# ECE657A_A3COVID_Group100

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## 1 THE COVID-19 DATASET ANALYSIS (CM1-4)


#### 1.0.1 Group 100

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[9]:
```
 import tensorflow as tf
 tf.config.run_functions_eagerly(True)
import keras
from keras.models import Sequential
import pandas as pd
from keras.layers import Dense, SimpleRNN, LSTM
import matplotlib.pyplot as plt
import numpy as np
from sklearn.model_selection import train_test_split
import time
from tensorflow.keras.callbacks import EarlyStopping
```

## 2 CM1 Preprocessing

[10]:
```
# load dkmacovid training data
df = pd.read_csv('dkmacovid_train.csv')

# remove comma from dataframe in 'Resident Population 2020 Census' and␣
 ↪'Population Density 2020 Census'
df = df.replace(',','', regex=True)
# convert string to numeric data
df['Resident Population 2020 Census'] = df['Resident Population 2020 Census'].
 ↪astype(float)
df['Population Density 2020 Census'] = df['Population Density 2020 Census'].
 ↪astype(float)
df['Confirmed'].replace({True:1,False:0},inplace=True)
df['Deaths'].replace({True:1,False:0},inplace=True)
df['Recovered'].replace({True:1,False:0},inplace=True)

from sklearn.preprocessing import StandardScaler
```

```
std_scaler = StandardScaler()
# select features to normalize
features=['Day','State ID','Lat','Long_','Active', 'Incident_Rate',␣
 ↪'Total_Test_Results', 'Case_Fatality_Ratio', 'Testing_Rate', 'Resident␣
 ↪Population 2020 Census', 'Population Density 2020 Census', 'Density Rank␣
 ↪2020 Census', 'SexRatio']
df_z= df.loc[:,features]
df_z.iloc[:,:]=std_scaler.fit_transform(df_z.iloc[:,:])
df_z.head()

X= df_z.loc[:,features]
# set y1= Confirmed y2= deaths y3= Recovered
y1=df.loc[:,'Confirmed']
y2=df.loc[:,'Deaths']
y3=df.loc[:,'Recovered']
```

[11]:
```
df.isnull().sum()
```

[11]:
```
Day                                0
State ID                           0
State                              0
Lat                                0
Long_                              0
Active                             0
Incident_Rate                      0
Total_Test_Results                 0
Case_Fatality_Ratio                0
Testing_Rate                       0
Resident Population 2020 Census    0
Population Density 2020 Census     0
Density Rank 2020 Census           0
SexRatio                           0
Confirmed                          0
Deaths                             0
Recovered                          0
dtype: int64
```

The dataset was checked for null values as the presence of these can hamper the performance of neural networks which are trained on the data for further analysis.

Some other pre-processing steps were performed to convert the data into a neural network ready format. This included removing 'commas' from some columns and updating the data types for columns which contained numbers in string formats. Finally, the dataset columns were scaled using StandardScaler. This is an important stpe to enhance the training and performance of neural networks.

Defining below some functions to be used for training further models

[12]:
```
#Defining a function which will be used for plotting model performance graphs
def plot_metric(history, metric):
    train_metrics = history.history[metric]
    val_metrics = history.history['val_'+metric]
    epochs = range(1, len(train_metrics) + 1)
    plt.plot(epochs, train_metrics)
    plt.plot(epochs, val_metrics)
    plt.title('Training and validation '+ metric)
    plt.xlabel("Epochs")
    plt.ylabel(metric)
    plt.legend(["train_"+metric, 'val_'+metric])
    plt.show()
```

[13]:
```
def model_trainer_1(model, y, X, epo, batch, es):
  model.reset_metrics()
  model.reset_states()
  y=np.ravel(y)
  X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
↪2,random_state =0)
  features = X_train.shape[1]
  strat_time = time.time()

  # ADD early stopping [1]
  if (es=='0'):
    history = model.fit(X_train,y_train,epochs=epo,validation_split=0.25,␣
↪batch_size=batch)
  else:
    history = model.fit(X_train,y_train,epochs=epo,validation_split=0.25,␣
↪batch_size=batch, callbacks=[es])

  end_time = time.time()
  print("Running time is {:.2f} seconds per {} epoches".
↪format(end_time-strat_time, epo))
  loss, acc = model.evaluate(X_test, y_test, verbose=0)
  print('Test Accuracy: %.3f' % acc)

  return history
```

## 3 CM2

Below is a neural network which has 2 hidden layers with 20 units each. The activation function used in both the layers is ReLU activation. For the output layer, softmax activation function has been used. Three separate models have been trained for the labels 'Confirmed', 'Recovered' and 'Deaths'.

[14]:
```
model_cm2 = Sequential()
model_cm2.add(Dense(20, activation='relu', input_shape=(13,)))
model_cm2.add(Dense(20, activation='relu'))
model_cm2.add(Dense(1, activation='softmax'))
model_cm2.compile(loss='binary_crossentropy',
              optimizer='sgd',
              metrics=['accuracy'])
```

[15]:
```
es_cm2= EarlyStopping(
    monitor='val_loss',
    patience=8,
    min_delta=0.001,

)
```

[16]:
```
history_cm2_y1=model_trainer_1(model_cm2, y1, X, 200, 10,es_cm2)
```

```
Epoch 1/200
 3/83 [>…] - ETA: 2s - loss: 0.4435 - accuracy:
0.9389

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

81/83 [============================>.] - ETA: 0s - loss: 0.4513 - accuracy:
0.9603

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 2s 29ms/step - loss: 0.4494 - accuracy:
0.9603 - val_loss: 0.3042 - val_accuracy: 0.9710
Epoch 2/200
83/83 [==============================] - 2s 30ms/step - loss: 0.3027 - accuracy:
0.9442 - val_loss: 0.2153 - val_accuracy: 0.9710
```

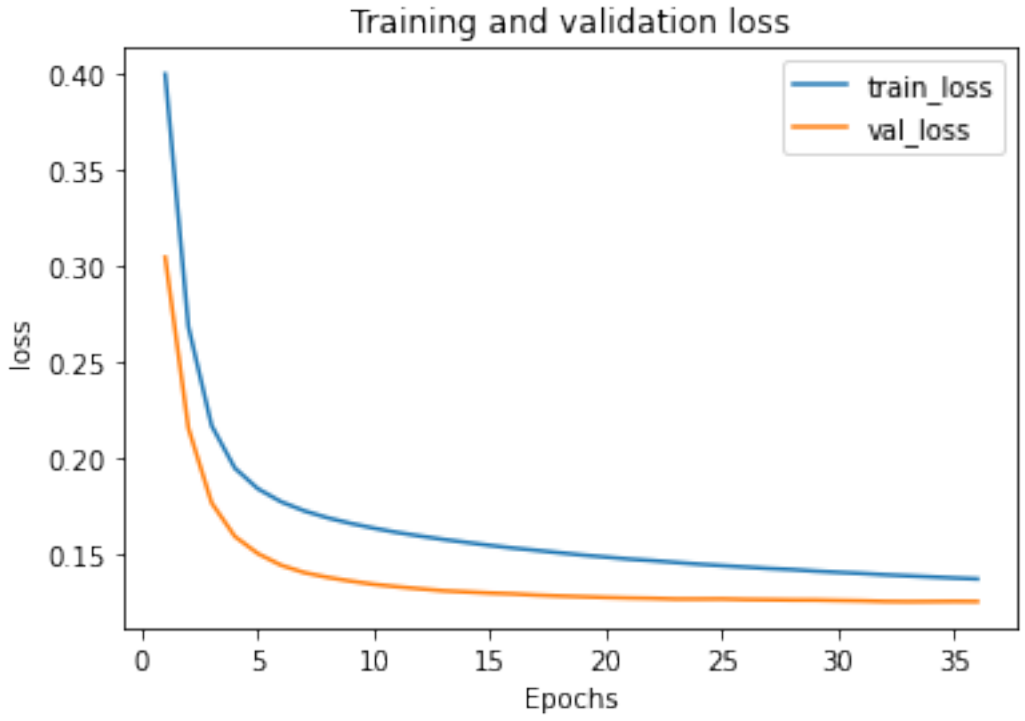
```
Epoch 3/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2551 - accuracy:
0.9448 - val_loss: 0.1764 - val_accuracy: 0.9710
Epoch 4/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2307 - accuracy:
0.9484 - val_loss: 0.1590 - val_accuracy: 0.9710
Epoch 5/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1669 - accuracy:
0.9664 - val_loss: 0.1500 - val_accuracy: 0.9710
Epoch 6/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1814 - accuracy:
0.9547 - val_loss: 0.1440 - val_accuracy: 0.9710
Epoch 7/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1684 - accuracy:
0.9605 - val_loss: 0.1401 - val_accuracy: 0.9710
Epoch 8/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1520 - accuracy:
0.9651 - val_loss: 0.1377 - val_accuracy: 0.9710
Epoch 9/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1674 - accuracy:
0.9562 - val_loss: 0.1357 - val_accuracy: 0.9710
Epoch 10/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1702 - accuracy:
0.9551 - val_loss: 0.1340 - val_accuracy: 0.9710
Epoch 11/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1584 - accuracy:
0.9588 - val_loss: 0.1328 - val_accuracy: 0.9710
Epoch 12/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1613 - accuracy:
0.9588 - val_loss: 0.1317 - val_accuracy: 0.9710
Epoch 13/200
83/83 [==============================] - 3s 30ms/step - loss: 0.1740 - accuracy:
0.9515 - val_loss: 0.1307 - val_accuracy: 0.9710
Epoch 14/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1488 - accuracy:
0.9610 - val_loss: 0.1301 - val_accuracy: 0.9710
Epoch 15/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1524 - accuracy:
0.9577 - val_loss: 0.1295 - val_accuracy: 0.9710
Epoch 16/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1290 - accuracy:
0.9660 - val_loss: 0.1291 - val_accuracy: 0.9710
Epoch 17/200
83/83 [==============================] - 3s 31ms/step - loss: 0.1845 - accuracy:
0.9494 - val_loss: 0.1284 - val_accuracy: 0.9710
Epoch 18/200
83/83 [==============================] - 3s 31ms/step - loss: 0.1680 - accuracy:
0.9496 - val_loss: 0.1280 - val_accuracy: 0.9710
```

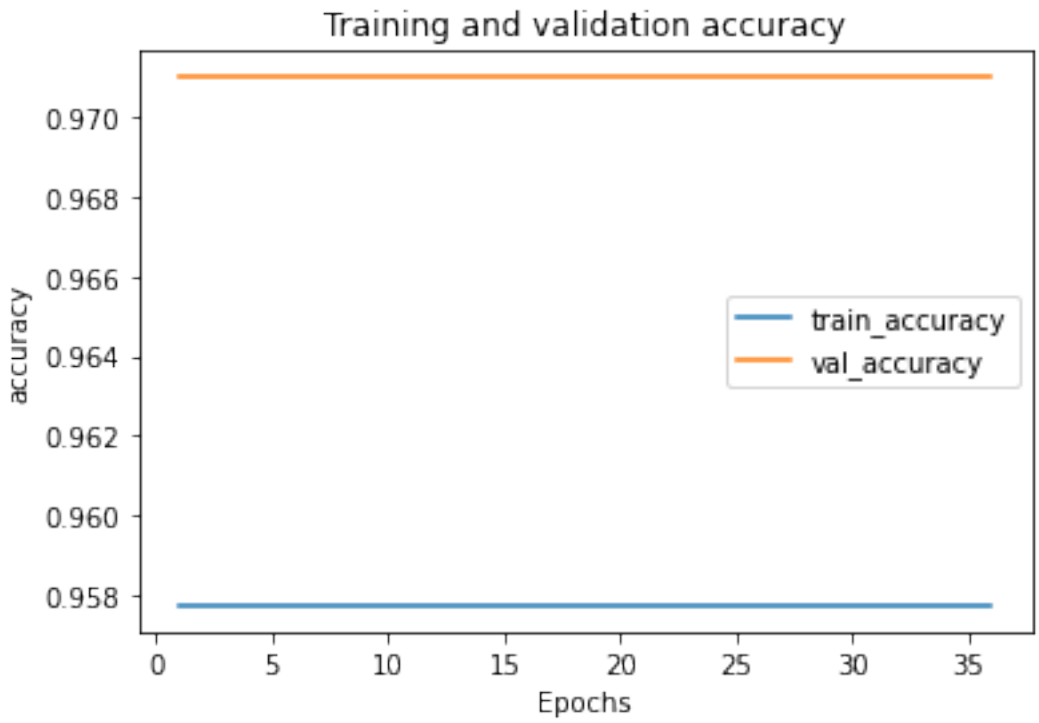
```
Epoch 19/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1813 - accuracy:
0.9467 - val_loss: 0.1276 - val_accuracy: 0.9710
Epoch 20/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1797 - accuracy:
0.9485 - val_loss: 0.1272 - val_accuracy: 0.9710
Epoch 21/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1452 - accuracy:
0.9561 - val_loss: 0.1269 - val_accuracy: 0.9710
Epoch 22/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1388 - accuracy:
0.9639 - val_loss: 0.1268 - val_accuracy: 0.9710
Epoch 23/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1598 - accuracy:
0.9512 - val_loss: 0.1264 - val_accuracy: 0.9710
Epoch 24/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1126 - accuracy:
0.9708 - val_loss: 0.1264 - val_accuracy: 0.9710
Epoch 25/200
83/83 [==============================] - 2s 28ms/step - loss: 0.0986 - accuracy:
0.9763 - val_loss: 0.1264 - val_accuracy: 0.9710
Epoch 26/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1253 - accuracy:
0.9649 - val_loss: 0.1262 - val_accuracy: 0.9710
Epoch 27/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1272 - accuracy:
0.9649 - val_loss: 0.1261 - val_accuracy: 0.9710
Epoch 28/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1390 - accuracy:
0.9590 - val_loss: 0.1259 - val_accuracy: 0.9710
Epoch 29/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1135 - accuracy:
0.9697 - val_loss: 0.1259 - val_accuracy: 0.9710
Epoch 30/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1630 - accuracy:
0.9523 - val_loss: 0.1256 - val_accuracy: 0.9710
Epoch 31/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1104 - accuracy:
0.9683 - val_loss: 0.1255 - val_accuracy: 0.9710
Epoch 32/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1640 - accuracy:
0.9469 - val_loss: 0.1252 - val_accuracy: 0.9710
Epoch 33/200
83/83 [==============================] - 2s 26ms/step - loss: 0.1380 - accuracy:
0.9586 - val_loss: 0.1250 - val_accuracy: 0.9710
Epoch 34/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1335 - accuracy:
0.9612 - val_loss: 0.1251 - val_accuracy: 0.9710
```

```
Epoch 35/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1155 - accuracy:
0.9635 - val_loss: 0.1252 - val_accuracy: 0.9710
Epoch 36/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1432 - accuracy:
0.9582 - val_loss: 0.1251 - val_accuracy: 0.9710
Running time is 84.82 seconds per 200 epoches
Test Accuracy: 0.971

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[17]:
```
plot_metric(history_cm2_y1,'loss')
plot_metric(history_cm2_y1,'accuracy')
```






[18]:
```
history_cm2_y2=model_trainer_1(model_cm2, y2, X, 200, 10,es_cm2)
```

```
Epoch 1/200
 4/83 [>…] - ETA: 1s - loss: 0.1035 - accuracy:
0.9750

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

82/83 [============================>.] - ETA: 0s - loss: 0.3786 - accuracy:
0.9000

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
```

```
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
83/83 [==============================] - 2s 27ms/step - loss: 0.3758 - accuracy:
0.9010 - val_loss: 0.3686 - val_accuracy: 0.8986
Epoch 2/200
83/83 [==============================] - 2s 29ms/step - loss: 0.3177 - accuracy:
0.9010 - val_loss: 0.3325 - val_accuracy: 0.8986
Epoch 3/200
83/83 [==============================] - 2s 26ms/step - loss: 0.3008 - accuracy:
0.9010 - val_loss: 0.3175 - val_accuracy: 0.8986
Epoch 4/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2922 - accuracy:
0.9010 - val_loss: 0.3084 - val_accuracy: 0.8986
Epoch 5/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2858 - accuracy:
0.9010 - val_loss: 0.3007 - val_accuracy: 0.8986
Epoch 6/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2804 - accuracy:
0.9010 - val_loss: 0.2944 - val_accuracy: 0.8986
Epoch 7/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2759 - accuracy:
0.9010 - val_loss: 0.2890 - val_accuracy: 0.8986
Epoch 8/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2714 - accuracy:
0.9010 - val_loss: 0.2844 - val_accuracy: 0.8986
Epoch 9/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2678 - accuracy:
0.9010 - val_loss: 0.2798 - val_accuracy: 0.8986
Epoch 10/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2647 - accuracy:
0.9010 - val_loss: 0.2764 - val_accuracy: 0.8986
Epoch 11/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2617 - accuracy:
0.9010 - val_loss: 0.2739 - val_accuracy: 0.8986
Epoch 12/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2592 - accuracy:
0.9010 - val_loss: 0.2718 - val_accuracy: 0.8986
Epoch 13/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2567 - accuracy:
0.9010 - val_loss: 0.2697 - val_accuracy: 0.8986
Epoch 14/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2546 - accuracy:
0.9010 - val_loss: 0.2680 - val_accuracy: 0.8986
Epoch 15/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2526 - accuracy:
0.9010 - val_loss: 0.2669 - val_accuracy: 0.8986
```

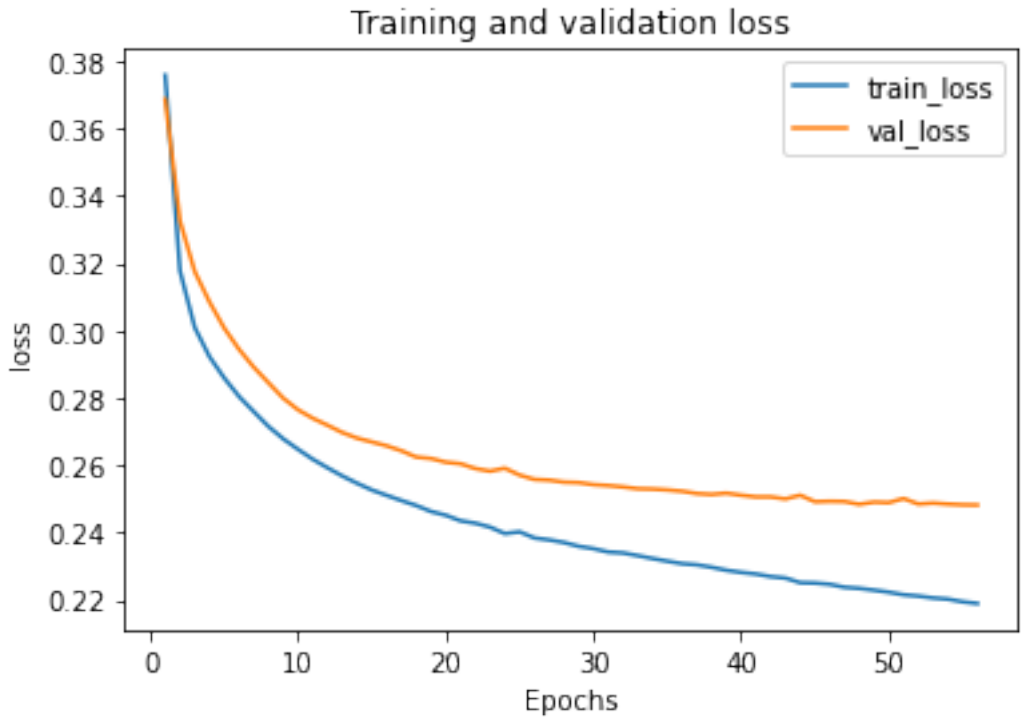
```
Epoch 16/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2510 - accuracy:
0.9010 - val_loss: 0.2657 - val_accuracy: 0.8986
Epoch 17/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2495 - accuracy:
0.9010 - val_loss: 0.2642 - val_accuracy: 0.8986
Epoch 18/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2480 - accuracy:
0.9010 - val_loss: 0.2624 - val_accuracy: 0.8986
Epoch 19/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2462 - accuracy:
0.9010 - val_loss: 0.2620 - val_accuracy: 0.8986
Epoch 20/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2451 - accuracy:
0.9010 - val_loss: 0.2609 - val_accuracy: 0.8986
Epoch 21/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2435 - accuracy:
0.9010 - val_loss: 0.2604 - val_accuracy: 0.8986
Epoch 22/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2427 - accuracy:
0.9010 - val_loss: 0.2590 - val_accuracy: 0.8986
Epoch 23/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2416 - accuracy:
0.9010 - val_loss: 0.2582 - val_accuracy: 0.8986
Epoch 24/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2397 - accuracy:
0.9010 - val_loss: 0.2591 - val_accuracy: 0.8986
Epoch 25/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2402 - accuracy:
0.9010 - val_loss: 0.2570 - val_accuracy: 0.8986
Epoch 26/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2384 - accuracy:
0.9010 - val_loss: 0.2557 - val_accuracy: 0.8986
Epoch 27/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2378 - accuracy:
0.9010 - val_loss: 0.2555 - val_accuracy: 0.8986
Epoch 28/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2370 - accuracy:
0.9010 - val_loss: 0.2549 - val_accuracy: 0.8986
Epoch 29/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2359 - accuracy:
0.9010 - val_loss: 0.2548 - val_accuracy: 0.8986
Epoch 30/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2352 - accuracy:
0.9010 - val_loss: 0.2542 - val_accuracy: 0.8986
Epoch 31/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2342 - accuracy:
0.9010 - val_loss: 0.2539 - val_accuracy: 0.8986
```

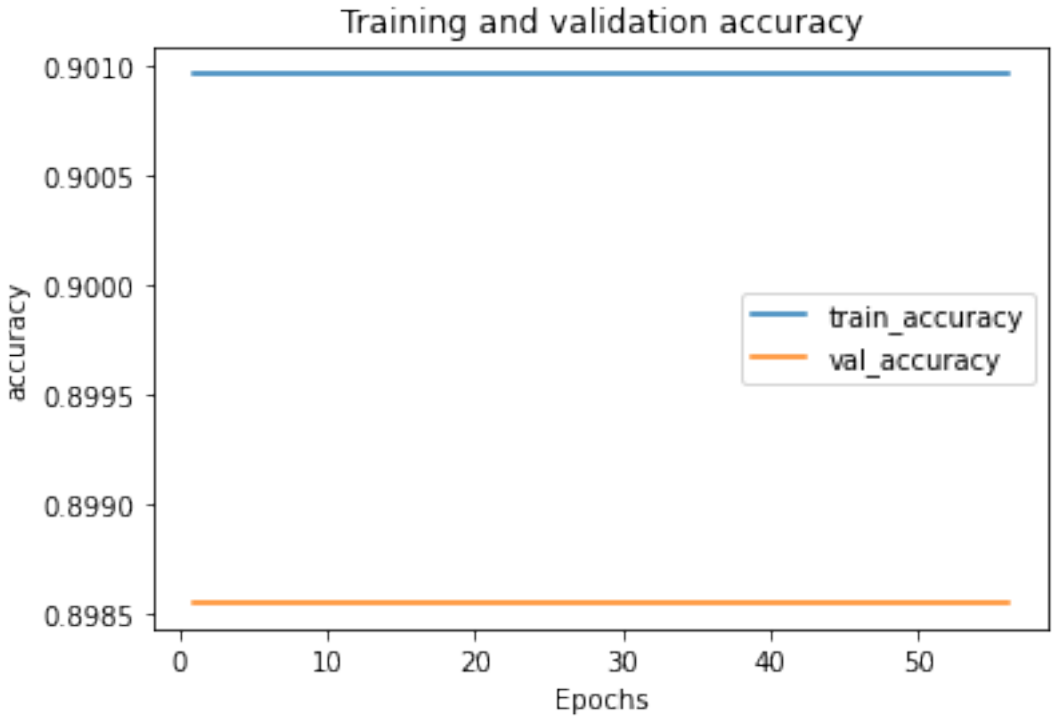
```
Epoch 32/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2339 - accuracy:
0.9010 - val_loss: 0.2535 - val_accuracy: 0.8986
Epoch 33/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2331 - accuracy:
0.9010 - val_loss: 0.2530 - val_accuracy: 0.8986
Epoch 34/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2323 - accuracy:
0.9010 - val_loss: 0.2529 - val_accuracy: 0.8986
Epoch 35/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2315 - accuracy:
0.9010 - val_loss: 0.2526 - val_accuracy: 0.8986
Epoch 36/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2307 - accuracy:
0.9010 - val_loss: 0.2522 - val_accuracy: 0.8986
Epoch 37/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2304 - accuracy:
0.9010 - val_loss: 0.2515 - val_accuracy: 0.8986
Epoch 38/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2297 - accuracy:
0.9010 - val_loss: 0.2513 - val_accuracy: 0.8986
Epoch 39/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2288 - accuracy:
0.9010 - val_loss: 0.2517 - val_accuracy: 0.8986
Epoch 40/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2281 - accuracy:
0.9010 - val_loss: 0.2510 - val_accuracy: 0.8986
Epoch 41/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2277 - accuracy:
0.9010 - val_loss: 0.2506 - val_accuracy: 0.8986
Epoch 42/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2269 - accuracy:
0.9010 - val_loss: 0.2506 - val_accuracy: 0.8986
Epoch 43/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2265 - accuracy:
0.9010 - val_loss: 0.2500 - val_accuracy: 0.8986
Epoch 44/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2251 - accuracy:
0.9010 - val_loss: 0.2511 - val_accuracy: 0.8986
Epoch 45/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2250 - accuracy:
0.9010 - val_loss: 0.2491 - val_accuracy: 0.8986
Epoch 46/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2246 - accuracy:
0.9010 - val_loss: 0.2493 - val_accuracy: 0.8986
Epoch 47/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2237 - accuracy:
0.9010 - val_loss: 0.2492 - val_accuracy: 0.8986
```

