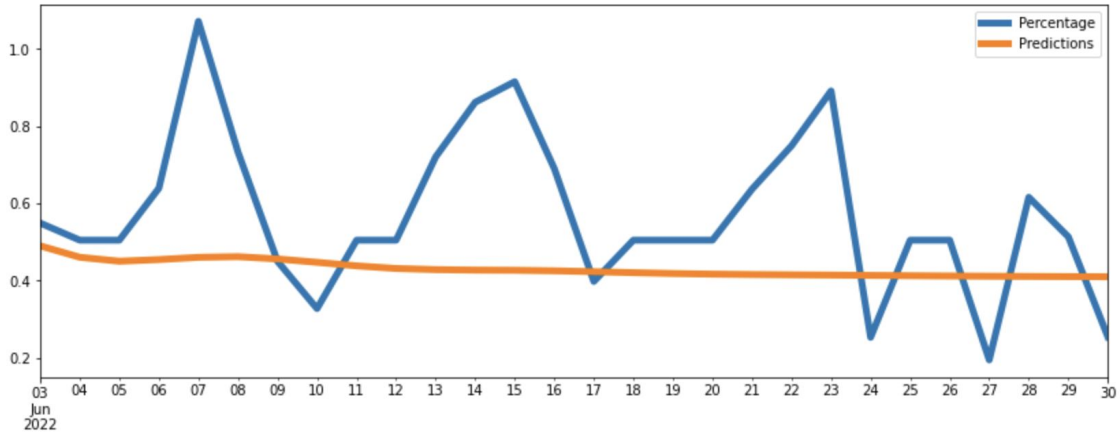
Code and slides by: Pranav Bhandari (ppb4)

LSTM Result - Denied

Loss vs Epoch



Performance on Test Set



RSME: 0.24

Code and slides by: Pranav Bhandari (ppb4)

Code Snippets

```
approved_pred = approved_predictor(False).to(device)

batch_size, lr = 10000, 5e-4

print(approved_pred)

approved_pred, losses = train(approved_pred, x_tr_tensor, y_tr_tensor_oh, learningRate=lr)

plt.plot(losses)
plt.ylabel('loss')
plt.xlabel('epoch')
plt.title("Learning rate %f"%(lr))
plt.show()


y_p_te = np.around( np.array(torch.argmax(approved_pred(x_te_tensor.float()) , dim=1).detach().cpu()))
y_p_tr = np.around( np.array(torch.argmax(approved_pred(x_tr_tensor.float()), dim=1).detach().cpu()))

conf_mat_tr = confusion_matrix(y_tr, y_p_tr)
conf_mat_te = confusion_matrix(y_te, y_p_te)
print("Training Confusion Matrix")
print(confusion_matrix(y_tr, y_p_tr))
print("\nTesting Confusion Matrix")
print(confusion_matrix(y_te, y_p_te))

print("\nAccuracy of the model in MSE: " , mean_squared_error(y_te, y_p_te) )
#print('r2_score_test :' ,r2_score(y_te, y_p_te))

test_models_regression['deep_le
```

```
class approved_predictor(nn.Module):
    def __init__(self, d_date=True):
        super(approved_predictor, self).__init__
        self.d_date = d_date
        inputSize = 11 if d_date else 8

        self.model = nn.Sequential(
            nn.Linear(inputSize, 16),
            nn.ReLU(),
            nn.Linear(16,16),
            nn.ReLU(),
            nn.Linear(16,8),
            nn.ReLU(),
            nn.Linear(8,8),
            nn.ReLU(),
            nn.Linear(8,8),
            nn.ReLU(),
            nn.Linear(8,8),
            nn.ReLU(),
            nn.Linear(8,4),
            nn.Softmax(dim=1)
        )

    def forward(self, x):
        if self.d_date == False:
            x = x[:, :8]
        return self.model(x)
```

```
for itr in range(MAX_iter):

    # Clear gradient buffers
    optimizer.zero_grad()

    # Create the iterations batch and labels
    rand_vec = torch.randint(0, points.size()[0
    batch = points.float()[rand_vec,:]
    batch_labels = labels.float()[rand_vec]

    # get output from the model, given the inpu
    outputs = model(batch)

    # get loss for the predicted output
    lossvalue = loss(outputs, batch_labels)
    if itr%100 == 0:
      losses.append(lossvalue.item())

    # get gradients w.r.t to parameters
    lossvalue.backward()

    optimizer.step()

    if itr % printEvery == 0:
        print("Epoch {}: loss={:.5f}".format(it

return model, losses
```

```
# Finding the best strategies for the data to altered and preprocessed for Lea

strategy = {}

for i in range(len(train_data.columns)):
    print(train_data.columns[i] , train_data.iloc[:, i].nunique(dropna = True))
    if (train_data.iloc[:, i].nunique(dropna = True) != train_data.iloc[:, i].
        strategy[i] = 'most_frequent'
    if (train_data.iloc[:, i].nunique(dropna = True) != train_data.iloc[:, i].
        strategy[i] = 'median'
print(strategy)
```