```
Epoch 48/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2234 - accuracy:
0.9010 - val_loss: 0.2484 - val_accuracy: 0.8986
Epoch 49/200
83/83 [==============================] - 3s 31ms/step - loss: 0.2229 - accuracy:
0.9010 - val_loss: 0.2490 - val_accuracy: 0.8986
Epoch 50/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2223 - accuracy:
0.9010 - val_loss: 0.2489 - val_accuracy: 0.8986
Epoch 51/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2215 - accuracy:
0.9010 - val_loss: 0.2501 - val_accuracy: 0.8986
Epoch 52/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2211 - accuracy:
0.9010 - val_loss: 0.2484 - val_accuracy: 0.8986
Epoch 53/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2206 - accuracy:
0.9010 - val_loss: 0.2487 - val_accuracy: 0.8986
Epoch 54/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2202 - accuracy:
0.9010 - val_loss: 0.2484 - val_accuracy: 0.8986
Epoch 55/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2194 - accuracy:
0.9010 - val_loss: 0.2482 - val_accuracy: 0.8986
Epoch 56/200
83/83 [==============================] - 3s 31ms/step - loss: 0.2189 - accuracy:
0.9010 - val_loss: 0.2481 - val_accuracy: 0.8986
Running time is 127.96 seconds per 200 epoches
Test Accuracy: 0.906
```

```
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[19]:
```
plot_metric(history_cm2_y2,'loss')
plot_metric(history_cm2_y2,'accuracy')
```


Training and validation loss
train_loss
val_loss
loss
Epochs
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0
10
20
30
40
50


Training and validation accuracy
train_accuracy
val_accuracy
accuracy
Epochs
0.9010
0.9005
0.9000
0.8995
0.8990
0.8985
0
10
20
30
40
50

[20]:
```
history_cm2_y3=model_trainer_1(model_cm2, y3, X, 200, 10,es_cm2)
```

```
Epoch 1/200
 4/83 [>…] - ETA: 1s - loss: 1.7716 - accuracy:
0.5750

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

81/83 [============================>.] - ETA: 0s - loss: 0.9266 - accuracy:
0.6222

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 3s 31ms/step - loss: 0.9180 - accuracy:
0.6232 - val_loss: 0.6771 - val_accuracy: 0.6196
Epoch 2/200
83/83 [==============================] - 2s 27ms/step - loss: 0.6151 - accuracy:
0.6232 - val_loss: 0.5639 - val_accuracy: 0.6196
Epoch 3/200
83/83 [==============================] - 2s 27ms/step - loss: 0.5332 - accuracy:
0.6232 - val_loss: 0.5077 - val_accuracy: 0.6196
Epoch 4/200
83/83 [==============================] - 2s 27ms/step - loss: 0.4853 - accuracy:
0.6232 - val_loss: 0.4726 - val_accuracy: 0.6196
Epoch 5/200
83/83 [==============================] - 2s 28ms/step - loss: 0.4532 - accuracy:
0.6232 - val_loss: 0.4473 - val_accuracy: 0.6196
Epoch 6/200
83/83 [==============================] - 2s 27ms/step - loss: 0.4290 - accuracy:
0.6232 - val_loss: 0.4269 - val_accuracy: 0.6196
Epoch 7/200
83/83 [==============================] - 2s 27ms/step - loss: 0.4093 - accuracy:
0.6232 - val_loss: 0.4109 - val_accuracy: 0.6196
Epoch 8/200
```

```
83/83 [==============================] - 2s 28ms/step - loss: 0.3933 - accuracy:
0.6232 - val_loss: 0.3977 - val_accuracy: 0.6196
Epoch 9/200
83/83 [==============================] - 2s 30ms/step - loss: 0.3799 - accuracy:
0.6232 - val_loss: 0.3851 - val_accuracy: 0.6196
Epoch 10/200
83/83 [==============================] - 2s 27ms/step - loss: 0.3678 - accuracy:
0.6232 - val_loss: 0.3743 - val_accuracy: 0.6196
Epoch 11/200
83/83 [==============================] - 2s 28ms/step - loss: 0.3573 - accuracy:
0.6232 - val_loss: 0.3646 - val_accuracy: 0.6196
Epoch 12/200
83/83 [==============================] - 2s 29ms/step - loss: 0.3474 - accuracy:
0.6232 - val_loss: 0.3559 - val_accuracy: 0.6196
Epoch 13/200
83/83 [==============================] - 2s 28ms/step - loss: 0.3394 - accuracy:
0.6232 - val_loss: 0.3475 - val_accuracy: 0.6196
Epoch 14/200
83/83 [==============================] - 2s 28ms/step - loss: 0.3314 - accuracy:
0.6232 - val_loss: 0.3396 - val_accuracy: 0.6196
Epoch 15/200
83/83 [==============================] - 2s 29ms/step - loss: 0.3239 - accuracy:
0.6232 - val_loss: 0.3309 - val_accuracy: 0.6196
Epoch 16/200
83/83 [==============================] - 2s 29ms/step - loss: 0.3169 - accuracy:
0.6232 - val_loss: 0.3264 - val_accuracy: 0.6196
Epoch 17/200
83/83 [==============================] - 2s 28ms/step - loss: 0.3109 - accuracy:
0.6232 - val_loss: 0.3178 - val_accuracy: 0.6196
Epoch 18/200
83/83 [==============================] - 2s 29ms/step - loss: 0.3046 - accuracy:
0.6232 - val_loss: 0.3106 - val_accuracy: 0.6196
Epoch 19/200
83/83 [==============================] - 3s 31ms/step - loss: 0.2993 - accuracy:
0.6232 - val_loss: 0.3037 - val_accuracy: 0.6196
Epoch 20/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2932 - accuracy:
0.6232 - val_loss: 0.3005 - val_accuracy: 0.6196
Epoch 21/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2885 - accuracy:
0.6232 - val_loss: 0.2911 - val_accuracy: 0.6196
Epoch 22/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2831 - accuracy:
0.6232 - val_loss: 0.2862 - val_accuracy: 0.6196
Epoch 23/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2785 - accuracy:
0.6232 - val_loss: 0.2801 - val_accuracy: 0.6196
Epoch 24/200
```

```
83/83 [==============================] - 2s 27ms/step - loss: 0.2740 - accuracy:
0.6232 - val_loss: 0.2734 - val_accuracy: 0.6196
Epoch 25/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2695 - accuracy:
0.6232 - val_loss: 0.2669 - val_accuracy: 0.6196
Epoch 26/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2654 - accuracy:
0.6232 - val_loss: 0.2630 - val_accuracy: 0.6196
Epoch 27/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2612 - accuracy:
0.6232 - val_loss: 0.2590 - val_accuracy: 0.6196
Epoch 28/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2575 - accuracy:
0.6232 - val_loss: 0.2532 - val_accuracy: 0.6196
Epoch 29/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2526 - accuracy:
0.6232 - val_loss: 0.2498 - val_accuracy: 0.6196
Epoch 30/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2497 - accuracy:
0.6232 - val_loss: 0.2438 - val_accuracy: 0.6196
Epoch 31/200
83/83 [==============================] - 2s 30ms/step - loss: 0.2463 - accuracy:
0.6232 - val_loss: 0.2389 - val_accuracy: 0.6196
Epoch 32/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2425 - accuracy:
0.6232 - val_loss: 0.2357 - val_accuracy: 0.6196
Epoch 33/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2390 - accuracy:
0.6232 - val_loss: 0.2314 - val_accuracy: 0.6196
Epoch 34/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2364 - accuracy:
0.6232 - val_loss: 0.2276 - val_accuracy: 0.6196
Epoch 35/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2348 - accuracy:
0.6232 - val_loss: 0.2229 - val_accuracy: 0.6196
Epoch 36/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2311 - accuracy:
0.6232 - val_loss: 0.2192 - val_accuracy: 0.6196
Epoch 37/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2285 - accuracy:
0.6232 - val_loss: 0.2159 - val_accuracy: 0.6196
Epoch 38/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2269 - accuracy:
0.6232 - val_loss: 0.2144 - val_accuracy: 0.6196
Epoch 39/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2231 - accuracy:
0.6232 - val_loss: 0.2085 - val_accuracy: 0.6196
Epoch 40/200
```

```
83/83 [==============================] - 2s 27ms/step - loss: 0.2219 - accuracy:
0.6232 - val_loss: 0.2076 - val_accuracy: 0.6196
Epoch 41/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2198 - accuracy:
0.6232 - val_loss: 0.2044 - val_accuracy: 0.6196
Epoch 42/200
83/83 [==============================] - 3s 30ms/step - loss: 0.2178 - accuracy:
0.6232 - val_loss: 0.2010 - val_accuracy: 0.6196
Epoch 43/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2160 - accuracy:
0.6232 - val_loss: 0.2002 - val_accuracy: 0.6196
Epoch 44/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2135 - accuracy:
0.6232 - val_loss: 0.1975 - val_accuracy: 0.6196
Epoch 45/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2125 - accuracy:
0.6232 - val_loss: 0.1962 - val_accuracy: 0.6196
Epoch 46/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2112 - accuracy:
0.6232 - val_loss: 0.1953 - val_accuracy: 0.6196
Epoch 47/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2097 - accuracy:
0.6232 - val_loss: 0.1956 - val_accuracy: 0.6196
Epoch 48/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2084 - accuracy:
0.6232 - val_loss: 0.1891 - val_accuracy: 0.6196
Epoch 49/200
83/83 [==============================] - 2s 26ms/step - loss: 0.2062 - accuracy:
0.6232 - val_loss: 0.1898 - val_accuracy: 0.6196
Epoch 50/200
83/83 [==============================] - 2s 29ms/step - loss: 0.2050 - accuracy:
0.6232 - val_loss: 0.1883 - val_accuracy: 0.6196
Epoch 51/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2046 - accuracy:
0.6232 - val_loss: 0.1876 - val_accuracy: 0.6196
Epoch 52/200
83/83 [==============================] - 2s 28ms/step - loss: 0.2040 - accuracy:
0.6232 - val_loss: 0.1871 - val_accuracy: 0.6196
Epoch 53/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2018 - accuracy:
0.6232 - val_loss: 0.1819 - val_accuracy: 0.6196
Epoch 54/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2012 - accuracy:
0.6232 - val_loss: 0.1833 - val_accuracy: 0.6196
Epoch 55/200
83/83 [==============================] - 2s 27ms/step - loss: 0.2009 - accuracy:
0.6232 - val_loss: 0.1785 - val_accuracy: 0.6196
Epoch 56/200
```

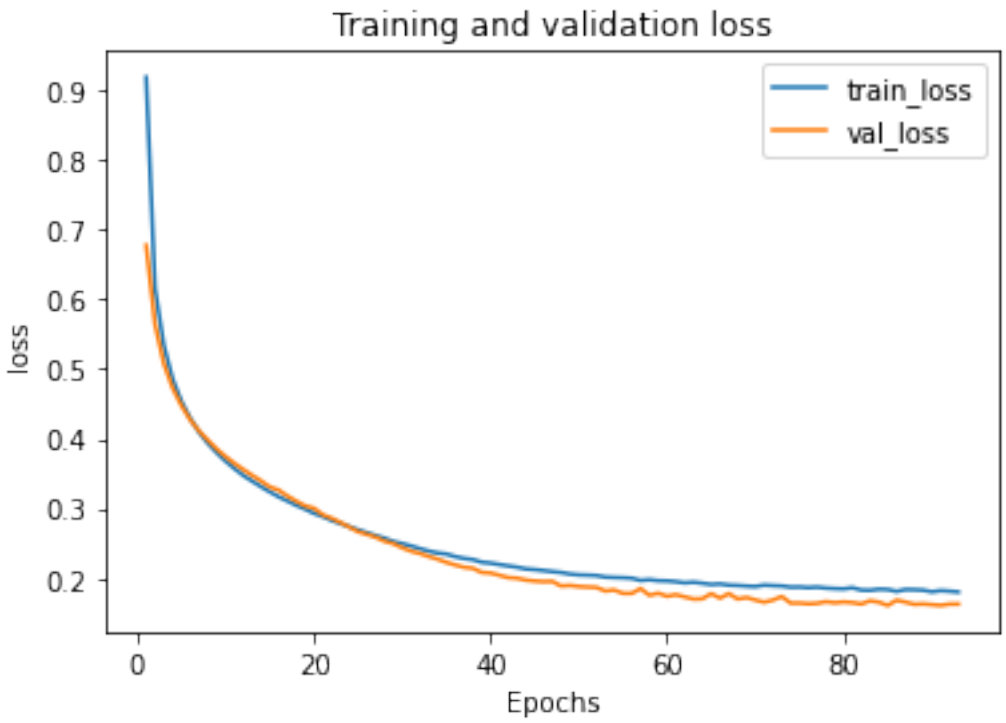
```
83/83 [==============================] - 2s 28ms/step - loss: 0.2002 - accuracy:
0.6232 - val_loss: 0.1784 - val_accuracy: 0.6196
Epoch 57/200
83/83 [==============================] - 3s 30ms/step - loss: 0.1970 - accuracy:
0.6232 - val_loss: 0.1853 - val_accuracy: 0.6196
Epoch 58/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1981 - accuracy:
0.6232 - val_loss: 0.1757 - val_accuracy: 0.6196
Epoch 59/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1966 - accuracy:
0.6232 - val_loss: 0.1787 - val_accuracy: 0.6196
Epoch 60/200
83/83 [==============================] - 2s 26ms/step - loss: 0.1963 - accuracy:
0.6232 - val_loss: 0.1744 - val_accuracy: 0.6196
Epoch 61/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1952 - accuracy:
0.6232 - val_loss: 0.1766 - val_accuracy: 0.6196
Epoch 62/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1936 - accuracy:
0.6232 - val_loss: 0.1734 - val_accuracy: 0.6196
Epoch 63/200
83/83 [==============================] - 3s 30ms/step - loss: 0.1944 - accuracy:
0.6232 - val_loss: 0.1703 - val_accuracy: 0.6196
Epoch 64/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1930 - accuracy:
0.6232 - val_loss: 0.1707 - val_accuracy: 0.6196
Epoch 65/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1912 - accuracy:
0.6232 - val_loss: 0.1781 - val_accuracy: 0.6196
Epoch 66/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1920 - accuracy:
0.6232 - val_loss: 0.1716 - val_accuracy: 0.6196
Epoch 67/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1903 - accuracy:
0.6232 - val_loss: 0.1782 - val_accuracy: 0.6196
Epoch 68/200
83/83 [==============================] - 3s 32ms/step - loss: 0.1898 - accuracy:
0.6232 - val_loss: 0.1704 - val_accuracy: 0.6196
Epoch 69/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1889 - accuracy:
0.6232 - val_loss: 0.1725 - val_accuracy: 0.6196
Epoch 70/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1883 - accuracy:
0.6232 - val_loss: 0.1691 - val_accuracy: 0.6196
Epoch 71/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1903 - accuracy:
0.6232 - val_loss: 0.1658 - val_accuracy: 0.6196
Epoch 72/200
```

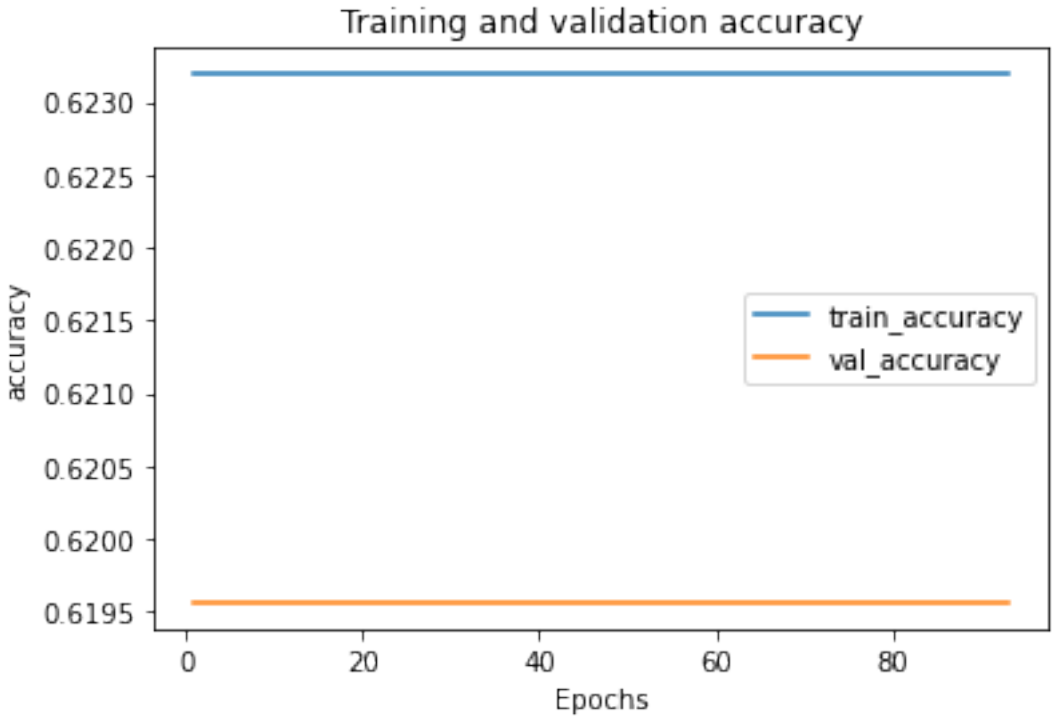
```
83/83 [==============================] - 3s 30ms/step - loss: 0.1896 - accuracy:
0.6232 - val_loss: 0.1689 - val_accuracy: 0.6196
Epoch 73/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1890 - accuracy:
0.6232 - val_loss: 0.1740 - val_accuracy: 0.6196
Epoch 74/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1874 - accuracy:
0.6232 - val_loss: 0.1645 - val_accuracy: 0.6196
Epoch 75/200
83/83 [==============================] - 2s 26ms/step - loss: 0.1876 - accuracy:
0.6232 - val_loss: 0.1646 - val_accuracy: 0.6196
Epoch 76/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1867 - accuracy:
0.6232 - val_loss: 0.1636 - val_accuracy: 0.6196
Epoch 77/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1874 - accuracy:
0.6232 - val_loss: 0.1642 - val_accuracy: 0.6196
Epoch 78/200
83/83 [==============================] - 3s 31ms/step - loss: 0.1861 - accuracy:
0.6232 - val_loss: 0.1666 - val_accuracy: 0.6196
Epoch 79/200
83/83 [==============================] - 3s 31ms/step - loss: 0.1853 - accuracy:
0.6232 - val_loss: 0.1650 - val_accuracy: 0.6196
Epoch 80/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1849 - accuracy:
0.6232 - val_loss: 0.1662 - val_accuracy: 0.6196
Epoch 81/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1866 - accuracy:
0.6232 - val_loss: 0.1652 - val_accuracy: 0.6196
Epoch 82/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1832 - accuracy:
0.6232 - val_loss: 0.1633 - val_accuracy: 0.6196
Epoch 83/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1829 - accuracy:
0.6232 - val_loss: 0.1678 - val_accuracy: 0.6196
Epoch 84/200
83/83 [==============================] - 2s 29ms/step - loss: 0.1844 - accuracy:
0.6232 - val_loss: 0.1659 - val_accuracy: 0.6196
Epoch 85/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1840 - accuracy:
0.6232 - val_loss: 0.1611 - val_accuracy: 0.6196
Epoch 86/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1813 - accuracy:
0.6232 - val_loss: 0.1687 - val_accuracy: 0.6196
Epoch 87/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1840 - accuracy:
0.6232 - val_loss: 0.1659 - val_accuracy: 0.6196
Epoch 88/200
```

```
83/83 [==============================] - 2s 30ms/step - loss: 0.1837 - accuracy:
0.6232 - val_loss: 0.1628 - val_accuracy: 0.6196
Epoch 89/200
83/83 [==============================] - 2s 30ms/step - loss: 0.1831 - accuracy:
0.6232 - val_loss: 0.1633 - val_accuracy: 0.6196
Epoch 90/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1808 - accuracy:
0.6232 - val_loss: 0.1623 - val_accuracy: 0.6196
Epoch 91/200
83/83 [==============================] - 2s 28ms/step - loss: 0.1824 - accuracy:
0.6232 - val_loss: 0.1612 - val_accuracy: 0.6196
Epoch 92/200
83/83 [==============================] - 3s 31ms/step - loss: 0.1816 - accuracy:
0.6232 - val_loss: 0.1631 - val_accuracy: 0.6196
Epoch 93/200
83/83 [==============================] - 2s 27ms/step - loss: 0.1804 - accuracy:
0.6232 - val_loss: 0.1632 - val_accuracy: 0.6196
Running time is 215.98 seconds per 200 epoches
Test Accuracy: 0.641

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[21]:
```
plot_metric(history_cm2_y3,'loss')
plot_metric(history_cm2_y3,'accuracy')
```


Training and validation loss
train_loss
val_loss
loss
Epochs
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
20
40
60
80


Training and validation accuracy
train_accuracy
val_accuracy
accuracy
Epochs
0.6230
0.6225
0.6220
0.6215
0.6210
0.6205
0.6200
0.6195
0
20
40
60
80

# 4 CM3

For this question, we have tried using different models to find out the one that performs the best. The models that we have considered and compared include a basic DNN architecture, 2 LSTM models and a RNN model.

### 4.0.1 CM3 - (i) [2]

Below is a neural network which has **7 hidden layers** with **64** and **128** units varying in each as can been seen from the code. The activation function used in all the hidden layers is **LeakyReLU activation** since it offers an improvement above the ReLU function. For the output layer, **sigmoid activation function** has been used. The optimizer which we have used is '**sgd**' which stands for Stochastic Gradient Descent. To prevent overfitting, the regularization method which we have used here is **early stopping** with a **delta value of 0.001**. The model stops training after we see no improvement in the validation loss for 4 epochs. The input layer uses 13 features to determine the output class label. Three separate models have been trained (**200 epochs and 40 batch size**) for the labels 'Confirmed', 'Recovered' and 'Deaths'. The performance of all the three models has been plotted using two graphs - The training and validation loss by epochs The training and validation accuracy by epochs

[22]:
```
# Basic architecture of a NNet
model_dnn = Sequential()
model_dnn.add(Dense(64, activation='LeakyReLU', input_shape=(13,)))
model_dnn.add(Dense(128, activation='LeakyReLU'))
model_dnn.add(Dense(128, activation='LeakyReLU'))
model_dnn.add(Dense(128, activation='LeakyReLU'))
model_dnn.add(Dense(64, activation='LeakyReLU'))
model_dnn.add(Dense(64, activation='LeakyReLU'))
model_dnn.add(Dense(64, activation='LeakyReLU'))
model_dnn.add(Dense(1, activation='sigmoid'))
model_dnn.compile(loss='binary_crossentropy',
              optimizer='sgd',
              metrics=['accuracy'])
```

[23]:
```
es_dnn= EarlyStopping(
    monitor='val_loss',
    patience=4,
    min_delta=0.001,

)
```

[24]:
```
history_dnn_y1=model_trainer_1(model_dnn, y1, X, 200, 40,es_dnn)
```

```
Epoch 1/200
 3/21 [===>…] - ETA: 0s - loss: 0.7063 - accuracy:
0.4167

/usr/local/lib/python3.7/dist-
```

```
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

21/21 [==============================] - 1s 40ms/step - loss: 0.6741 - accuracy:
0.7101 - val_loss: 0.5801 - val_accuracy: 0.9710
Epoch 2/200
 1/21 [>…] - ETA: 0s - loss: 0.5854 - accuracy:
0.9500

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

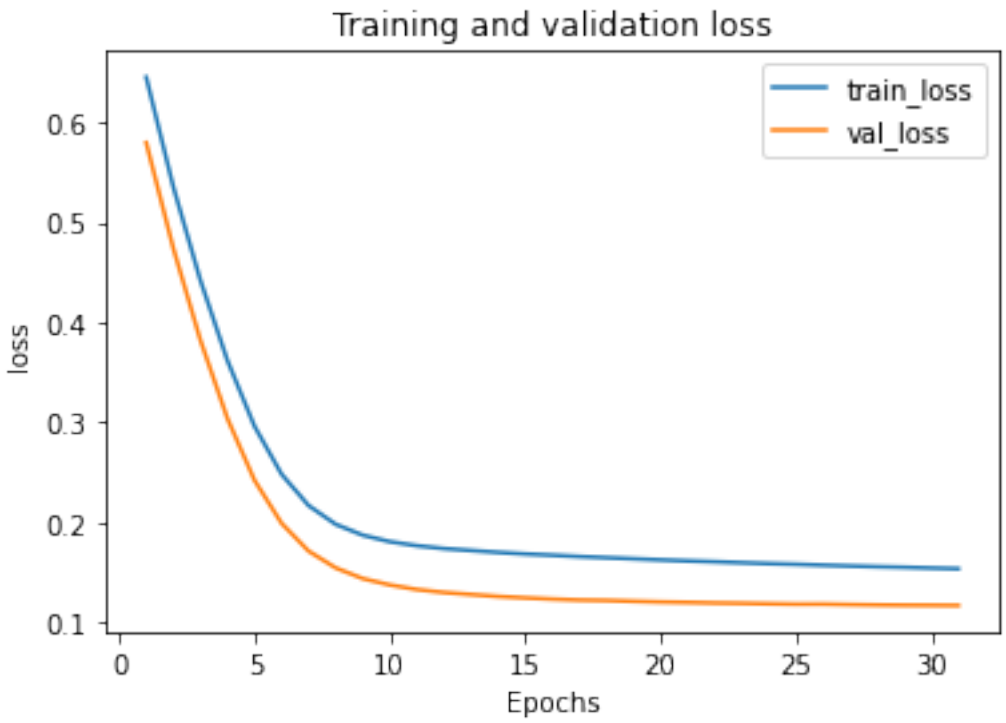
21/21 [==============================] - 1s 37ms/step - loss: 0.5611 - accuracy:
0.9499 - val_loss: 0.4745 - val_accuracy: 0.9710
Epoch 3/200
21/21 [==============================] - 1s 37ms/step - loss: 0.4646 - accuracy:
0.9547 - val_loss: 0.3825 - val_accuracy: 0.9710
Epoch 4/200
21/21 [==============================] - 1s 37ms/step - loss: 0.3804 - accuracy:
0.9565 - val_loss: 0.3039 - val_accuracy: 0.9710
Epoch 5/200
21/21 [==============================] - 1s 38ms/step - loss: 0.3082 - accuracy:
0.9585 - val_loss: 0.2421 - val_accuracy: 0.9710
Epoch 6/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2507 - accuracy:
0.9615 - val_loss: 0.1991 - val_accuracy: 0.9710
Epoch 7/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2337 - accuracy:
0.9516 - val_loss: 0.1712 - val_accuracy: 0.9710
Epoch 8/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2107 - accuracy:
0.9537 - val_loss: 0.1544 - val_accuracy: 0.9710
Epoch 9/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2077 - accuracy:
0.9496 - val_loss: 0.1437 - val_accuracy: 0.9710
Epoch 10/200
```

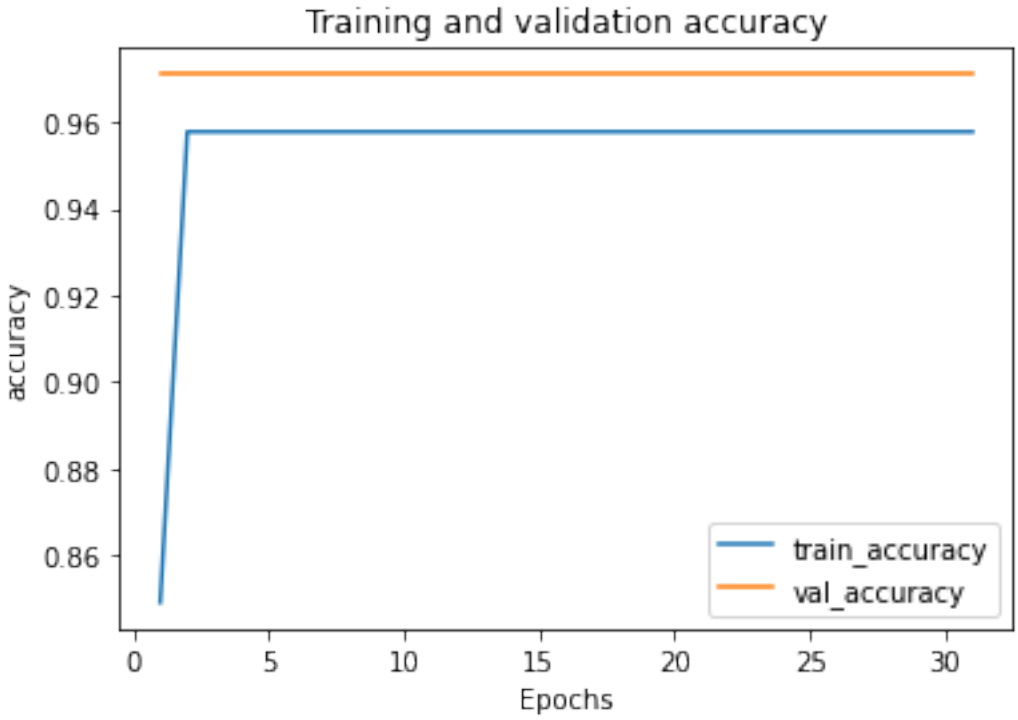
```
21/21 [==============================] - 1s 35ms/step - loss: 0.1649 - accuracy:
0.9648 - val_loss: 0.1373 - val_accuracy: 0.9710
Epoch 11/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1845 - accuracy:
0.9556 - val_loss: 0.1327 - val_accuracy: 0.9710
Epoch 12/200
21/21 [==============================] - 1s 35ms/step - loss: 0.1836 - accuracy:
0.9548 - val_loss: 0.1297 - val_accuracy: 0.9710
Epoch 13/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1451 - accuracy:
0.9674 - val_loss: 0.1277 - val_accuracy: 0.9710
Epoch 14/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1757 - accuracy:
0.9565 - val_loss: 0.1258 - val_accuracy: 0.9710
Epoch 15/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1873 - accuracy:
0.9517 - val_loss: 0.1244 - val_accuracy: 0.9710
Epoch 16/200
21/21 [==============================] - 1s 35ms/step - loss: 0.1682 - accuracy:
0.9581 - val_loss: 0.1231 - val_accuracy: 0.9710
Epoch 17/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1783 - accuracy:
0.9534 - val_loss: 0.1222 - val_accuracy: 0.9710
Epoch 18/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1268 - accuracy:
0.9708 - val_loss: 0.1218 - val_accuracy: 0.9710
Epoch 19/200
21/21 [==============================] - 1s 38ms/step - loss: 0.1654 - accuracy:
0.9562 - val_loss: 0.1209 - val_accuracy: 0.9710
Epoch 20/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1846 - accuracy:
0.9496 - val_loss: 0.1202 - val_accuracy: 0.9710
Epoch 21/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1540 - accuracy:
0.9599 - val_loss: 0.1198 - val_accuracy: 0.9710
Epoch 22/200
21/21 [==============================] - 1s 35ms/step - loss: 0.1694 - accuracy:
0.9529 - val_loss: 0.1193 - val_accuracy: 0.9710
Epoch 23/200
21/21 [==============================] - 1s 38ms/step - loss: 0.1472 - accuracy:
0.9612 - val_loss: 0.1189 - val_accuracy: 0.9710
Epoch 24/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1668 - accuracy:
0.9551 - val_loss: 0.1184 - val_accuracy: 0.9710
Epoch 25/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1655 - accuracy:
0.9542 - val_loss: 0.1180 - val_accuracy: 0.9710
Epoch 26/200
```

```
21/21 [==============================] - 1s 36ms/step - loss: 0.1448 - accuracy:
0.9612 - val_loss: 0.1181 - val_accuracy: 0.9710
Epoch 27/200
21/21 [==============================] - 1s 38ms/step - loss: 0.1603 - accuracy:
0.9534 - val_loss: 0.1176 - val_accuracy: 0.9710
Epoch 28/200
21/21 [==============================] - 1s 38ms/step - loss: 0.1679 - accuracy:
0.9544 - val_loss: 0.1173 - val_accuracy: 0.9710
Epoch 29/200
21/21 [==============================] - 1s 37ms/step - loss: 0.1651 - accuracy:
0.9526 - val_loss: 0.1170 - val_accuracy: 0.9710
Epoch 30/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1383 - accuracy:
0.9620 - val_loss: 0.1169 - val_accuracy: 0.9710
Epoch 31/200
21/21 [==============================] - 1s 36ms/step - loss: 0.1669 - accuracy:
0.9529 - val_loss: 0.1167 - val_accuracy: 0.9710
Running time is 23.95 seconds per 200 epoches
Test Accuracy: 0.971

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[25]:
```
plot_metric(history_dnn_y1,'loss')
plot_metric(history_dnn_y1,'accuracy')
```


Training and validation loss
train_loss
val_loss
loss
0.6
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
30
Epochs


Training and validation accuracy
train_accuracy
val_accuracy
accuracy
0.96
0.94
0.92
0.90
0.88
0.86
0
5
10
15
20
25
30
Epochs

[26]:
```
history_dnn_y2=model_trainer_1(model_dnn, y2, X, 200, 40,es_dnn)
```

```
Epoch 1/200
 3/21 [===>…] - ETA: 0s - loss: 0.3961 - accuracy:
0.8917

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

21/21 [==============================] - 1s 39ms/step - loss: 0.3744 - accuracy:
0.9010 - val_loss: 0.3728 - val_accuracy: 0.8986
Epoch 2/200
 1/21 [>…] - ETA: 0s - loss: 0.3727 - accuracy:
0.8750

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

21/21 [==============================] - 1s 35ms/step - loss: 0.3393 - accuracy:
0.9010 - val_loss: 0.3467 - val_accuracy: 0.8986
Epoch 3/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3237 - accuracy:
0.9010 - val_loss: 0.3324 - val_accuracy: 0.8986
Epoch 4/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3147 - accuracy:
0.9010 - val_loss: 0.3235 - val_accuracy: 0.8986
Epoch 5/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3089 - accuracy:
0.9010 - val_loss: 0.3171 - val_accuracy: 0.8986
Epoch 6/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3044 - accuracy:
0.9010 - val_loss: 0.3115 - val_accuracy: 0.8986
Epoch 7/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3007 - accuracy:
0.9010 - val_loss: 0.3069 - val_accuracy: 0.8986
Epoch 8/200
```

```
21/21 [==============================] - 1s 36ms/step - loss: 0.2970 - accuracy:
0.9010 - val_loss: 0.3030 - val_accuracy: 0.8986
Epoch 9/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2944 - accuracy:
0.9010 - val_loss: 0.2995 - val_accuracy: 0.8986
Epoch 10/200
21/21 [==============================] - 1s 33ms/step - loss: 0.2916 - accuracy:
0.9010 - val_loss: 0.2964 - val_accuracy: 0.8986
Epoch 11/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2892 - accuracy:
0.9010 - val_loss: 0.2936 - val_accuracy: 0.8986
Epoch 12/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2870 - accuracy:
0.9010 - val_loss: 0.2911 - val_accuracy: 0.8986
Epoch 13/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2852 - accuracy:
0.9010 - val_loss: 0.2885 - val_accuracy: 0.8986
Epoch 14/200
21/21 [==============================] - 1s 34ms/step - loss: 0.2832 - accuracy:
0.9010 - val_loss: 0.2864 - val_accuracy: 0.8986
Epoch 15/200
21/21 [==============================] - 1s 34ms/step - loss: 0.2814 - accuracy:
0.9010 - val_loss: 0.2842 - val_accuracy: 0.8986
Epoch 16/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2797 - accuracy:
0.9010 - val_loss: 0.2821 - val_accuracy: 0.8986
Epoch 17/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2780 - accuracy:
0.9010 - val_loss: 0.2801 - val_accuracy: 0.8986
Epoch 18/200
21/21 [==============================] - 1s 34ms/step - loss: 0.2763 - accuracy:
0.9010 - val_loss: 0.2781 - val_accuracy: 0.8986
Epoch 19/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2747 - accuracy:
0.9010 - val_loss: 0.2763 - val_accuracy: 0.8986
Epoch 20/200
21/21 [==============================] - 1s 45ms/step - loss: 0.2730 - accuracy:
0.9010 - val_loss: 0.2744 - val_accuracy: 0.8986
Epoch 21/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2714 - accuracy:
0.9010 - val_loss: 0.2729 - val_accuracy: 0.8986
Epoch 22/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2700 - accuracy:
0.9010 - val_loss: 0.2715 - val_accuracy: 0.8986
Epoch 23/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2686 - accuracy:
0.9010 - val_loss: 0.2702 - val_accuracy: 0.8986
Epoch 24/200
```

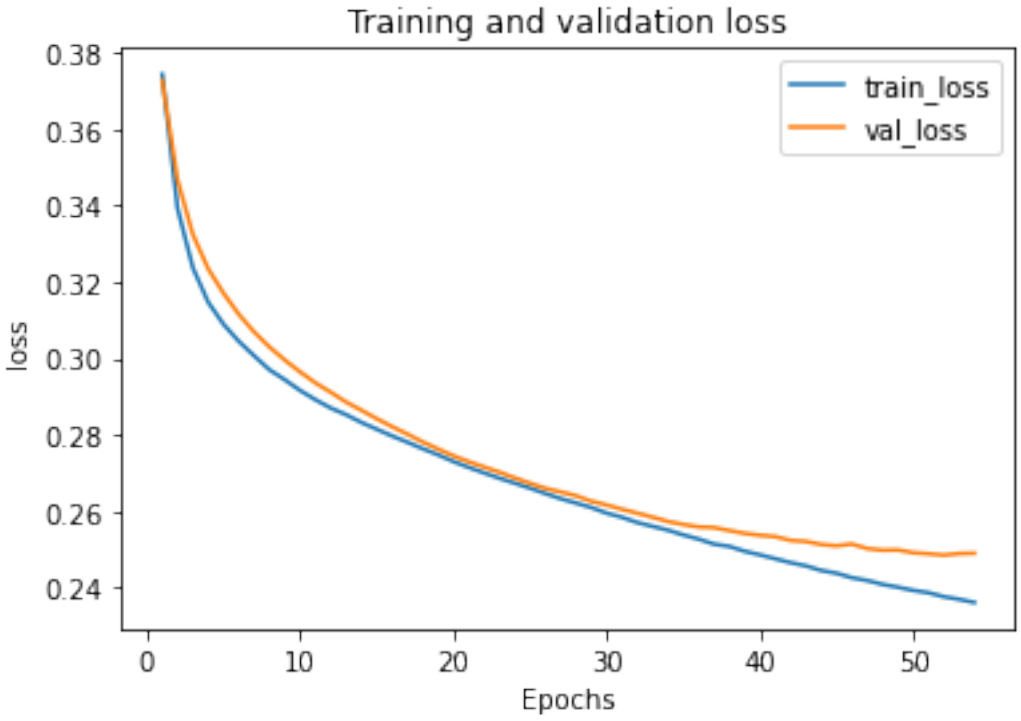
```
21/21 [==============================] - 1s 36ms/step - loss: 0.2673 - accuracy:
0.9010 - val_loss: 0.2687 - val_accuracy: 0.8986
Epoch 25/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2660 - accuracy:
0.9010 - val_loss: 0.2673 - val_accuracy: 0.8986
Epoch 26/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2646 - accuracy:
0.9010 - val_loss: 0.2659 - val_accuracy: 0.8986
Epoch 27/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2632 - accuracy:
0.9010 - val_loss: 0.2650 - val_accuracy: 0.8986
Epoch 28/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2621 - accuracy:
0.9010 - val_loss: 0.2640 - val_accuracy: 0.8986
Epoch 29/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2609 - accuracy:
0.9010 - val_loss: 0.2626 - val_accuracy: 0.8986
Epoch 30/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2594 - accuracy:
0.9010 - val_loss: 0.2616 - val_accuracy: 0.8986
Epoch 31/200
21/21 [==============================] - 1s 33ms/step - loss: 0.2583 - accuracy:
0.9010 - val_loss: 0.2605 - val_accuracy: 0.8986
Epoch 32/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2570 - accuracy:
0.9010 - val_loss: 0.2594 - val_accuracy: 0.8986
Epoch 33/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2560 - accuracy:
0.9010 - val_loss: 0.2584 - val_accuracy: 0.8986
Epoch 34/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2550 - accuracy:
0.9010 - val_loss: 0.2573 - val_accuracy: 0.8986
Epoch 35/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2537 - accuracy:
0.9010 - val_loss: 0.2565 - val_accuracy: 0.8986
Epoch 36/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2527 - accuracy:
0.9010 - val_loss: 0.2558 - val_accuracy: 0.8986
Epoch 37/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2513 - accuracy:
0.9010 - val_loss: 0.2557 - val_accuracy: 0.8986
Epoch 38/200
21/21 [==============================] - 1s 34ms/step - loss: 0.2507 - accuracy:
0.9010 - val_loss: 0.2549 - val_accuracy: 0.8986
Epoch 39/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2495 - accuracy:
0.9010 - val_loss: 0.2541 - val_accuracy: 0.8986
Epoch 40/200
```