Code Snippets

```
def plotmap1(column,value,title):
    demo = data_viz.loc[data_viz['CASE_STATUS'] == value]
    experiment = demo.groupby(column).sum().rename(columns = {'WORKSITE_WORKERS' : 'Count'})
    fig = px.choropleth(experiment,
                        locations=experiment.index,
                        locationmode="USA-states",
                        scope="usa",
                        color='Count',
                        color_continuous_scale="Viridis_r"
                        )

    fig.update_layout(
          title_text = title,
          title_font_family="Times New Roman",
          title_font_size = 22,
          title_font_color="black",
          title_x=0.45,
          showlegend=False
            )
    fig.show()
```

```
# Dropping rows with missing values
data_x.dropna(inplace = True)

# Converting Decision date and received date to date time
data_x['DECISION_DATE'] = pd.to_datetime(data_x['DECISION_DATE'])
data_x['RECEIVED_DATE'] = pd.to_datetime(data_x['RECEIVED_DATE'])

# Sorting by decision date
data_x.sort_values(by = ['DECISION_DATE'],inplace = True)

#Dropping columns not needed in LSTM
data_x.drop(['RECEIVED_DATE','EMPLOYER_CITY','EMPLOYER_STATE','WORKSITE_CITY','WORKSITE_STATE','WORKSITE_WORKERS'],axis = 1,inplace = Tru

# Adding total visas processed per data to dataframe
trial = {}
sum = 0
for i in data_x['DECISION_DATE']:
  if i not in trial:
    trial[i] = 1
  else:
    trial[i] += 1

for k,v in trial.items():
  data_x.loc[data_x['DECISION_DATE'] == k, 'TOTAL_COUNT'] = int(v)

#Resetting the index to get correct dates
data_x.reset_index(drop=True, inplace=True)
```

```
def data_prep_lstm(case):
  # Creating a copy of the dataset
  data_x_copy = data_x.copy()

  # Filtering to particular case status
  certified = data_x_copy[data_x_copy["CASE_STATUS"] == case]

  #Finding percentage of case status with respect to total visas given that day
  certified1 = {}
  sum = 0
  for i in certified['DECISION_DATE']:
    if i not in certified1:
      certified1[i] = 1
    else:
      certified1[i] += 1
  for k,v in certified1.items():
    certified.loc[certified['DECISION_DATE'] == k, 'COUNT'] = int(v)

  #Dropping duplicate decision dates
  certified = certified.drop_duplicates(subset=['DECISION_DATE'], keep='last')

  #Finding percentage
  certified['Percentage'] = (certified['COUNT']/certified['TOTAL_COUNT'])*100

  #Dropping unrequired columns
  certified.drop(['CASE_STATUS','TOTAL_COUNT','COUNT'],axis = 1,inplace = True)

  #Setting decision date as the index
  certified.reset_index(drop=True, inplace=True)
  certified.set_index('DECISION_DATE',inplace = True)
```

```
#Dropping unrequired columns
certified.drop(['CASE_STATUS','TOTAL_COUNT','COUNT'],axis = 1,inplace = True)

#Setting decision date as the index
certified.reset_index(drop=True, inplace=True)
certified.set_index('DECISION_DATE',inplace = True)

#Adding missing dates
new_date_range = pd.date_range(start=data_x['DECISION_DATE'][0], end=data_x['DECISION_DATE'].iat[-1],
                               freq="D")
certified = certified.reindex(new_date_range, fill_value=np.NaN)

#Filling missing values for newly added dates by mean
certified = certified.fillna(certified.mean())

return certified
```

Slide and Code by: Pranav Bhandari (ppb4)

Thanks!