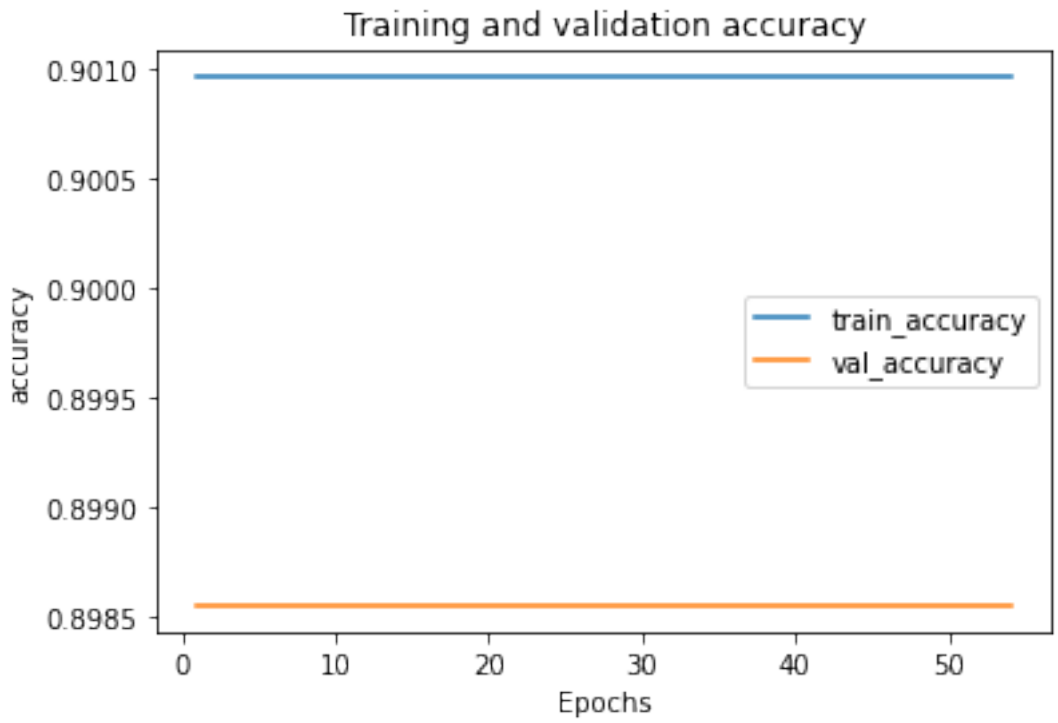
```
21/21 [==============================] - 1s 36ms/step - loss: 0.2485 - accuracy:
0.9010 - val_loss: 0.2536 - val_accuracy: 0.8986
Epoch 41/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2475 - accuracy:
0.9010 - val_loss: 0.2533 - val_accuracy: 0.8986
Epoch 42/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2465 - accuracy:
0.9010 - val_loss: 0.2523 - val_accuracy: 0.8986
Epoch 43/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2456 - accuracy:
0.9010 - val_loss: 0.2520 - val_accuracy: 0.8986
Epoch 44/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2444 - accuracy:
0.9010 - val_loss: 0.2512 - val_accuracy: 0.8986
Epoch 45/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2437 - accuracy:
0.9010 - val_loss: 0.2509 - val_accuracy: 0.8986
Epoch 46/200
21/21 [==============================] - 1s 34ms/step - loss: 0.2425 - accuracy:
0.9010 - val_loss: 0.2513 - val_accuracy: 0.8986
Epoch 47/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2418 - accuracy:
0.9010 - val_loss: 0.2502 - val_accuracy: 0.8986
Epoch 48/200
21/21 [==============================] - 1s 39ms/step - loss: 0.2408 - accuracy:
0.9010 - val_loss: 0.2497 - val_accuracy: 0.8986
Epoch 49/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2400 - accuracy:
0.9010 - val_loss: 0.2498 - val_accuracy: 0.8986
Epoch 50/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2392 - accuracy:
0.9010 - val_loss: 0.2491 - val_accuracy: 0.8986
Epoch 51/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2386 - accuracy:
0.9010 - val_loss: 0.2488 - val_accuracy: 0.8986
Epoch 52/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2376 - accuracy:
0.9010 - val_loss: 0.2484 - val_accuracy: 0.8986
Epoch 53/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2369 - accuracy:
0.9010 - val_loss: 0.2489 - val_accuracy: 0.8986
Epoch 54/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2360 - accuracy:
0.9010 - val_loss: 0.2489 - val_accuracy: 0.8986
Running time is 40.79 seconds per 200 epoches
Test Accuracy: 0.906

/usr/local/lib/python3.7/dist-
```

```
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[27]:
```
plot_metric(history_dnn_y2,'loss')
plot_metric(history_dnn_y2,'accuracy')
```






[28]:
```
history_dnn_y3=model_trainer_1(model_dnn, y3, X, 200, 40,es_dnn)
```

```
Epoch 1/200
 3/21 [===>…] - ETA: 0s - loss: 1.5531 - accuracy:
0.5833

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

21/21 [==============================] - 1s 40ms/step - loss: 0.9241 - accuracy:
0.6280 - val_loss: 0.6806 - val_accuracy: 0.6594
Epoch 2/200
 1/21 [>…] - ETA: 0s - loss: 0.5940 - accuracy:
0.7000
```

```
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
21/21 [==============================] - 1s 38ms/step - loss: 0.6384 - accuracy:
0.6655 - val_loss: 0.6153 - val_accuracy: 0.7065
Epoch 3/200
21/21 [==============================] - 1s 37ms/step - loss: 0.5922 - accuracy:
0.6848 - val_loss: 0.5832 - val_accuracy: 0.7029
Epoch 4/200
21/21 [==============================] - 1s 37ms/step - loss: 0.5609 - accuracy:
0.7017 - val_loss: 0.5559 - val_accuracy: 0.6993
Epoch 5/200
21/21 [==============================] - 1s 35ms/step - loss: 0.5333 - accuracy:
0.7246 - val_loss: 0.5316 - val_accuracy: 0.7065
Epoch 6/200
21/21 [==============================] - 1s 37ms/step - loss: 0.5091 - accuracy:
0.7464 - val_loss: 0.5094 - val_accuracy: 0.7210
Epoch 7/200
21/21 [==============================] - 1s 36ms/step - loss: 0.4861 - accuracy:
0.7585 - val_loss: 0.4895 - val_accuracy: 0.7319
Epoch 8/200
21/21 [==============================] - 1s 38ms/step - loss: 0.4661 - accuracy:
0.7766 - val_loss: 0.4706 - val_accuracy: 0.7391
Epoch 9/200
21/21 [==============================] - 1s 35ms/step - loss: 0.4471 - accuracy:
0.7838 - val_loss: 0.4543 - val_accuracy: 0.7500
Epoch 10/200
21/21 [==============================] - 1s 36ms/step - loss: 0.4318 - accuracy:
0.7886 - val_loss: 0.4442 - val_accuracy: 0.8116
Epoch 11/200
21/21 [==============================] - 1s 37ms/step - loss: 0.4190 - accuracy:
0.8092 - val_loss: 0.4318 - val_accuracy: 0.7899
Epoch 12/200
21/21 [==============================] - 1s 37ms/step - loss: 0.4075 - accuracy:
0.8152 - val_loss: 0.4194 - val_accuracy: 0.7971
Epoch 13/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3970 - accuracy:
0.8164 - val_loss: 0.4084 - val_accuracy: 0.8333
Epoch 14/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3872 - accuracy:
0.8273 - val_loss: 0.3998 - val_accuracy: 0.8406
Epoch 15/200
21/21 [==============================] - 1s 38ms/step - loss: 0.3769 - accuracy:
0.8321 - val_loss: 0.3917 - val_accuracy: 0.8297
```

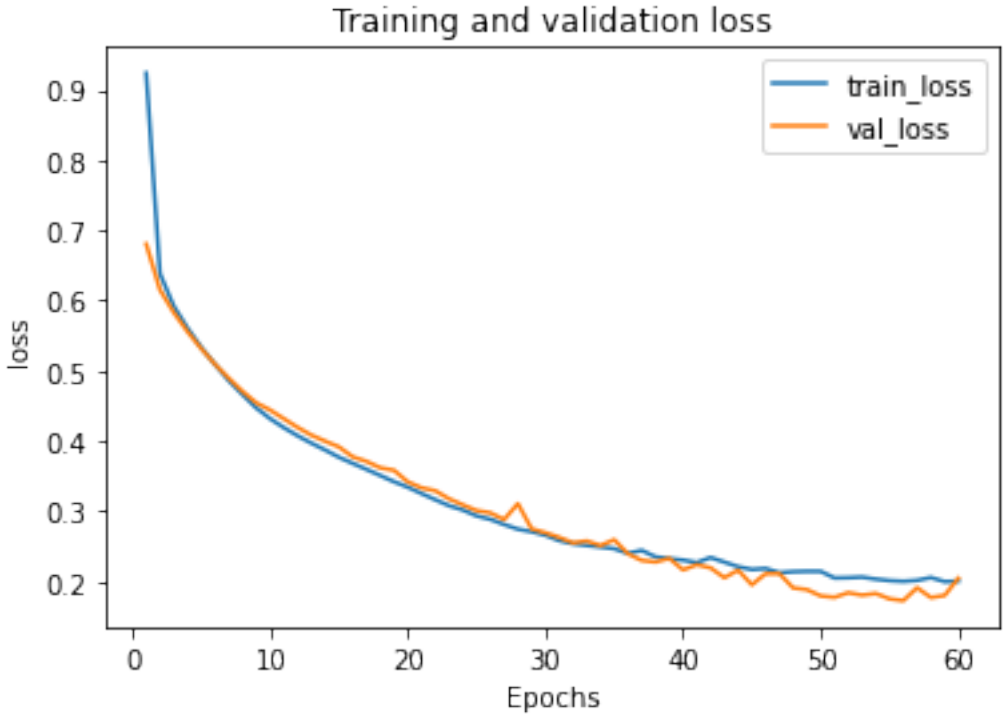
```
Epoch 16/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3682 - accuracy:
0.8309 - val_loss: 0.3775 - val_accuracy: 0.8406
Epoch 17/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3597 - accuracy:
0.8370 - val_loss: 0.3710 - val_accuracy: 0.8478
Epoch 18/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3509 - accuracy:
0.8370 - val_loss: 0.3619 - val_accuracy: 0.8478
Epoch 19/200
21/21 [==============================] - 1s 37ms/step - loss: 0.3421 - accuracy:
0.8527 - val_loss: 0.3583 - val_accuracy: 0.8478
Epoch 20/200
21/21 [==============================] - 1s 39ms/step - loss: 0.3343 - accuracy:
0.8599 - val_loss: 0.3419 - val_accuracy: 0.8587
Epoch 21/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3252 - accuracy:
0.8720 - val_loss: 0.3333 - val_accuracy: 0.8551
Epoch 22/200
21/21 [==============================] - 1s 37ms/step - loss: 0.3164 - accuracy:
0.8792 - val_loss: 0.3292 - val_accuracy: 0.8623
Epoch 23/200
21/21 [==============================] - 1s 35ms/step - loss: 0.3079 - accuracy:
0.8768 - val_loss: 0.3177 - val_accuracy: 0.8768
Epoch 24/200
21/21 [==============================] - 1s 36ms/step - loss: 0.3019 - accuracy:
0.8877 - val_loss: 0.3091 - val_accuracy: 0.8841
Epoch 25/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2934 - accuracy:
0.8889 - val_loss: 0.3009 - val_accuracy: 0.8877
Epoch 26/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2885 - accuracy:
0.8865 - val_loss: 0.2977 - val_accuracy: 0.9058
Epoch 27/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2811 - accuracy:
0.8937 - val_loss: 0.2881 - val_accuracy: 0.8877
Epoch 28/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2745 - accuracy:
0.8949 - val_loss: 0.3109 - val_accuracy: 0.8406
Epoch 29/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2709 - accuracy:
0.8925 - val_loss: 0.2749 - val_accuracy: 0.9058
Epoch 30/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2658 - accuracy:
0.8937 - val_loss: 0.2693 - val_accuracy: 0.9130
Epoch 31/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2581 - accuracy:
0.9034 - val_loss: 0.2628 - val_accuracy: 0.9167
```

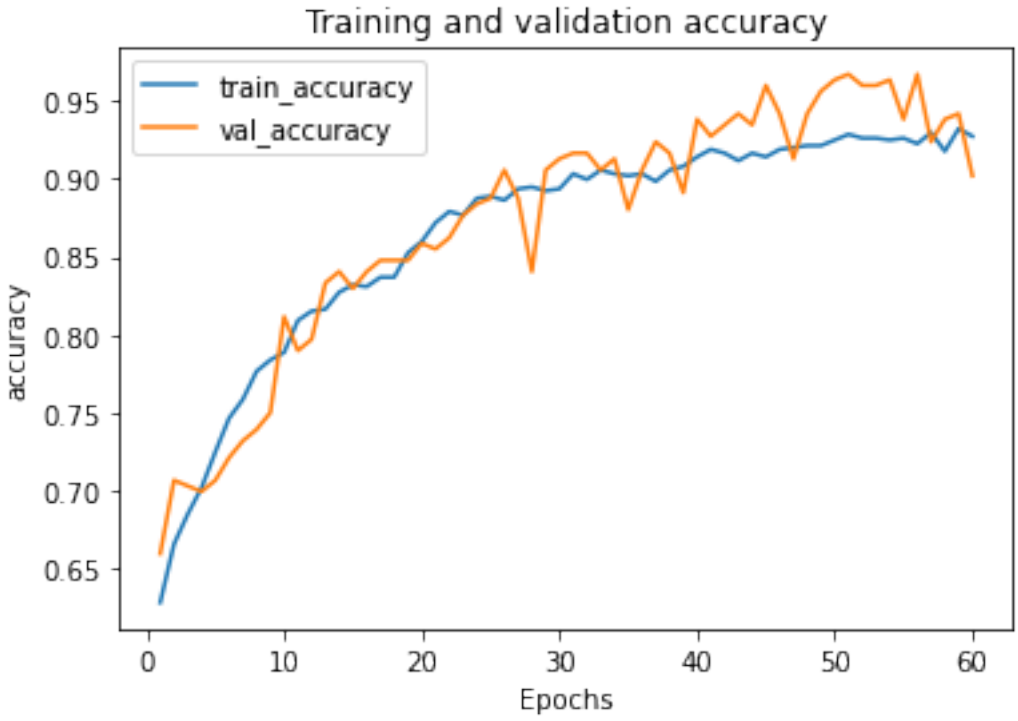
```
Epoch 32/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2537 - accuracy:
0.8998 - val_loss: 0.2551 - val_accuracy: 0.9167
Epoch 33/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2514 - accuracy:
0.9058 - val_loss: 0.2576 - val_accuracy: 0.9058
Epoch 34/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2491 - accuracy:
0.9034 - val_loss: 0.2511 - val_accuracy: 0.9130
Epoch 35/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2466 - accuracy:
0.9022 - val_loss: 0.2594 - val_accuracy: 0.8804
Epoch 36/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2400 - accuracy:
0.9034 - val_loss: 0.2394 - val_accuracy: 0.9058
Epoch 37/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2442 - accuracy:
0.8986 - val_loss: 0.2300 - val_accuracy: 0.9239
Epoch 38/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2350 - accuracy:
0.9058 - val_loss: 0.2277 - val_accuracy: 0.9167
Epoch 39/200
21/21 [==============================] - 1s 39ms/step - loss: 0.2325 - accuracy:
0.9082 - val_loss: 0.2329 - val_accuracy: 0.8913
Epoch 40/200
21/21 [==============================] - 1s 39ms/step - loss: 0.2304 - accuracy:
0.9143 - val_loss: 0.2164 - val_accuracy: 0.9384
Epoch 41/200
21/21 [==============================] - 1s 39ms/step - loss: 0.2269 - accuracy:
0.9191 - val_loss: 0.2240 - val_accuracy: 0.9275
Epoch 42/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2341 - accuracy:
0.9167 - val_loss: 0.2194 - val_accuracy: 0.9348
Epoch 43/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2276 - accuracy:
0.9118 - val_loss: 0.2053 - val_accuracy: 0.9420
Epoch 44/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2209 - accuracy:
0.9167 - val_loss: 0.2161 - val_accuracy: 0.9348
Epoch 45/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2171 - accuracy:
0.9143 - val_loss: 0.1952 - val_accuracy: 0.9601
Epoch 46/200
21/21 [==============================] - 1s 35ms/step - loss: 0.2184 - accuracy:
0.9191 - val_loss: 0.2111 - val_accuracy: 0.9420
Epoch 47/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2125 - accuracy:
0.9203 - val_loss: 0.2112 - val_accuracy: 0.9130
```

```
Epoch 48/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2139 - accuracy:
0.9215 - val_loss: 0.1908 - val_accuracy: 0.9420
Epoch 49/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2144 - accuracy:
0.9215 - val_loss: 0.1884 - val_accuracy: 0.9565
Epoch 50/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2143 - accuracy:
0.9251 - val_loss: 0.1794 - val_accuracy: 0.9638
Epoch 51/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2049 - accuracy:
0.9287 - val_loss: 0.1774 - val_accuracy: 0.9674
Epoch 52/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2053 - accuracy:
0.9263 - val_loss: 0.1839 - val_accuracy: 0.9601
Epoch 53/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2062 - accuracy:
0.9263 - val_loss: 0.1805 - val_accuracy: 0.9601
Epoch 54/200
21/21 [==============================] - 1s 37ms/step - loss: 0.2033 - accuracy:
0.9251 - val_loss: 0.1828 - val_accuracy: 0.9638
Epoch 55/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2012 - accuracy:
0.9263 - val_loss: 0.1752 - val_accuracy: 0.9384
Epoch 56/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2002 - accuracy:
0.9227 - val_loss: 0.1727 - val_accuracy: 0.9674
Epoch 57/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2015 - accuracy:
0.9300 - val_loss: 0.1911 - val_accuracy: 0.9239
Epoch 58/200
21/21 [==============================] - 1s 36ms/step - loss: 0.2056 - accuracy:
0.9179 - val_loss: 0.1771 - val_accuracy: 0.9384
Epoch 59/200
21/21 [==============================] - 1s 38ms/step - loss: 0.1997 - accuracy:
0.9324 - val_loss: 0.1800 - val_accuracy: 0.9420
Epoch 60/200
21/21 [==============================] - 1s 38ms/step - loss: 0.2004 - accuracy:
0.9275 - val_loss: 0.2047 - val_accuracy: 0.9022
Running time is 46.21 seconds per 200 epoches
Test Accuracy: 0.928

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
```

[29]:
```
plot_metric(history_dnn_y3,'loss')
plot_metric(history_dnn_y3,'accuracy')
```



#### 4.0.2 LSTM [3]

[30]:
```
# LSTM

import numpy
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import LSTM
from keras.preprocessing import sequence
from sklearn.model_selection import train_test_split
```

[31]:
```
def model_trainer2(model, y, X, epo,batch, es ):
  model.reset_metrics()
  model.reset_states()
  X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.
↪2,random_state =0)
  features = X_train.shape[1]
  X_train = X_train.values.reshape(X_train.shape[0], features,1)
  X_test  = X_test.values.reshape(X_test.shape[0], features,1)
  strat_time = time.time()

  # ADD early stopping
  if (es=='0'):
    history = model.fit(X_train,y_train,epochs=epo,validation_split=0.25,␣
↪batch_size=batch)
  else:
    history = model.fit(X_train,y_train,epochs=epo,validation_split=0.25,␣
↪batch_size=batch, callbacks=[es])

  end_time = time.time()
  print("Running time is {:.2f} seconds per {} epoches".
↪format(end_time-strat_time, epo))
  loss, acc = model.evaluate(X_test, y_test, verbose=0)
  print('Test Accuracy: %.3f' % acc)
  return history
```

#### 4.0.3 CM3- (ii)

Below is a neural network which which uses the LSTM architecture followed by **3 hidden layers** with **40** and **10** units varying in each as can been seen from the code. The activation functions used include **ReLU** and **softmax** activations. For the output layer, **sigmoid activation function** has been used. The optimizer which we have used is '**Adam**' which performs faster than sgd. To prevent overfitting, we tried using **early stopping** with a **delta value of 0.001**, but it worsened the performance and hence we have set the corresponding parameter to **zero**. The input layer uses 13 features to determine the output class label. Three separate models have been trained (**200**

**epochs and 40 batch size**) for the labels 'Confirmed', 'Recovered' and 'Deaths'. The performance of all the three models has been plotted using two graphs - The training and validation loss by epochs The training and validation accuracy by epochs

[32]:
```
# 0.16491 score model
model_LSTM = Sequential()
model_LSTM.add(LSTM(40, input_shape=(13,1)))  #, return_sequences=True
model_LSTM.add(Dense(40, activation='relu'))
model_LSTM.add(Dense(40, activation='relu'))
model_LSTM.add(Dense(10, activation='softmax'))
model_LSTM.add(Dense(1, activation='sigmoid'))
model_LSTM.compile(loss='mse',
              optimizer='adam',
              metrics=['accuracy'])
model_LSTM.summary()
model_LSTM
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 40)                6720
_________________________________________________________________
dense_15 (Dense)             (None, 40)                1640
_________________________________________________________________
dense_16 (Dense)             (None, 40)                1640
_________________________________________________________________
dense_17 (Dense)             (None, 10)                410
_________________________________________________________________
dense_18 (Dense)             (None, 1)                 11
=================================================================
Total params: 10,421
Trainable params: 10,421
Non-trainable params: 0
_________________________________________________________________
```

[32]:
```
<keras.engine.sequential.Sequential at 0x7f31979e2850>
```

[33]:
```
hist_lstm_y1=model_trainer2(model_LSTM, y1, X, 100, 10, '0')
```

```
Epoch 1/100
 2/83 […] - ETA: 4s - loss: 0.2564 - accuracy:
0.0500

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
```

```
  "Even though the `tf.config.experimental_run_functions_eagerly` "
83/83 [==============================] - 5s 59ms/step - loss: 0.2245 - accuracy:
0.6615 - val_loss: 0.1393 - val_accuracy: 0.9710
Epoch 2/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1303 - accuracy:
0.9635 - val_loss: 0.0926 - val_accuracy: 0.9710
Epoch 3/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0948 - accuracy:
0.9569 - val_loss: 0.0777 - val_accuracy: 0.9710
Epoch 4/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0807 - accuracy:
0.9600 - val_loss: 0.0678 - val_accuracy: 0.9710
Epoch 5/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0691 - accuracy:
0.9651 - val_loss: 0.0604 - val_accuracy: 0.9710
Epoch 6/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0648 - accuracy:
0.9612 - val_loss: 0.0549 - val_accuracy: 0.9710
Epoch 7/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0646 - accuracy:
0.9535 - val_loss: 0.0505 - val_accuracy: 0.9710
Epoch 8/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0590 - accuracy:
0.9564 - val_loss: 0.0471 - val_accuracy: 0.9710
Epoch 9/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0542 - accuracy:
0.9593 - val_loss: 0.0443 - val_accuracy: 0.9710
Epoch 10/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0464 - accuracy:
0.9672 - val_loss: 0.0421 - val_accuracy: 0.9710
Epoch 11/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0466 - accuracy:
0.9641 - val_loss: 0.0403 - val_accuracy: 0.9710
Epoch 12/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0558 - accuracy:
0.9490 - val_loss: 0.0388 - val_accuracy: 0.9710
Epoch 13/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0468 - accuracy:
0.9596 - val_loss: 0.0375 - val_accuracy: 0.9710
Epoch 14/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0470 - accuracy:
0.9579 - val_loss: 0.0364 - val_accuracy: 0.9710
Epoch 15/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0475 - accuracy:
0.9561 - val_loss: 0.0355 - val_accuracy: 0.9710
Epoch 16/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0436 - accuracy:
```

```
0.9602 - val_loss: 0.0347 - val_accuracy: 0.9710
Epoch 17/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0414 - accuracy:
0.9622 - val_loss: 0.0340 - val_accuracy: 0.9710
Epoch 18/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0459 - accuracy:
0.9558 - val_loss: 0.0334 - val_accuracy: 0.9710
Epoch 19/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0364 - accuracy:
0.9671 - val_loss: 0.0329 - val_accuracy: 0.9710
Epoch 20/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0546 - accuracy:
0.9439 - val_loss: 0.0324 - val_accuracy: 0.9710
Epoch 21/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0409 - accuracy:
0.9605 - val_loss: 0.0320 - val_accuracy: 0.9710
Epoch 22/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0439 - accuracy:
0.9565 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 23/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0510 - accuracy:
0.9474 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 24/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0368 - accuracy:
0.9644 - val_loss: 0.0311 - val_accuracy: 0.9710
Epoch 25/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0491 - accuracy:
0.9494 - val_loss: 0.0308 - val_accuracy: 0.9710
Epoch 26/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0413 - accuracy:
0.9585 - val_loss: 0.0306 - val_accuracy: 0.9710
Epoch 27/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0402 - accuracy:
0.9595 - val_loss: 0.0304 - val_accuracy: 0.9710
Epoch 28/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0425 - accuracy:
0.9567 - val_loss: 0.0303 - val_accuracy: 0.9710
Epoch 29/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0461 - accuracy:
0.9523 - val_loss: 0.0301 - val_accuracy: 0.9710
Epoch 30/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0500 - accuracy:
0.9477 - val_loss: 0.0299 - val_accuracy: 0.9710
Epoch 31/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0466 - accuracy:
0.9516 - val_loss: 0.0298 - val_accuracy: 0.9710
Epoch 32/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0427 - accuracy:
```

```
0.9561 - val_loss: 0.0297 - val_accuracy: 0.9710
Epoch 33/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0438 - accuracy:
0.9546 - val_loss: 0.0296 - val_accuracy: 0.9710
Epoch 34/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0411 - accuracy:
0.9577 - val_loss: 0.0295 - val_accuracy: 0.9710
Epoch 35/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0365 - accuracy:
0.9629 - val_loss: 0.0294 - val_accuracy: 0.9710
Epoch 36/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0424 - accuracy:
0.9561 - val_loss: 0.0293 - val_accuracy: 0.9710
Epoch 37/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0433 - accuracy:
0.9550 - val_loss: 0.0292 - val_accuracy: 0.9710
Epoch 38/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0424 - accuracy:
0.9559 - val_loss: 0.0292 - val_accuracy: 0.9710
Epoch 39/100
83/83 [==============================] - 6s 69ms/step - loss: 0.0455 - accuracy:
0.9524 - val_loss: 0.0291 - val_accuracy: 0.9710
Epoch 40/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0363 - accuracy:
0.9628 - val_loss: 0.0290 - val_accuracy: 0.9710
Epoch 41/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0305 - accuracy:
0.9693 - val_loss: 0.0290 - val_accuracy: 0.9710
Epoch 42/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0370 - accuracy:
0.9619 - val_loss: 0.0289 - val_accuracy: 0.9710
Epoch 43/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0443 - accuracy:
0.9537 - val_loss: 0.0289 - val_accuracy: 0.9710
Epoch 44/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0365 - accuracy:
0.9624 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 45/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0408 - accuracy:
0.9576 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 46/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0396 - accuracy:
0.9589 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 47/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0416 - accuracy:
0.9566 - val_loss: 0.0287 - val_accuracy: 0.9710
Epoch 48/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0449 - accuracy:
```

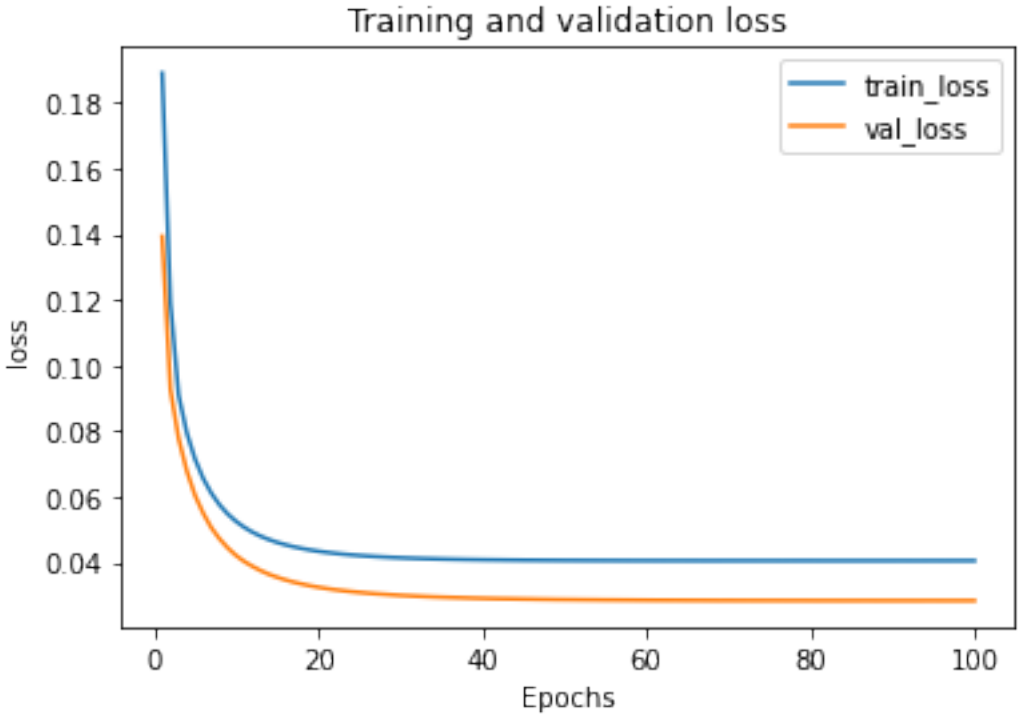
```
0.9529 - val_loss: 0.0287 - val_accuracy: 0.9710
Epoch 49/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0379 - accuracy:
0.9608 - val_loss: 0.0287 - val_accuracy: 0.9710
Epoch 50/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0336 - accuracy:
0.9655 - val_loss: 0.0286 - val_accuracy: 0.9710
Epoch 51/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0447 - accuracy:
0.9532 - val_loss: 0.0286 - val_accuracy: 0.9710
Epoch 52/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0357 - accuracy:
0.9631 - val_loss: 0.0286 - val_accuracy: 0.9710
Epoch 53/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0403 - accuracy:
0.9580 - val_loss: 0.0286 - val_accuracy: 0.9710
Epoch 54/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0377 - accuracy:
0.9608 - val_loss: 0.0286 - val_accuracy: 0.9710
Epoch 55/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0381 - accuracy:
0.9604 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 56/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0433 - accuracy:
0.9546 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 57/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0366 - accuracy:
0.9621 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 58/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0497 - accuracy:
0.9475 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 59/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0480 - accuracy:
0.9494 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 60/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0364 - accuracy:
0.9623 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 61/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0473 - accuracy:
0.9502 - val_loss: 0.0285 - val_accuracy: 0.9710
Epoch 62/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0389 - accuracy:
0.9595 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 63/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0360 - accuracy:
0.9627 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 64/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0553 - accuracy:
```

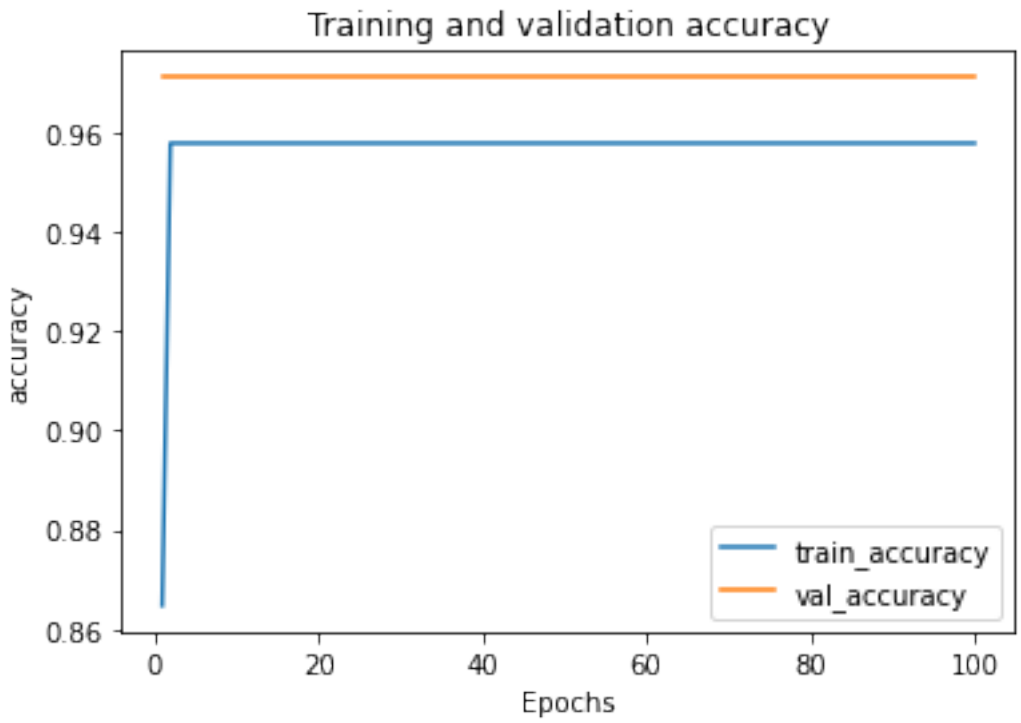
```
0.9414 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 65/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0451 - accuracy:
0.9527 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 66/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0447 - accuracy:
0.9531 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 67/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0467 - accuracy:
0.9509 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 68/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0363 - accuracy:
0.9624 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 69/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0275 - accuracy:
0.9720 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 70/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0425 - accuracy:
0.9556 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 71/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0415 - accuracy:
0.9566 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 72/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0470 - accuracy:
0.9506 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 73/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0371 - accuracy:
0.9614 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 74/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0396 - accuracy:
0.9587 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 75/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0378 - accuracy:
0.9607 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 76/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0419 - accuracy:
0.9562 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 77/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0419 - accuracy:
0.9562 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 78/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0391 - accuracy:
0.9593 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 79/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0483 - accuracy:
0.9491 - val_loss: 0.0284 - val_accuracy: 0.9710
Epoch 80/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0365 - accuracy:
```

```
0.9621 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 81/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0388 - accuracy:
0.9596 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 82/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0373 - accuracy:
0.9613 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 83/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0455 - accuracy:
0.9522 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 84/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0396 - accuracy:
0.9587 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 85/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0337 - accuracy:
0.9652 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 86/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0416 - accuracy:
0.9565 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 87/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0389 - accuracy:
0.9595 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 88/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0380 - accuracy:
0.9604 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 89/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0388 - accuracy:
0.9595 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 90/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0370 - accuracy:
0.9616 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 91/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0355 - accuracy:
0.9632 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 92/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0388 - accuracy:
0.9595 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 93/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0382 - accuracy:
0.9602 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 94/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0343 - accuracy:
0.9645 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 95/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0529 - accuracy:
0.9442 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 96/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0438 - accuracy:
```

```
0.9541 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 97/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0443 - accuracy:
0.9536 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 98/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0542 - accuracy:
0.9427 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 99/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0365 - accuracy:
0.9621 - val_loss: 0.0283 - val_accuracy: 0.9710
Epoch 100/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0395 - accuracy:
0.9589 - val_loss: 0.0283 - val_accuracy: 0.9710
Running time is 505.84 seconds per 100 epoches
Test Accuracy: 0.971
```

[34]:
```
plot_metric(hist_lstm_y1,'loss')
plot_metric(hist_lstm_y1,'accuracy')
```






[35]:
```
hist_lstm_y2=model_trainer2(model_LSTM, y2, X, 100, 10, '0')
```

```
Epoch 1/100
 2/83 […] - ETA: 4s - loss: 0.0476 - accuracy:
0.9500

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 65ms/step - loss: 0.0922 - accuracy:
0.9010 - val_loss: 0.0941 - val_accuracy: 0.8986
Epoch 2/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0916 - accuracy:
0.9010 - val_loss: 0.0934 - val_accuracy: 0.8986
Epoch 3/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0911 - accuracy:
0.9010 - val_loss: 0.0929 - val_accuracy: 0.8986
Epoch 4/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0906 - accuracy:
0.9010 - val_loss: 0.0925 - val_accuracy: 0.8986
Epoch 5/100
```

```
83/83 [==============================] - 5s 57ms/step - loss: 0.0902 - accuracy:
0.9010 - val_loss: 0.0921 - val_accuracy: 0.8986
Epoch 6/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0899 - accuracy:
0.9010 - val_loss: 0.0918 - val_accuracy: 0.8986
Epoch 7/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0897 - accuracy:
0.9010 - val_loss: 0.0916 - val_accuracy: 0.8986
Epoch 8/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0895 - accuracy:
0.9010 - val_loss: 0.0915 - val_accuracy: 0.8986
Epoch 9/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0894 - accuracy:
0.9010 - val_loss: 0.0914 - val_accuracy: 0.8986
Epoch 10/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0894 - accuracy:
0.9010 - val_loss: 0.0913 - val_accuracy: 0.8986
Epoch 11/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0913 - val_accuracy: 0.8986
Epoch 12/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 13/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 14/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 15/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 16/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 17/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 18/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 19/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 20/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 21/100
```

```
83/83 [==============================] - 6s 67ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 22/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 23/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 24/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 25/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 26/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 27/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0912 - val_accuracy: 0.8986
Epoch 28/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0911 - val_accuracy: 0.8986
Epoch 29/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0863 - accuracy:
0.9010 - val_loss: 0.0834 - val_accuracy: 0.8986
Epoch 30/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0808 - accuracy:
0.9010 - val_loss: 0.0833 - val_accuracy: 0.8986
Epoch 31/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0792 - accuracy:
0.9010 - val_loss: 0.0831 - val_accuracy: 0.8986
Epoch 32/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0787 - accuracy:
0.9010 - val_loss: 0.0822 - val_accuracy: 0.8986
Epoch 33/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0783 - accuracy:
0.9010 - val_loss: 0.0825 - val_accuracy: 0.8986
Epoch 34/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0781 - accuracy:
0.9010 - val_loss: 0.0833 - val_accuracy: 0.8986
Epoch 35/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0780 - accuracy:
0.9010 - val_loss: 0.0828 - val_accuracy: 0.8986
Epoch 36/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0774 - accuracy:
0.9010 - val_loss: 0.0802 - val_accuracy: 0.8986
Epoch 37/100
```

```
83/83 [==============================] - 5s 58ms/step - loss: 0.0785 - accuracy:
0.9010 - val_loss: 0.0805 - val_accuracy: 0.8986
Epoch 38/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0762 - accuracy:
0.9010 - val_loss: 0.0808 - val_accuracy: 0.8986
Epoch 39/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0757 - accuracy:
0.9010 - val_loss: 0.0809 - val_accuracy: 0.8986
Epoch 40/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0758 - accuracy:
0.9010 - val_loss: 0.0806 - val_accuracy: 0.8986
Epoch 41/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0758 - accuracy:
0.9010 - val_loss: 0.0811 - val_accuracy: 0.8986
Epoch 42/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0754 - accuracy:
0.9010 - val_loss: 0.0802 - val_accuracy: 0.8986
Epoch 43/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0748 - accuracy:
0.9010 - val_loss: 0.0808 - val_accuracy: 0.8986
Epoch 44/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0764 - accuracy:
0.9010 - val_loss: 0.0799 - val_accuracy: 0.8986
Epoch 45/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0751 - accuracy:
0.9010 - val_loss: 0.0792 - val_accuracy: 0.8986
Epoch 46/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0752 - accuracy:
0.9010 - val_loss: 0.0804 - val_accuracy: 0.8986
Epoch 47/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0745 - accuracy:
0.9010 - val_loss: 0.0802 - val_accuracy: 0.8986
Epoch 48/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0746 - accuracy:
0.9022 - val_loss: 0.0798 - val_accuracy: 0.8986
Epoch 49/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0739 - accuracy:
0.9094 - val_loss: 0.0784 - val_accuracy: 0.9094
Epoch 50/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0745 - accuracy:
0.9058 - val_loss: 0.0801 - val_accuracy: 0.8986
Epoch 51/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0790 - accuracy:
0.9094 - val_loss: 0.0786 - val_accuracy: 0.8913
Epoch 52/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0742 - accuracy:
0.9130 - val_loss: 0.0798 - val_accuracy: 0.8986
Epoch 53/100
```

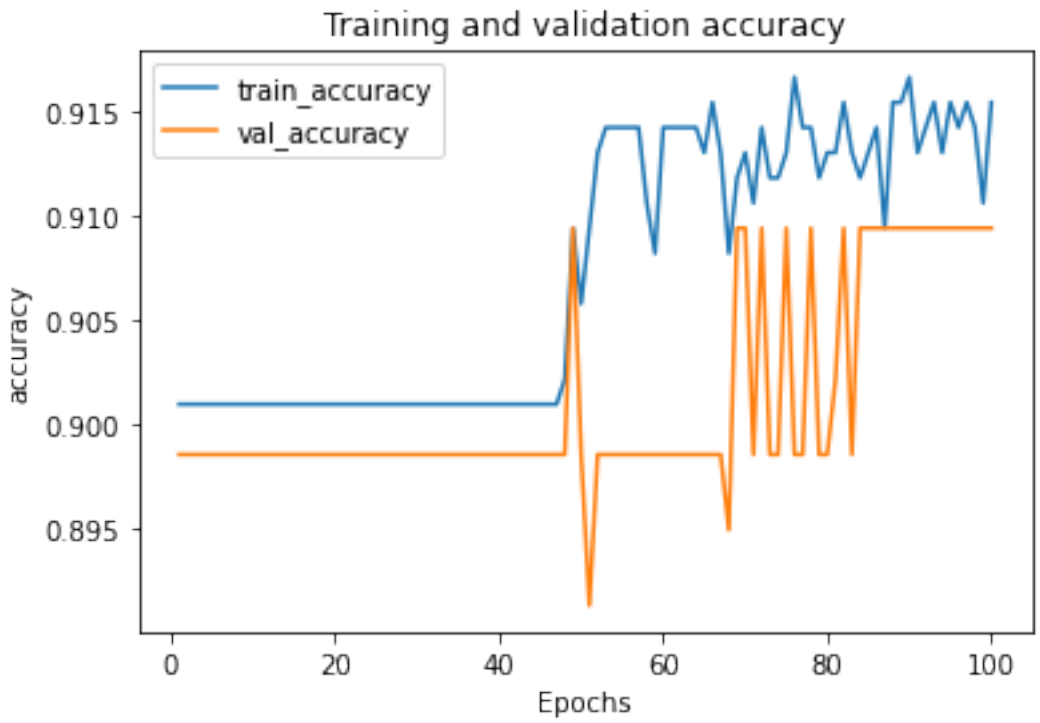
```
83/83 [==============================] - 5s 59ms/step - loss: 0.0739 - accuracy:
0.9143 - val_loss: 0.0795 - val_accuracy: 0.8986
Epoch 54/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0741 - accuracy:
0.9143 - val_loss: 0.0793 - val_accuracy: 0.8986
Epoch 55/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0736 - accuracy:
0.9143 - val_loss: 0.0790 - val_accuracy: 0.8986
Epoch 56/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0729 - accuracy:
0.9143 - val_loss: 0.0791 - val_accuracy: 0.8986
Epoch 57/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0734 - accuracy:
0.9143 - val_loss: 0.0784 - val_accuracy: 0.8986
Epoch 58/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0743 - accuracy:
0.9106 - val_loss: 0.0792 - val_accuracy: 0.8986
Epoch 59/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0739 - accuracy:
0.9082 - val_loss: 0.0773 - val_accuracy: 0.8986
Epoch 60/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0737 - accuracy:
0.9143 - val_loss: 0.0789 - val_accuracy: 0.8986
Epoch 61/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0733 - accuracy:
0.9143 - val_loss: 0.0778 - val_accuracy: 0.8986
Epoch 62/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0732 - accuracy:
0.9143 - val_loss: 0.0788 - val_accuracy: 0.8986
Epoch 63/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0728 - accuracy:
0.9143 - val_loss: 0.0789 - val_accuracy: 0.8986
Epoch 64/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0730 - accuracy:
0.9143 - val_loss: 0.0788 - val_accuracy: 0.8986
Epoch 65/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0732 - accuracy:
0.9130 - val_loss: 0.0784 - val_accuracy: 0.8986
Epoch 66/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0721 - accuracy:
0.9155 - val_loss: 0.0786 - val_accuracy: 0.8986
Epoch 67/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0731 - accuracy:
0.9130 - val_loss: 0.0787 - val_accuracy: 0.8986
Epoch 68/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0730 - accuracy:
0.9082 - val_loss: 0.0797 - val_accuracy: 0.8949
Epoch 69/100
```

```
83/83 [==============================] - 5s 66ms/step - loss: 0.0732 - accuracy:
0.9118 - val_loss: 0.0783 - val_accuracy: 0.9094
Epoch 70/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0731 - accuracy:
0.9130 - val_loss: 0.0786 - val_accuracy: 0.9094
Epoch 71/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0729 - accuracy:
0.9106 - val_loss: 0.0784 - val_accuracy: 0.8986
Epoch 72/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0729 - accuracy:
0.9143 - val_loss: 0.0781 - val_accuracy: 0.9094
Epoch 73/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0727 - accuracy:
0.9118 - val_loss: 0.0783 - val_accuracy: 0.8986
Epoch 74/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0726 - accuracy:
0.9118 - val_loss: 0.0776 - val_accuracy: 0.8986
Epoch 75/100
83/83 [==============================] - 6s 69ms/step - loss: 0.0728 - accuracy:
0.9130 - val_loss: 0.0781 - val_accuracy: 0.9094
Epoch 76/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0731 - accuracy:
0.9167 - val_loss: 0.0771 - val_accuracy: 0.8986
Epoch 77/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0727 - accuracy:
0.9143 - val_loss: 0.0781 - val_accuracy: 0.8986
Epoch 78/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0725 - accuracy:
0.9143 - val_loss: 0.0785 - val_accuracy: 0.9094
Epoch 79/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0723 - accuracy:
0.9118 - val_loss: 0.0782 - val_accuracy: 0.8986
Epoch 80/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0724 - accuracy:
0.9130 - val_loss: 0.0783 - val_accuracy: 0.8986
Epoch 81/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0720 - accuracy:
0.9130 - val_loss: 0.0778 - val_accuracy: 0.9022
Epoch 82/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0723 - accuracy:
0.9155 - val_loss: 0.0777 - val_accuracy: 0.9094
Epoch 83/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0713 - accuracy:
0.9130 - val_loss: 0.0784 - val_accuracy: 0.8986
Epoch 84/100
83/83 [==============================] - 6s 69ms/step - loss: 0.0727 - accuracy:
0.9118 - val_loss: 0.0776 - val_accuracy: 0.9094
Epoch 85/100
```

```
83/83 [==============================] - 5s 59ms/step - loss: 0.0722 - accuracy:
0.9130 - val_loss: 0.0777 - val_accuracy: 0.9094
Epoch 86/100
83/83 [==============================] - 6s 69ms/step - loss: 0.0713 - accuracy:
0.9143 - val_loss: 0.0775 - val_accuracy: 0.9094
Epoch 87/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0724 - accuracy:
0.9094 - val_loss: 0.0777 - val_accuracy: 0.9094
Epoch 88/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0718 - accuracy:
0.9155 - val_loss: 0.0776 - val_accuracy: 0.9094
Epoch 89/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0721 - accuracy:
0.9155 - val_loss: 0.0779 - val_accuracy: 0.9094
Epoch 90/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0708 - accuracy:
0.9167 - val_loss: 0.0776 - val_accuracy: 0.9094
Epoch 91/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0719 - accuracy:
0.9130 - val_loss: 0.0774 - val_accuracy: 0.9094
Epoch 92/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0715 - accuracy:
0.9143 - val_loss: 0.0777 - val_accuracy: 0.9094
Epoch 93/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0723 - accuracy:
0.9155 - val_loss: 0.0777 - val_accuracy: 0.9094
Epoch 94/100
83/83 [==============================] - 6s 68ms/step - loss: 0.0720 - accuracy:
0.9130 - val_loss: 0.0775 - val_accuracy: 0.9094
Epoch 95/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0720 - accuracy:
0.9155 - val_loss: 0.0771 - val_accuracy: 0.9094
Epoch 96/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0715 - accuracy:
0.9143 - val_loss: 0.0769 - val_accuracy: 0.9094
Epoch 97/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0720 - accuracy:
0.9155 - val_loss: 0.0770 - val_accuracy: 0.9094
Epoch 98/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0713 - accuracy:
0.9143 - val_loss: 0.0770 - val_accuracy: 0.9094
Epoch 99/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0721 - accuracy:
0.9106 - val_loss: 0.0767 - val_accuracy: 0.9094
Epoch 100/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0712 - accuracy:
0.9155 - val_loss: 0.0770 - val_accuracy: 0.9094
Running time is 561.97 seconds per 100 epoches
```

```
Test Accuracy: 0.909
```

[36]:
```
plot_metric(hist_lstm_y2,'loss')
plot_metric(hist_lstm_y2,'accuracy')
```




[37]:
```
hist_lstm_y3=model_trainer2(model_LSTM, y3, X, 100, 10, '0')
```

```
Epoch 1/100
 3/83 [>…] - ETA: 3s - loss: 0.4320 - accuracy:
0.4667

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 58ms/step - loss: 0.3184 - accuracy:
0.6147 - val_loss: 0.2864 - val_accuracy: 0.6703
Epoch 2/100
83/83 [==============================] - 5s 57ms/step - loss: 0.2645 - accuracy:
0.6473 - val_loss: 0.2160 - val_accuracy: 0.6812
Epoch 3/100
83/83 [==============================] - 5s 63ms/step - loss: 0.2184 - accuracy:
0.6522 - val_loss: 0.2005 - val_accuracy: 0.6848
Epoch 4/100
83/83 [==============================] - 5s 55ms/step - loss: 0.2098 - accuracy:
0.6558 - val_loss: 0.1913 - val_accuracy: 0.6848
Epoch 5/100
```

```
83/83 [==============================] - 5s 64ms/step - loss: 0.1938 - accuracy:
0.6558 - val_loss: 0.1755 - val_accuracy: 0.6848
Epoch 6/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1784 - accuracy:
0.6558 - val_loss: 0.1640 - val_accuracy: 0.6848
Epoch 7/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1697 - accuracy:
0.6606 - val_loss: 0.1593 - val_accuracy: 0.6957
Epoch 8/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1573 - accuracy:
0.7862 - val_loss: 0.1568 - val_accuracy: 0.8007
Epoch 9/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1624 - accuracy:
0.7850 - val_loss: 0.1618 - val_accuracy: 0.7464
Epoch 10/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1529 - accuracy:
0.8031 - val_loss: 0.1431 - val_accuracy: 0.8080
Epoch 11/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1472 - accuracy:
0.8152 - val_loss: 0.1418 - val_accuracy: 0.8043
Epoch 12/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1516 - accuracy:
0.8007 - val_loss: 0.1477 - val_accuracy: 0.7971
Epoch 13/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1553 - accuracy:
0.7874 - val_loss: 0.1512 - val_accuracy: 0.7826
Epoch 14/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1503 - accuracy:
0.7983 - val_loss: 0.1381 - val_accuracy: 0.8080
Epoch 15/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1435 - accuracy:
0.8116 - val_loss: 0.1459 - val_accuracy: 0.7935
Epoch 16/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1420 - accuracy:
0.8176 - val_loss: 0.1375 - val_accuracy: 0.8116
Epoch 17/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1414 - accuracy:
0.8164 - val_loss: 0.1474 - val_accuracy: 0.7862
Epoch 18/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1432 - accuracy:
0.8092 - val_loss: 0.1383 - val_accuracy: 0.8080
Epoch 19/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1400 - accuracy:
0.8200 - val_loss: 0.1361 - val_accuracy: 0.8152
Epoch 20/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1394 - accuracy:
0.8200 - val_loss: 0.1468 - val_accuracy: 0.7862
Epoch 21/100
```

```
83/83 [==============================] - 5s 61ms/step - loss: 0.1421 - accuracy:
0.8104 - val_loss: 0.1426 - val_accuracy: 0.8007
Epoch 22/100
83/83 [==============================] - 6s 67ms/step - loss: 0.1346 - accuracy:
0.8321 - val_loss: 0.1304 - val_accuracy: 0.8261
Epoch 23/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1349 - accuracy:
0.8297 - val_loss: 0.1349 - val_accuracy: 0.8188
Epoch 24/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1307 - accuracy:
0.8357 - val_loss: 0.1292 - val_accuracy: 0.8297
Epoch 25/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1254 - accuracy:
0.8502 - val_loss: 0.1351 - val_accuracy: 0.8152
Epoch 26/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1245 - accuracy:
0.8527 - val_loss: 0.1227 - val_accuracy: 0.8442
Epoch 27/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1229 - accuracy:
0.8551 - val_loss: 0.1227 - val_accuracy: 0.8442
Epoch 28/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1210 - accuracy:
0.8587 - val_loss: 0.1237 - val_accuracy: 0.8406
Epoch 29/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1208 - accuracy:
0.8563 - val_loss: 0.1275 - val_accuracy: 0.8333
Epoch 30/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1188 - accuracy:
0.8599 - val_loss: 0.1237 - val_accuracy: 0.8406
Epoch 31/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1180 - accuracy:
0.8611 - val_loss: 0.1238 - val_accuracy: 0.8406
Epoch 32/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1177 - accuracy:
0.8611 - val_loss: 0.1238 - val_accuracy: 0.8406
Epoch 33/100
83/83 [==============================] - 6s 67ms/step - loss: 0.1175 - accuracy:
0.8611 - val_loss: 0.1239 - val_accuracy: 0.8406
Epoch 34/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1223 - accuracy:
0.8514 - val_loss: 0.1394 - val_accuracy: 0.8116
Epoch 35/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1212 - accuracy:
0.8527 - val_loss: 0.1304 - val_accuracy: 0.8261
Epoch 36/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1203 - accuracy:
0.8551 - val_loss: 0.1122 - val_accuracy: 0.8623
Epoch 37/100
```

```
83/83 [==============================] - 5s 60ms/step - loss: 0.1149 - accuracy:
0.8659 - val_loss: 0.1066 - val_accuracy: 0.8732
Epoch 38/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1138 - accuracy:
0.8671 - val_loss: 0.1047 - val_accuracy: 0.8768
Epoch 39/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1110 - accuracy:
0.8720 - val_loss: 0.1044 - val_accuracy: 0.8768
Epoch 40/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1108 - accuracy:
0.8720 - val_loss: 0.1042 - val_accuracy: 0.8768
Epoch 41/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1106 - accuracy:
0.8720 - val_loss: 0.1041 - val_accuracy: 0.8768
Epoch 42/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1105 - accuracy:
0.8720 - val_loss: 0.1041 - val_accuracy: 0.8768
Epoch 43/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1104 - accuracy:
0.8720 - val_loss: 0.1040 - val_accuracy: 0.8768
Epoch 44/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1103 - accuracy:
0.8720 - val_loss: 0.1040 - val_accuracy: 0.8768
Epoch 45/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1102 - accuracy:
0.8720 - val_loss: 0.1039 - val_accuracy: 0.8768
Epoch 46/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1101 - accuracy:
0.8720 - val_loss: 0.1039 - val_accuracy: 0.8768
Epoch 47/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1100 - accuracy:
0.8720 - val_loss: 0.1039 - val_accuracy: 0.8768
Epoch 48/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1100 - accuracy:
0.8720 - val_loss: 0.1038 - val_accuracy: 0.8768
Epoch 49/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1099 - accuracy:
0.8720 - val_loss: 0.1038 - val_accuracy: 0.8768
Epoch 50/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1099 - accuracy:
0.8720 - val_loss: 0.1037 - val_accuracy: 0.8768
Epoch 51/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1099 - accuracy:
0.8720 - val_loss: 0.1037 - val_accuracy: 0.8768
Epoch 52/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1099 - accuracy:
0.8720 - val_loss: 0.1037 - val_accuracy: 0.8768
Epoch 53/100
```

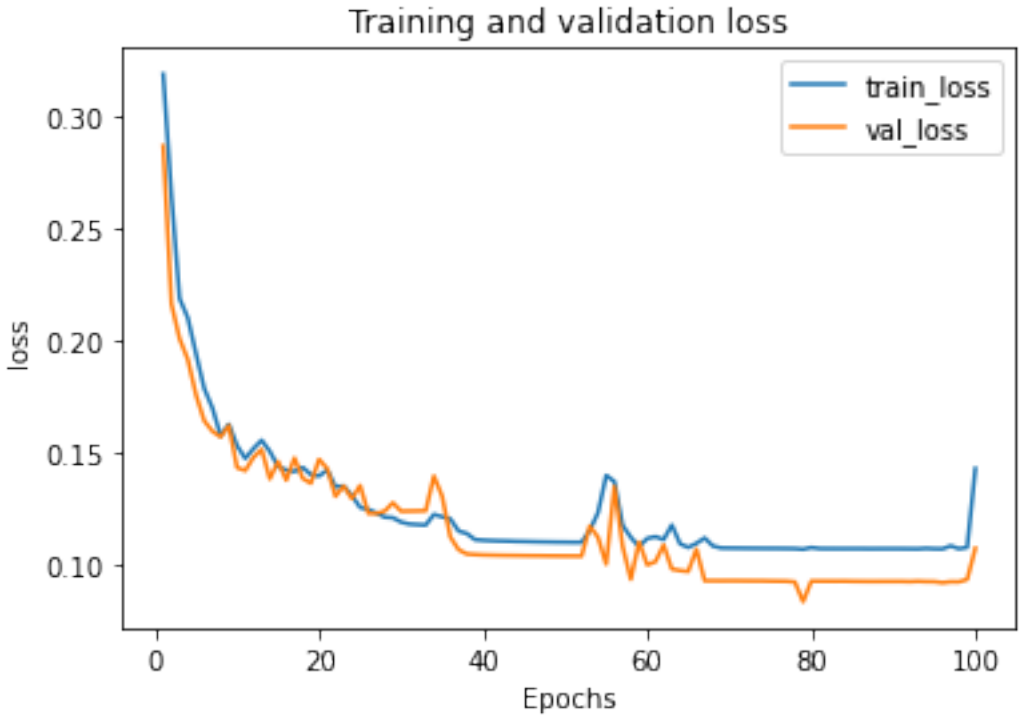
```
83/83 [==============================] - 5s 59ms/step - loss: 0.1152 - accuracy:
0.8623 - val_loss: 0.1171 - val_accuracy: 0.8551
Epoch 54/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1230 - accuracy:
0.8502 - val_loss: 0.1121 - val_accuracy: 0.8623
Epoch 55/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1397 - accuracy:
0.8213 - val_loss: 0.1001 - val_accuracy: 0.8804
Epoch 56/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1369 - accuracy:
0.8261 - val_loss: 0.1347 - val_accuracy: 0.8261
Epoch 57/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1174 - accuracy:
0.8599 - val_loss: 0.1081 - val_accuracy: 0.8768
Epoch 58/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1121 - accuracy:
0.8708 - val_loss: 0.0934 - val_accuracy: 0.8949
Epoch 59/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1079 - accuracy:
0.8768 - val_loss: 0.1101 - val_accuracy: 0.8659
Epoch 60/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1116 - accuracy:
0.8696 - val_loss: 0.0998 - val_accuracy: 0.8841
Epoch 61/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1124 - accuracy:
0.8671 - val_loss: 0.1012 - val_accuracy: 0.8804
Epoch 62/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1111 - accuracy:
0.8696 - val_loss: 0.1086 - val_accuracy: 0.8659
Epoch 63/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1175 - accuracy:
0.8587 - val_loss: 0.0979 - val_accuracy: 0.8841
Epoch 64/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1092 - accuracy:
0.8732 - val_loss: 0.0973 - val_accuracy: 0.8877
Epoch 65/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1076 - accuracy:
0.8768 - val_loss: 0.0969 - val_accuracy: 0.8877
Epoch 66/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1094 - accuracy:
0.8732 - val_loss: 0.1068 - val_accuracy: 0.8696
Epoch 67/100
83/83 [==============================] - 5s 62ms/step - loss: 0.1118 - accuracy:
0.8696 - val_loss: 0.0928 - val_accuracy: 0.8949
Epoch 68/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1082 - accuracy:
0.8756 - val_loss: 0.0928 - val_accuracy: 0.8949
Epoch 69/100
```

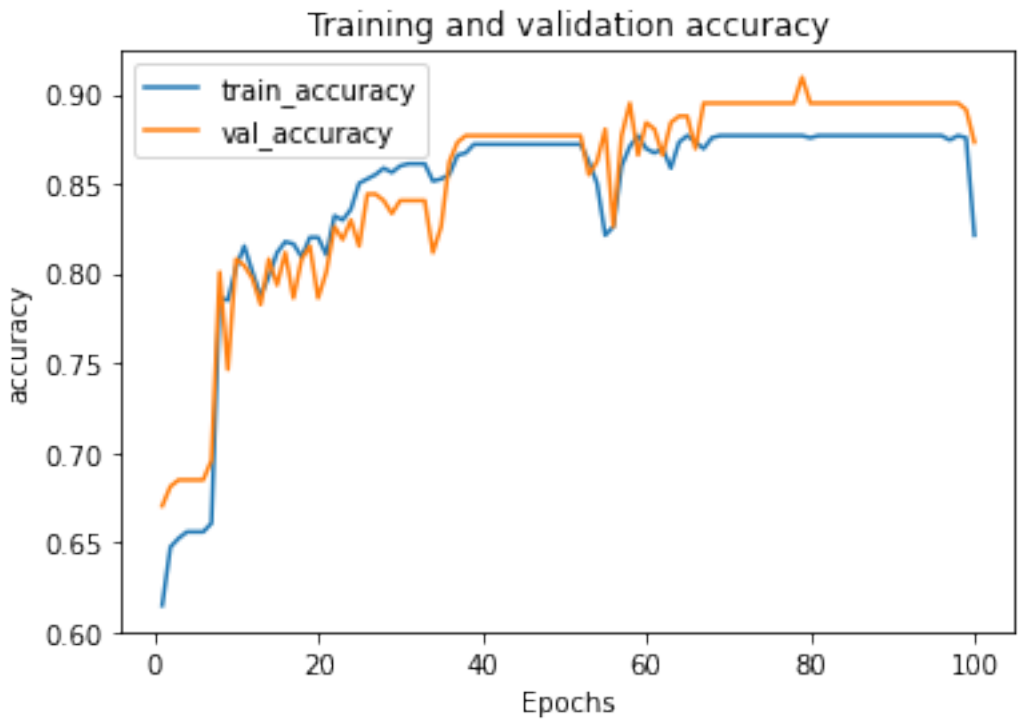
```
83/83 [==============================] - 5s 59ms/step - loss: 0.1073 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 70/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1073 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 71/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1072 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 72/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1072 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 73/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1072 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 74/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0927 - val_accuracy: 0.8949
Epoch 75/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0926 - val_accuracy: 0.8949
Epoch 76/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 77/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 78/100
83/83 [==============================] - 5s 62ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0922 - val_accuracy: 0.8949
Epoch 79/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1067 - accuracy:
0.8768 - val_loss: 0.0834 - val_accuracy: 0.9094
Epoch 80/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1075 - accuracy:
0.8756 - val_loss: 0.0926 - val_accuracy: 0.8949
Epoch 81/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0926 - val_accuracy: 0.8949
Epoch 82/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 83/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 84/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 85/100
```

```
83/83 [==============================] - 5s 65ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 86/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 87/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 88/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 89/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 90/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 91/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0924 - val_accuracy: 0.8949
Epoch 92/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0923 - val_accuracy: 0.8949
Epoch 93/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1069 - accuracy:
0.8768 - val_loss: 0.0925 - val_accuracy: 0.8949
Epoch 94/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1071 - accuracy:
0.8768 - val_loss: 0.0923 - val_accuracy: 0.8949
Epoch 95/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0923 - val_accuracy: 0.8949
Epoch 96/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1069 - accuracy:
0.8768 - val_loss: 0.0919 - val_accuracy: 0.8949
Epoch 97/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1083 - accuracy:
0.8744 - val_loss: 0.0923 - val_accuracy: 0.8949
Epoch 98/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1070 - accuracy:
0.8768 - val_loss: 0.0922 - val_accuracy: 0.8949
Epoch 99/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1076 - accuracy:
0.8756 - val_loss: 0.0933 - val_accuracy: 0.8913
Epoch 100/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1427 - accuracy:
0.8213 - val_loss: 0.1072 - val_accuracy: 0.8732
Running time is 499.57 seconds per 100 epoches
```

```
Test Accuracy: 0.841
```

[38]:
```
plot_metric(hist_lstm_y3,'loss')
plot_metric(hist_lstm_y3,'accuracy')
```






#### 4.0.4 CM3- (iii)

Below is a neural network which has been trained based upon the LSTM architecture exactly similar to the previous one. The only difference is that we have used the **'sgd'** optimizer here to see the changes in the performance.

[39]:
```
# LSTM with sgd
model_LSTM.compile(loss='mse',
              optimizer='sgd',
              metrics=['accuracy'])
```

[40]:
```
hist_lstm_y1_sgd=model_trainer2(model_LSTM, y1, X,  100, 10, '0')
```

```
Epoch 1/100
 2/83 […] - ETA: 4s - loss: 0.2143 - accuracy:
0.7000

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 56ms/step - loss: 0.2781 - accuracy:
```

```
0.6137 - val_loss: 0.2791 - val_accuracy: 0.6087
Epoch 2/100
83/83 [==============================] - 4s 53ms/step - loss: 0.2488 - accuracy:
0.6449 - val_loss: 0.2642 - val_accuracy: 0.6159
Epoch 3/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2205 - accuracy:
0.6691 - val_loss: 0.2161 - val_accuracy: 0.6594
Epoch 4/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1827 - accuracy:
0.7058 - val_loss: 0.2036 - val_accuracy: 0.6630
Epoch 5/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1756 - accuracy:
0.7025 - val_loss: 0.1919 - val_accuracy: 0.6630
Epoch 6/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1723 - accuracy:
0.6899 - val_loss: 0.1800 - val_accuracy: 0.6630
Epoch 7/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1653 - accuracy:
0.6919 - val_loss: 0.1681 - val_accuracy: 0.6630
Epoch 8/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1467 - accuracy:
0.6969 - val_loss: 0.1565 - val_accuracy: 0.6630
Epoch 9/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1427 - accuracy:
0.6780 - val_loss: 0.1455 - val_accuracy: 0.6630
Epoch 10/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1225 - accuracy:
0.7105 - val_loss: 0.1351 - val_accuracy: 0.6630
Epoch 11/100
83/83 [==============================] - 5s 54ms/step - loss: 0.1191 - accuracy:
0.6903 - val_loss: 0.1257 - val_accuracy: 0.6667
Epoch 12/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1119 - accuracy:
0.6858 - val_loss: 0.1172 - val_accuracy: 0.6703
Epoch 13/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0985 - accuracy:
0.8272 - val_loss: 0.1097 - val_accuracy: 0.9384
Epoch 14/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0884 - accuracy:
0.9553 - val_loss: 0.1031 - val_accuracy: 0.9384
Epoch 15/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0869 - accuracy:
0.9610 - val_loss: 0.0973 - val_accuracy: 0.9384
Epoch 16/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0869 - accuracy:
0.9479 - val_loss: 0.0922 - val_accuracy: 0.9384
Epoch 17/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0796 - accuracy:
```

```
0.9507 - val_loss: 0.0879 - val_accuracy: 0.9384
Epoch 18/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0828 - accuracy:
0.9471 - val_loss: 0.0840 - val_accuracy: 0.9384
Epoch 19/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0884 - accuracy:
0.9321 - val_loss: 0.0807 - val_accuracy: 0.9384
Epoch 20/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0640 - accuracy:
0.9536 - val_loss: 0.0778 - val_accuracy: 0.9384
Epoch 21/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0660 - accuracy:
0.9574 - val_loss: 0.0752 - val_accuracy: 0.9384
Epoch 22/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0673 - accuracy:
0.9494 - val_loss: 0.0730 - val_accuracy: 0.9384
Epoch 23/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0702 - accuracy:
0.9403 - val_loss: 0.0710 - val_accuracy: 0.9384
Epoch 24/100
83/83 [==============================] - 5s 60ms/step - loss: 0.0652 - accuracy:
0.9428 - val_loss: 0.0691 - val_accuracy: 0.9384
Epoch 25/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0583 - accuracy:
0.9498 - val_loss: 0.0676 - val_accuracy: 0.9384
Epoch 26/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0618 - accuracy:
0.9451 - val_loss: 0.0661 - val_accuracy: 0.9384
Epoch 27/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0727 - accuracy:
0.9315 - val_loss: 0.0648 - val_accuracy: 0.9384
Epoch 28/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0562 - accuracy:
0.9484 - val_loss: 0.0636 - val_accuracy: 0.9384
Epoch 29/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0548 - accuracy:
0.9500 - val_loss: 0.0626 - val_accuracy: 0.9384
Epoch 30/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0604 - accuracy:
0.9418 - val_loss: 0.0616 - val_accuracy: 0.9384
Epoch 31/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0604 - accuracy:
0.9423 - val_loss: 0.0607 - val_accuracy: 0.9384
Epoch 32/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0549 - accuracy:
0.9538 - val_loss: 0.0599 - val_accuracy: 0.9384
Epoch 33/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0563 - accuracy:
```

```
0.9477 - val_loss: 0.0592 - val_accuracy: 0.9384
Epoch 34/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0588 - accuracy:
0.9413 - val_loss: 0.0585 - val_accuracy: 0.9384
Epoch 35/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0575 - accuracy:
0.9413 - val_loss: 0.0578 - val_accuracy: 0.9384
Epoch 36/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0468 - accuracy:
0.9545 - val_loss: 0.0572 - val_accuracy: 0.9384
Epoch 37/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0571 - accuracy:
0.9415 - val_loss: 0.0567 - val_accuracy: 0.9384
Epoch 38/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0585 - accuracy:
0.9379 - val_loss: 0.0562 - val_accuracy: 0.9384
Epoch 39/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0504 - accuracy:
0.9500 - val_loss: 0.0557 - val_accuracy: 0.9384
Epoch 40/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0582 - accuracy:
0.9402 - val_loss: 0.0552 - val_accuracy: 0.9384
Epoch 41/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0638 - accuracy:
0.9358 - val_loss: 0.0548 - val_accuracy: 0.9384
Epoch 42/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0578 - accuracy:
0.9390 - val_loss: 0.0544 - val_accuracy: 0.9384
Epoch 43/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0551 - accuracy:
0.9436 - val_loss: 0.0540 - val_accuracy: 0.9384
Epoch 44/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0500 - accuracy:
0.9470 - val_loss: 0.0536 - val_accuracy: 0.9384
Epoch 45/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0599 - accuracy:
0.9358 - val_loss: 0.0533 - val_accuracy: 0.9384
Epoch 46/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0463 - accuracy:
0.9522 - val_loss: 0.0529 - val_accuracy: 0.9384
Epoch 47/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0546 - accuracy:
0.9429 - val_loss: 0.0526 - val_accuracy: 0.9384
Epoch 48/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0498 - accuracy:
0.9465 - val_loss: 0.0523 - val_accuracy: 0.9384
Epoch 49/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0527 - accuracy:
```

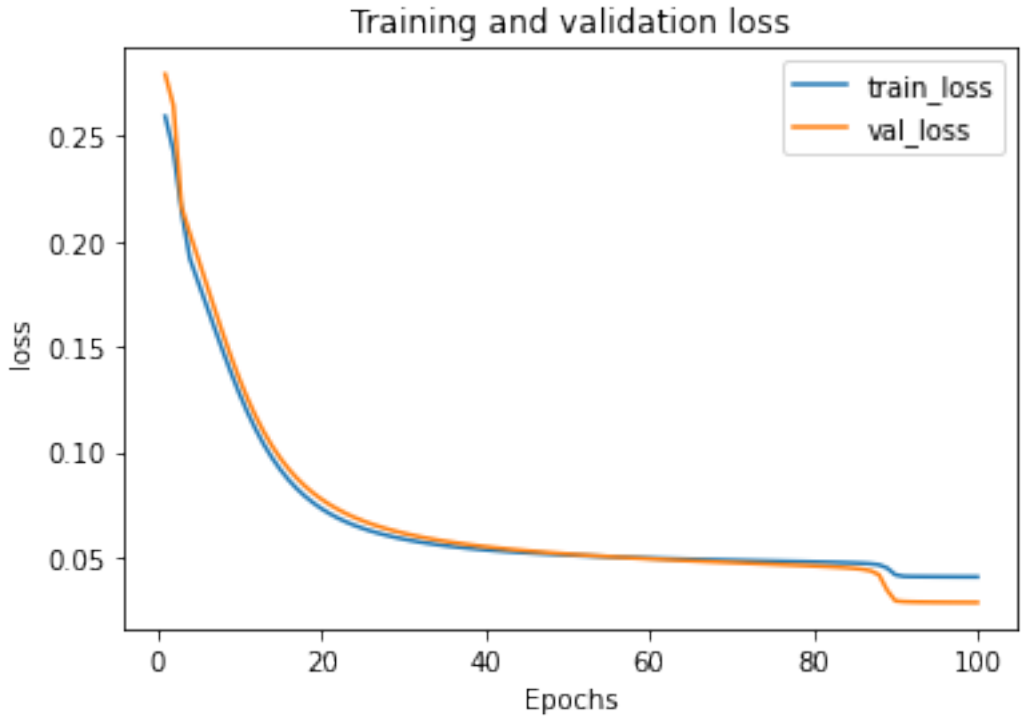
```
0.9443 - val_loss: 0.0520 - val_accuracy: 0.9384
Epoch 50/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0569 - accuracy:
0.9359 - val_loss: 0.0517 - val_accuracy: 0.9384
Epoch 51/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0539 - accuracy:
0.9417 - val_loss: 0.0515 - val_accuracy: 0.9384
Epoch 52/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0487 - accuracy:
0.9467 - val_loss: 0.0512 - val_accuracy: 0.9384
Epoch 53/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0389 - accuracy:
0.9572 - val_loss: 0.0510 - val_accuracy: 0.9384
Epoch 54/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0517 - accuracy:
0.9432 - val_loss: 0.0507 - val_accuracy: 0.9384
Epoch 55/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0454 - accuracy:
0.9505 - val_loss: 0.0505 - val_accuracy: 0.9384
Epoch 56/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0527 - accuracy:
0.9398 - val_loss: 0.0503 - val_accuracy: 0.9384
Epoch 57/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0554 - accuracy:
0.9380 - val_loss: 0.0501 - val_accuracy: 0.9384
Epoch 58/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0582 - accuracy:
0.9332 - val_loss: 0.0498 - val_accuracy: 0.9384
Epoch 59/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0629 - accuracy:
0.9300 - val_loss: 0.0496 - val_accuracy: 0.9384
Epoch 60/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0463 - accuracy:
0.9519 - val_loss: 0.0494 - val_accuracy: 0.9384
Epoch 61/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0497 - accuracy:
0.9456 - val_loss: 0.0492 - val_accuracy: 0.9384
Epoch 62/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0509 - accuracy:
0.9424 - val_loss: 0.0491 - val_accuracy: 0.9384
Epoch 63/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0487 - accuracy:
0.9446 - val_loss: 0.0489 - val_accuracy: 0.9384
Epoch 64/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0483 - accuracy:
0.9432 - val_loss: 0.0487 - val_accuracy: 0.9384
Epoch 65/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0527 - accuracy:
```

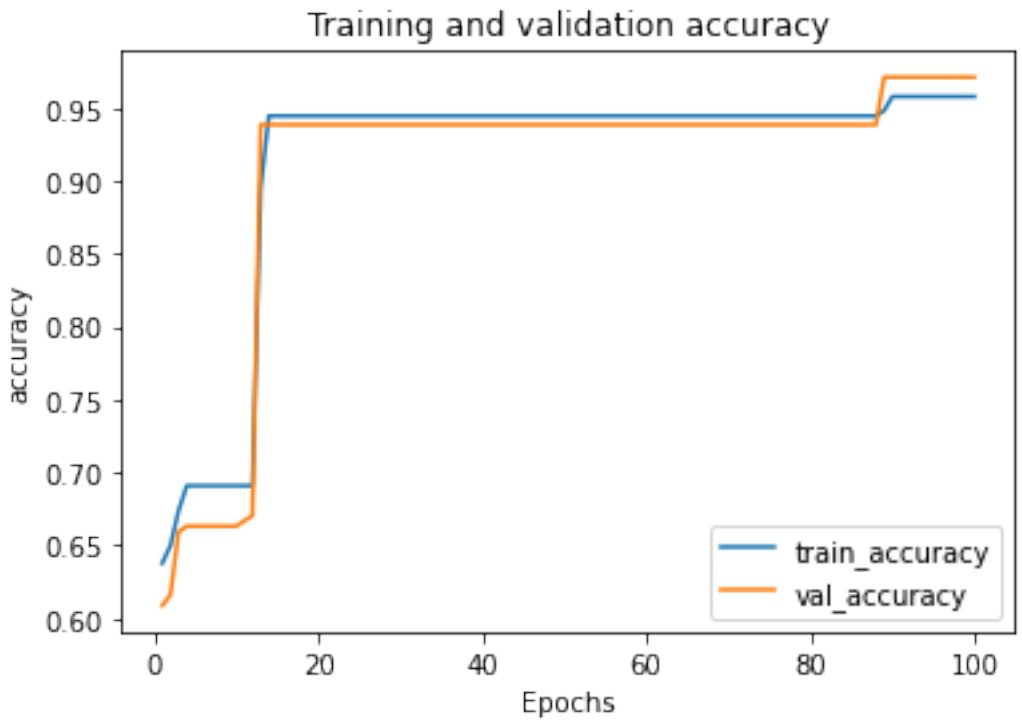
```
0.9412 - val_loss: 0.0485 - val_accuracy: 0.9384
Epoch 66/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0508 - accuracy:
0.9422 - val_loss: 0.0483 - val_accuracy: 0.9384
Epoch 67/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0454 - accuracy:
0.9488 - val_loss: 0.0482 - val_accuracy: 0.9384
Epoch 68/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0529 - accuracy:
0.9408 - val_loss: 0.0480 - val_accuracy: 0.9384
Epoch 69/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0548 - accuracy:
0.9386 - val_loss: 0.0478 - val_accuracy: 0.9384
Epoch 70/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0506 - accuracy:
0.9422 - val_loss: 0.0477 - val_accuracy: 0.9384
Epoch 71/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0444 - accuracy:
0.9482 - val_loss: 0.0475 - val_accuracy: 0.9384
Epoch 72/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0395 - accuracy:
0.9536 - val_loss: 0.0473 - val_accuracy: 0.9384
Epoch 73/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0615 - accuracy:
0.9310 - val_loss: 0.0472 - val_accuracy: 0.9384
Epoch 74/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0483 - accuracy:
0.9444 - val_loss: 0.0470 - val_accuracy: 0.9384
Epoch 75/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0564 - accuracy:
0.9344 - val_loss: 0.0469 - val_accuracy: 0.9384
Epoch 76/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0510 - accuracy:
0.9419 - val_loss: 0.0467 - val_accuracy: 0.9384
Epoch 77/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0534 - accuracy:
0.9409 - val_loss: 0.0466 - val_accuracy: 0.9384
Epoch 78/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0469 - accuracy:
0.9466 - val_loss: 0.0464 - val_accuracy: 0.9384
Epoch 79/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0499 - accuracy:
0.9415 - val_loss: 0.0462 - val_accuracy: 0.9384
Epoch 80/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0532 - accuracy:
0.9362 - val_loss: 0.0461 - val_accuracy: 0.9384
Epoch 81/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0434 - accuracy:
```

```
0.9503 - val_loss: 0.0459 - val_accuracy: 0.9384
Epoch 82/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0410 - accuracy:
0.9529 - val_loss: 0.0457 - val_accuracy: 0.9384
Epoch 83/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0458 - accuracy:
0.9473 - val_loss: 0.0455 - val_accuracy: 0.9384
Epoch 84/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0460 - accuracy:
0.9453 - val_loss: 0.0452 - val_accuracy: 0.9384
Epoch 85/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0562 - accuracy:
0.9350 - val_loss: 0.0449 - val_accuracy: 0.9384
Epoch 86/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0507 - accuracy:
0.9375 - val_loss: 0.0445 - val_accuracy: 0.9384
Epoch 87/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0475 - accuracy:
0.9425 - val_loss: 0.0438 - val_accuracy: 0.9384
Epoch 88/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0536 - accuracy:
0.9334 - val_loss: 0.0419 - val_accuracy: 0.9384
Epoch 89/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0442 - accuracy:
0.9477 - val_loss: 0.0346 - val_accuracy: 0.9710
Epoch 90/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0376 - accuracy:
0.9636 - val_loss: 0.0295 - val_accuracy: 0.9710
Epoch 91/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0382 - accuracy:
0.9609 - val_loss: 0.0291 - val_accuracy: 0.9710
Epoch 92/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0523 - accuracy:
0.9459 - val_loss: 0.0290 - val_accuracy: 0.9710
Epoch 93/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0376 - accuracy:
0.9610 - val_loss: 0.0290 - val_accuracy: 0.9710
Epoch 94/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0413 - accuracy:
0.9571 - val_loss: 0.0289 - val_accuracy: 0.9710
Epoch 95/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0379 - accuracy:
0.9612 - val_loss: 0.0289 - val_accuracy: 0.9710
Epoch 96/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0445 - accuracy:
0.9520 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 97/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0461 - accuracy:
```

```
0.9524 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 98/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0371 - accuracy:
0.9626 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 99/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0385 - accuracy:
0.9613 - val_loss: 0.0288 - val_accuracy: 0.9710
Epoch 100/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0364 - accuracy:
0.9629 - val_loss: 0.0288 - val_accuracy: 0.9710
Running time is 501.98 seconds per 100 epoches
Test Accuracy: 0.971
```

[41]:
```
plot_metric(hist_lstm_y1_sgd,'loss')
plot_metric(hist_lstm_y1_sgd,'accuracy')
```






[42]:
```
hist_lstm_y2_sgd=model_trainer2(model_LSTM, y2, X, 100, 10, '0')
```

```
Epoch 1/100
 3/83 [>…] - ETA: 3s - loss: 0.0307 - accuracy:
0.9667

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 58ms/step - loss: 0.0954 - accuracy:
0.9010 - val_loss: 0.0975 - val_accuracy: 0.8986
Epoch 2/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0950 - accuracy:
0.9010 - val_loss: 0.0958 - val_accuracy: 0.8986
Epoch 3/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0939 - accuracy:
0.9010 - val_loss: 0.0946 - val_accuracy: 0.8986
Epoch 4/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0933 - accuracy:
0.8998 - val_loss: 0.0952 - val_accuracy: 0.8986
Epoch 5/100
```

```
83/83 [==============================] - 5s 55ms/step - loss: 0.0931 - accuracy:
0.9010 - val_loss: 0.0951 - val_accuracy: 0.8986
Epoch 6/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0932 - accuracy:
0.9010 - val_loss: 0.0955 - val_accuracy: 0.9094
Epoch 7/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0931 - accuracy:
0.8986 - val_loss: 0.0951 - val_accuracy: 0.9058
Epoch 8/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0931 - accuracy:
0.8998 - val_loss: 0.0952 - val_accuracy: 0.9094
Epoch 9/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0931 - accuracy:
0.9010 - val_loss: 0.0949 - val_accuracy: 0.8986
Epoch 10/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0932 - accuracy:
0.8998 - val_loss: 0.0950 - val_accuracy: 0.8986
Epoch 11/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0931 - accuracy:
0.9010 - val_loss: 0.0949 - val_accuracy: 0.8986
Epoch 12/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0931 - accuracy:
0.9010 - val_loss: 0.0951 - val_accuracy: 0.9094
Epoch 13/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0931 - accuracy:
0.8998 - val_loss: 0.0949 - val_accuracy: 0.8986
Epoch 14/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0930 - accuracy:
0.9022 - val_loss: 0.0949 - val_accuracy: 0.9058
Epoch 15/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0931 - accuracy:
0.9010 - val_loss: 0.0953 - val_accuracy: 0.9058
Epoch 16/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0930 - accuracy:
0.8973 - val_loss: 0.0952 - val_accuracy: 0.9058
Epoch 17/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0930 - accuracy:
0.8998 - val_loss: 0.0950 - val_accuracy: 0.9094
Epoch 18/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0930 - accuracy:
0.9022 - val_loss: 0.0949 - val_accuracy: 0.9094
Epoch 19/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0930 - accuracy:
0.8986 - val_loss: 0.0948 - val_accuracy: 0.9094
Epoch 20/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0930 - accuracy:
0.8998 - val_loss: 0.0947 - val_accuracy: 0.9058
Epoch 21/100
```

```
83/83 [==============================] - 5s 63ms/step - loss: 0.0930 - accuracy:
0.9022 - val_loss: 0.0948 - val_accuracy: 0.9094
Epoch 22/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0930 - accuracy:
0.8986 - val_loss: 0.0949 - val_accuracy: 0.9094
Epoch 23/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0929 - accuracy:
0.8998 - val_loss: 0.0948 - val_accuracy: 0.9094
Epoch 24/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0930 - accuracy:
0.8998 - val_loss: 0.0949 - val_accuracy: 0.9058
Epoch 25/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0929 - accuracy:
0.8998 - val_loss: 0.0947 - val_accuracy: 0.9094
Epoch 26/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0930 - accuracy:
0.8998 - val_loss: 0.0951 - val_accuracy: 0.9022
Epoch 27/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0929 - accuracy:
0.8998 - val_loss: 0.0953 - val_accuracy: 0.8986
Epoch 28/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0929 - accuracy:
0.8998 - val_loss: 0.0952 - val_accuracy: 0.8986
Epoch 29/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0929 - accuracy:
0.8998 - val_loss: 0.0950 - val_accuracy: 0.9022
Epoch 30/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0930 - accuracy:
0.8998 - val_loss: 0.0948 - val_accuracy: 0.9058
Epoch 31/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0928 - accuracy:
0.9010 - val_loss: 0.0952 - val_accuracy: 0.8986
Epoch 32/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0950 - val_accuracy: 0.9022
Epoch 33/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0928 - accuracy:
0.9010 - val_loss: 0.0949 - val_accuracy: 0.9022
Epoch 34/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0929 - accuracy:
0.9010 - val_loss: 0.0947 - val_accuracy: 0.9058
Epoch 35/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0928 - accuracy:
0.9010 - val_loss: 0.0944 - val_accuracy: 0.9094
Epoch 36/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0929 - accuracy:
0.9010 - val_loss: 0.0946 - val_accuracy: 0.9058
Epoch 37/100
```

```
83/83 [==============================] - 5s 59ms/step - loss: 0.0928 - accuracy:
0.9022 - val_loss: 0.0943 - val_accuracy: 0.9094
Epoch 38/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0949 - val_accuracy: 0.9022
Epoch 39/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0928 - accuracy:
0.9010 - val_loss: 0.0945 - val_accuracy: 0.9058
Epoch 40/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0928 - accuracy:
0.8973 - val_loss: 0.0946 - val_accuracy: 0.9058
Epoch 41/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0948 - val_accuracy: 0.9022
Epoch 42/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0945 - val_accuracy: 0.9058
Epoch 43/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0927 - accuracy:
0.9010 - val_loss: 0.0947 - val_accuracy: 0.9022
Epoch 44/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0928 - accuracy:
0.9010 - val_loss: 0.0943 - val_accuracy: 0.9058
Epoch 45/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0943 - val_accuracy: 0.9058
Epoch 46/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0927 - accuracy:
0.9022 - val_loss: 0.0941 - val_accuracy: 0.9058
Epoch 47/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0944 - val_accuracy: 0.9058
Epoch 48/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0927 - accuracy:
0.9010 - val_loss: 0.0940 - val_accuracy: 0.9094
Epoch 49/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0927 - accuracy:
0.8986 - val_loss: 0.0939 - val_accuracy: 0.9094
Epoch 50/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0927 - accuracy:
0.9010 - val_loss: 0.0944 - val_accuracy: 0.9058
Epoch 51/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0926 - accuracy:
0.8998 - val_loss: 0.0946 - val_accuracy: 0.9022
Epoch 52/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0928 - accuracy:
0.8998 - val_loss: 0.0946 - val_accuracy: 0.9022
Epoch 53/100
```

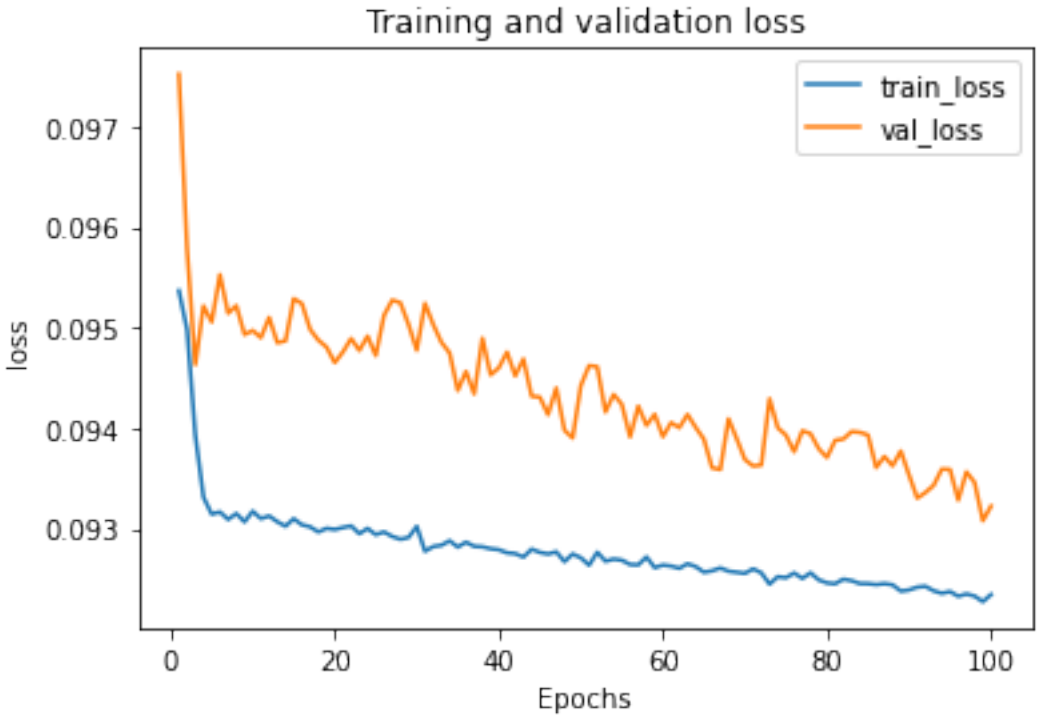
```
83/83 [==============================] - 5s 57ms/step - loss: 0.0927 - accuracy:
0.9022 - val_loss: 0.0942 - val_accuracy: 0.9058
Epoch 54/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0927 - accuracy:
0.9010 - val_loss: 0.0943 - val_accuracy: 0.9058
Epoch 55/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0927 - accuracy:
0.9022 - val_loss: 0.0942 - val_accuracy: 0.9058
Epoch 56/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0926 - accuracy:
0.9022 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 57/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0942 - val_accuracy: 0.9058
Epoch 58/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0927 - accuracy:
0.9022 - val_loss: 0.0940 - val_accuracy: 0.9058
Epoch 59/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0926 - accuracy:
0.8998 - val_loss: 0.0941 - val_accuracy: 0.9058
Epoch 60/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 61/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0926 - accuracy:
0.8998 - val_loss: 0.0941 - val_accuracy: 0.9058
Epoch 62/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.8998 - val_loss: 0.0940 - val_accuracy: 0.9058
Epoch 63/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0941 - val_accuracy: 0.9058
Epoch 64/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0940 - val_accuracy: 0.9058
Epoch 65/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 66/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0926 - accuracy:
0.9022 - val_loss: 0.0936 - val_accuracy: 0.9094
Epoch 67/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0926 - accuracy:
0.9022 - val_loss: 0.0936 - val_accuracy: 0.9094
Epoch 68/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0941 - val_accuracy: 0.9058
Epoch 69/100
```

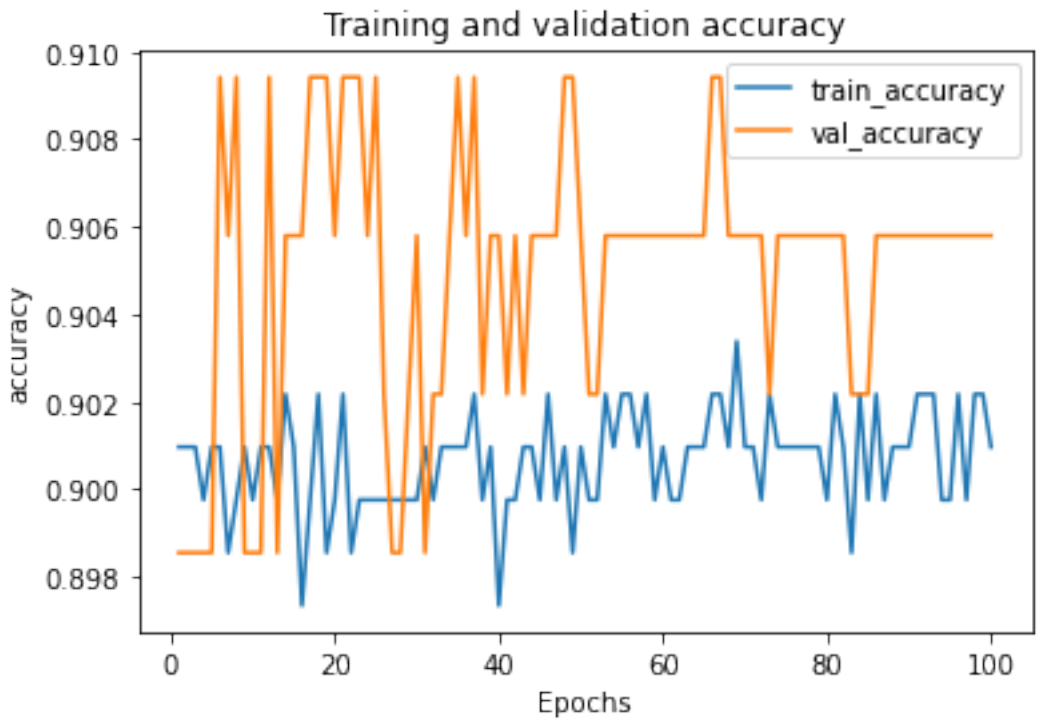
```
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.9034 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 70/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0937 - val_accuracy: 0.9058
Epoch 71/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 72/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0926 - accuracy:
0.8998 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 73/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0924 - accuracy:
0.9022 - val_loss: 0.0943 - val_accuracy: 0.9022
Epoch 74/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0925 - accuracy:
0.9010 - val_loss: 0.0940 - val_accuracy: 0.9058
Epoch 75/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0925 - accuracy:
0.9010 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 76/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0938 - val_accuracy: 0.9058
Epoch 77/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0925 - accuracy:
0.9010 - val_loss: 0.0940 - val_accuracy: 0.9058
Epoch 78/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0926 - accuracy:
0.9010 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 79/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0925 - accuracy:
0.9010 - val_loss: 0.0938 - val_accuracy: 0.9058
Epoch 80/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0925 - accuracy:
0.8998 - val_loss: 0.0937 - val_accuracy: 0.9058
Epoch 81/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0925 - accuracy:
0.9022 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 82/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0925 - accuracy:
0.9010 - val_loss: 0.0939 - val_accuracy: 0.9058
Epoch 83/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0925 - accuracy:
0.8986 - val_loss: 0.0940 - val_accuracy: 0.9022
Epoch 84/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0925 - accuracy:
0.9022 - val_loss: 0.0940 - val_accuracy: 0.9022
Epoch 85/100
```

```
83/83 [==============================] - 5s 63ms/step - loss: 0.0925 - accuracy:
0.8998 - val_loss: 0.0939 - val_accuracy: 0.9022
Epoch 86/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0924 - accuracy:
0.9022 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 87/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0925 - accuracy:
0.8998 - val_loss: 0.0937 - val_accuracy: 0.9058
Epoch 88/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0924 - accuracy:
0.9010 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 89/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0924 - accuracy:
0.9010 - val_loss: 0.0938 - val_accuracy: 0.9058
Epoch 90/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0924 - accuracy:
0.9010 - val_loss: 0.0935 - val_accuracy: 0.9058
Epoch 91/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0924 - accuracy:
0.9022 - val_loss: 0.0933 - val_accuracy: 0.9058
Epoch 92/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0924 - accuracy:
0.9022 - val_loss: 0.0934 - val_accuracy: 0.9058
Epoch 93/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0924 - accuracy:
0.9022 - val_loss: 0.0934 - val_accuracy: 0.9058
Epoch 94/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0924 - accuracy:
0.8998 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 95/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0924 - accuracy:
0.8998 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 96/100
83/83 [==============================] - 5s 66ms/step - loss: 0.0923 - accuracy:
0.9022 - val_loss: 0.0933 - val_accuracy: 0.9058
Epoch 97/100
83/83 [==============================] - 5s 59ms/step - loss: 0.0923 - accuracy:
0.8998 - val_loss: 0.0936 - val_accuracy: 0.9058
Epoch 98/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0923 - accuracy:
0.9022 - val_loss: 0.0935 - val_accuracy: 0.9058
Epoch 99/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0923 - accuracy:
0.9022 - val_loss: 0.0931 - val_accuracy: 0.9058
Epoch 100/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0923 - accuracy:
0.9010 - val_loss: 0.0932 - val_accuracy: 0.9058
Running time is 489.33 seconds per 100 epoches
```

```
Test Accuracy: 0.906
```

[43]:
```
plot_metric(hist_lstm_y2_sgd,'loss')
plot_metric(hist_lstm_y2_sgd,'accuracy')
```






[44]:
```
hist_lstm_y3_sgd=model_trainer2(model_LSTM, y3, X, 100, 10, '0')
```

```
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

Epoch 1/100
83/83 [==============================] - 5s 58ms/step - loss: 0.3138 - accuracy:
0.6329 - val_loss: 0.2984 - val_accuracy: 0.6522
Epoch 2/100
83/83 [==============================] - 5s 58ms/step - loss: 0.3088 - accuracy:
0.6365 - val_loss: 0.2933 - val_accuracy: 0.6522
Epoch 3/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2999 - accuracy:
0.6365 - val_loss: 0.2601 - val_accuracy: 0.6848
Epoch 4/100
83/83 [==============================] - 5s 57ms/step - loss: 0.2827 - accuracy:
0.6558 - val_loss: 0.2552 - val_accuracy: 0.6848
Epoch 5/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2778 - accuracy:
0.6558 - val_loss: 0.2499 - val_accuracy: 0.6848
```

```
Epoch 6/100
83/83 [==============================] - 5s 62ms/step - loss: 0.2719 - accuracy:
0.6558 - val_loss: 0.2440 - val_accuracy: 0.6848
Epoch 7/100
83/83 [==============================] - 5s 63ms/step - loss: 0.2653 - accuracy:
0.6558 - val_loss: 0.2376 - val_accuracy: 0.6848
Epoch 8/100
83/83 [==============================] - 5s 63ms/step - loss: 0.2589 - accuracy:
0.6558 - val_loss: 0.2309 - val_accuracy: 0.6848
Epoch 9/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2520 - accuracy:
0.6558 - val_loss: 0.2238 - val_accuracy: 0.6848
Epoch 10/100
83/83 [==============================] - 5s 57ms/step - loss: 0.2446 - accuracy:
0.6558 - val_loss: 0.2162 - val_accuracy: 0.6848
Epoch 11/100
83/83 [==============================] - 5s 64ms/step - loss: 0.2368 - accuracy:
0.6558 - val_loss: 0.2082 - val_accuracy: 0.6848
Epoch 12/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2286 - accuracy:
0.6558 - val_loss: 0.1999 - val_accuracy: 0.6848
Epoch 13/100
83/83 [==============================] - 5s 62ms/step - loss: 0.2199 - accuracy:
0.6558 - val_loss: 0.1921 - val_accuracy: 0.6848
Epoch 14/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2094 - accuracy:
0.6558 - val_loss: 0.1854 - val_accuracy: 0.6848
Epoch 15/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1985 - accuracy:
0.6558 - val_loss: 0.1756 - val_accuracy: 0.6848
Epoch 16/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1896 - accuracy:
0.6558 - val_loss: 0.1673 - val_accuracy: 0.6848
Epoch 17/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1812 - accuracy:
0.6558 - val_loss: 0.1617 - val_accuracy: 0.6812
Epoch 18/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1727 - accuracy:
0.6570 - val_loss: 0.1522 - val_accuracy: 0.6848
Epoch 19/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1655 - accuracy:
0.6570 - val_loss: 0.1481 - val_accuracy: 0.6812
Epoch 20/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1582 - accuracy:
0.6582 - val_loss: 0.1449 - val_accuracy: 0.6775
Epoch 21/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1524 - accuracy:
0.6582 - val_loss: 0.1405 - val_accuracy: 0.6775
```

```
Epoch 22/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1471 - accuracy:
0.7633 - val_loss: 0.1318 - val_accuracy: 0.8732
Epoch 23/100
83/83 [==============================] - 5s 62ms/step - loss: 0.1448 - accuracy:
0.8587 - val_loss: 0.1331 - val_accuracy: 0.8659
Epoch 24/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1414 - accuracy:
0.8551 - val_loss: 0.1306 - val_accuracy: 0.8659
Epoch 25/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1354 - accuracy:
0.8611 - val_loss: 0.1291 - val_accuracy: 0.8623
Epoch 26/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1328 - accuracy:
0.8611 - val_loss: 0.1269 - val_accuracy: 0.8659
Epoch 27/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1301 - accuracy:
0.8635 - val_loss: 0.1241 - val_accuracy: 0.8623
Epoch 28/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1274 - accuracy:
0.8647 - val_loss: 0.1193 - val_accuracy: 0.8623
Epoch 29/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1274 - accuracy:
0.8599 - val_loss: 0.1203 - val_accuracy: 0.8659
Epoch 30/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1275 - accuracy:
0.8563 - val_loss: 0.1224 - val_accuracy: 0.8587
Epoch 31/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1235 - accuracy:
0.8659 - val_loss: 0.1146 - val_accuracy: 0.8696
Epoch 32/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1230 - accuracy:
0.8635 - val_loss: 0.1196 - val_accuracy: 0.8623
Epoch 33/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1207 - accuracy:
0.8635 - val_loss: 0.1174 - val_accuracy: 0.8659
Epoch 34/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1191 - accuracy:
0.8671 - val_loss: 0.1172 - val_accuracy: 0.8623
Epoch 35/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1171 - accuracy:
0.8696 - val_loss: 0.1162 - val_accuracy: 0.8623
Epoch 36/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1178 - accuracy:
0.8659 - val_loss: 0.1151 - val_accuracy: 0.8659
Epoch 37/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1170 - accuracy:
0.8684 - val_loss: 0.1164 - val_accuracy: 0.8623
```

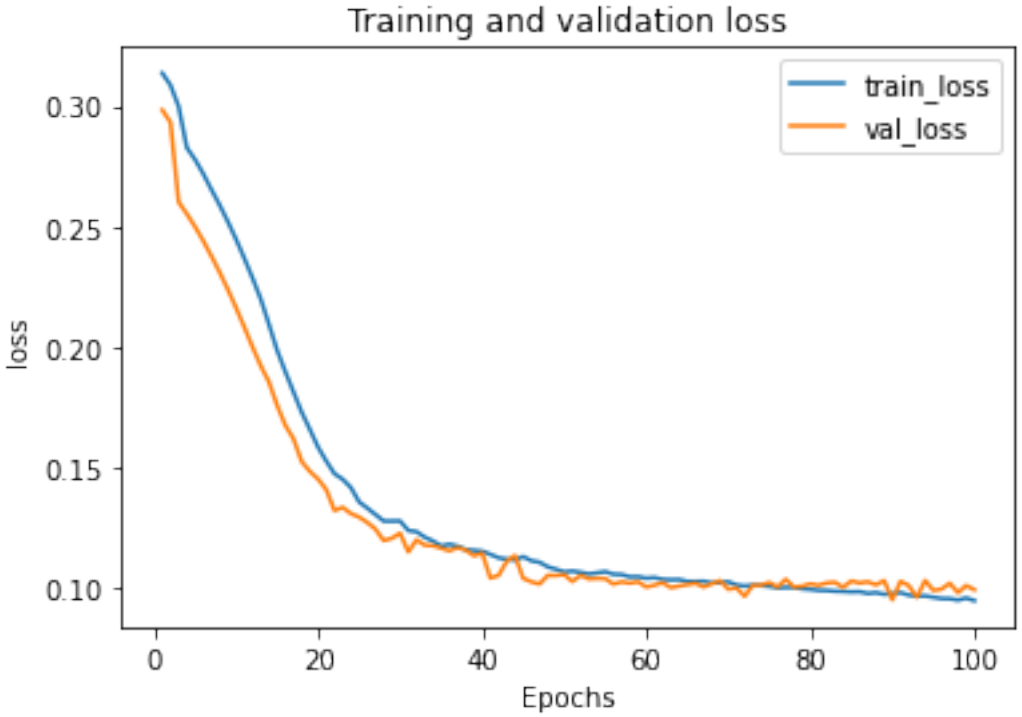
```
Epoch 38/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1156 - accuracy:
0.8684 - val_loss: 0.1154 - val_accuracy: 0.8659
Epoch 39/100
83/83 [==============================] - 6s 68ms/step - loss: 0.1152 - accuracy:
0.8671 - val_loss: 0.1130 - val_accuracy: 0.8659
Epoch 40/100
83/83 [==============================] - 5s 62ms/step - loss: 0.1149 - accuracy:
0.8696 - val_loss: 0.1141 - val_accuracy: 0.8659
Epoch 41/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1136 - accuracy:
0.8720 - val_loss: 0.1037 - val_accuracy: 0.8804
Epoch 42/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1121 - accuracy:
0.8744 - val_loss: 0.1048 - val_accuracy: 0.8804
Epoch 43/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1116 - accuracy:
0.8756 - val_loss: 0.1107 - val_accuracy: 0.8696
Epoch 44/100
83/83 [==============================] - 5s 66ms/step - loss: 0.1112 - accuracy:
0.8720 - val_loss: 0.1131 - val_accuracy: 0.8551
Epoch 45/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1127 - accuracy:
0.8720 - val_loss: 0.1036 - val_accuracy: 0.8768
Epoch 46/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1109 - accuracy:
0.8744 - val_loss: 0.1022 - val_accuracy: 0.8768
Epoch 47/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1103 - accuracy:
0.8744 - val_loss: 0.1012 - val_accuracy: 0.8768
Epoch 48/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1084 - accuracy:
0.8768 - val_loss: 0.1048 - val_accuracy: 0.8732
Epoch 49/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1074 - accuracy:
0.8780 - val_loss: 0.1048 - val_accuracy: 0.8732
Epoch 50/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1063 - accuracy:
0.8804 - val_loss: 0.1052 - val_accuracy: 0.8732
Epoch 51/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1066 - accuracy:
0.8780 - val_loss: 0.1023 - val_accuracy: 0.8768
Epoch 52/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1061 - accuracy:
0.8792 - val_loss: 0.1049 - val_accuracy: 0.8732
Epoch 53/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1054 - accuracy:
0.8804 - val_loss: 0.1034 - val_accuracy: 0.8732
```

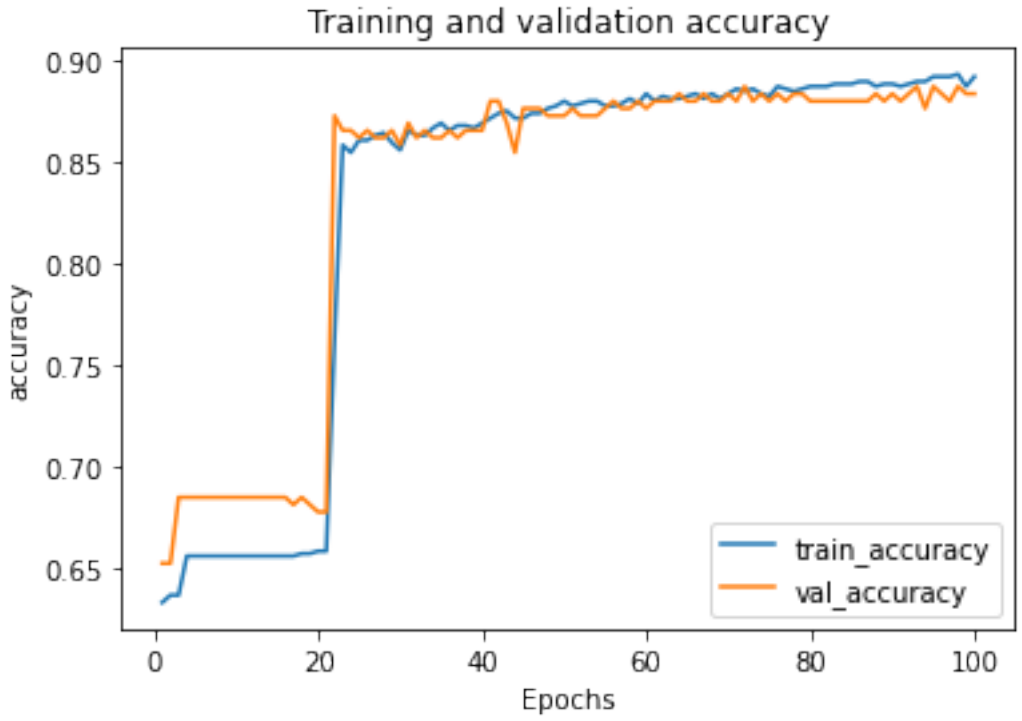
```
Epoch 54/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1059 - accuracy:
0.8804 - val_loss: 0.1036 - val_accuracy: 0.8732
Epoch 55/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1064 - accuracy:
0.8780 - val_loss: 0.1035 - val_accuracy: 0.8768
Epoch 56/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1053 - accuracy:
0.8780 - val_loss: 0.1012 - val_accuracy: 0.8804
Epoch 57/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1052 - accuracy:
0.8792 - val_loss: 0.1022 - val_accuracy: 0.8768
Epoch 58/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1042 - accuracy:
0.8816 - val_loss: 0.1016 - val_accuracy: 0.8768
Epoch 59/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1043 - accuracy:
0.8792 - val_loss: 0.1022 - val_accuracy: 0.8804
Epoch 60/100
83/83 [==============================] - 5s 64ms/step - loss: 0.1037 - accuracy:
0.8841 - val_loss: 0.1000 - val_accuracy: 0.8768
Epoch 61/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1039 - accuracy:
0.8804 - val_loss: 0.1008 - val_accuracy: 0.8804
Epoch 62/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1032 - accuracy:
0.8829 - val_loss: 0.1018 - val_accuracy: 0.8804
Epoch 63/100
83/83 [==============================] - 5s 58ms/step - loss: 0.1030 - accuracy:
0.8816 - val_loss: 0.0998 - val_accuracy: 0.8804
Epoch 64/100
83/83 [==============================] - 5s 65ms/step - loss: 0.1031 - accuracy:
0.8816 - val_loss: 0.1004 - val_accuracy: 0.8841
Epoch 65/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1023 - accuracy:
0.8829 - val_loss: 0.1010 - val_accuracy: 0.8804
Epoch 66/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1023 - accuracy:
0.8841 - val_loss: 0.1016 - val_accuracy: 0.8804
Epoch 67/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1024 - accuracy:
0.8816 - val_loss: 0.1001 - val_accuracy: 0.8841
Epoch 68/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1017 - accuracy:
0.8841 - val_loss: 0.1013 - val_accuracy: 0.8804
Epoch 69/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1018 - accuracy:
0.8816 - val_loss: 0.1026 - val_accuracy: 0.8804
```

```
Epoch 70/100
83/83 [==============================] - 5s 57ms/step - loss: 0.1022 - accuracy:
0.8841 - val_loss: 0.0991 - val_accuracy: 0.8841
Epoch 71/100
83/83 [==============================] - 5s 63ms/step - loss: 0.1008 - accuracy:
0.8865 - val_loss: 0.0997 - val_accuracy: 0.8804
Epoch 72/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1004 - accuracy:
0.8853 - val_loss: 0.0962 - val_accuracy: 0.8877
Epoch 73/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1008 - accuracy:
0.8865 - val_loss: 0.1007 - val_accuracy: 0.8804
Epoch 74/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1006 - accuracy:
0.8841 - val_loss: 0.1007 - val_accuracy: 0.8841
Epoch 75/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1003 - accuracy:
0.8829 - val_loss: 0.1019 - val_accuracy: 0.8804
Epoch 76/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0997 - accuracy:
0.8877 - val_loss: 0.1000 - val_accuracy: 0.8841
Epoch 77/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0998 - accuracy:
0.8865 - val_loss: 0.1032 - val_accuracy: 0.8804
Epoch 78/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0998 - accuracy:
0.8853 - val_loss: 0.1000 - val_accuracy: 0.8841
Epoch 79/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0993 - accuracy:
0.8865 - val_loss: 0.1003 - val_accuracy: 0.8841
Epoch 80/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0990 - accuracy:
0.8877 - val_loss: 0.1013 - val_accuracy: 0.8804
Epoch 81/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0986 - accuracy:
0.8877 - val_loss: 0.1007 - val_accuracy: 0.8804
Epoch 82/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0986 - accuracy:
0.8877 - val_loss: 0.1017 - val_accuracy: 0.8804
Epoch 83/100
83/83 [==============================] - 5s 61ms/step - loss: 0.0983 - accuracy:
0.8889 - val_loss: 0.1020 - val_accuracy: 0.8804
Epoch 84/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0981 - accuracy:
0.8889 - val_loss: 0.0999 - val_accuracy: 0.8804
Epoch 85/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0980 - accuracy:
0.8889 - val_loss: 0.1025 - val_accuracy: 0.8804
```

```
Epoch 86/100
83/83 [==============================] - 5s 58ms/step - loss: 0.0981 - accuracy:
0.8901 - val_loss: 0.1017 - val_accuracy: 0.8804
Epoch 87/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0973 - accuracy:
0.8901 - val_loss: 0.1022 - val_accuracy: 0.8804
Epoch 88/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0977 - accuracy:
0.8877 - val_loss: 0.1009 - val_accuracy: 0.8841
Epoch 89/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0970 - accuracy:
0.8889 - val_loss: 0.1027 - val_accuracy: 0.8804
Epoch 90/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0972 - accuracy:
0.8889 - val_loss: 0.0947 - val_accuracy: 0.8841
Epoch 91/100
83/83 [==============================] - 5s 63ms/step - loss: 0.0977 - accuracy:
0.8877 - val_loss: 0.1024 - val_accuracy: 0.8804
Epoch 92/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0966 - accuracy:
0.8889 - val_loss: 0.1006 - val_accuracy: 0.8841
Epoch 93/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0961 - accuracy:
0.8901 - val_loss: 0.0957 - val_accuracy: 0.8877
Epoch 94/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0963 - accuracy:
0.8901 - val_loss: 0.1027 - val_accuracy: 0.8768
Epoch 95/100
83/83 [==============================] - 6s 67ms/step - loss: 0.0957 - accuracy:
0.8925 - val_loss: 0.0986 - val_accuracy: 0.8877
Epoch 96/100
83/83 [==============================] - 5s 57ms/step - loss: 0.0952 - accuracy:
0.8925 - val_loss: 0.0991 - val_accuracy: 0.8841
Epoch 97/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0952 - accuracy:
0.8925 - val_loss: 0.1016 - val_accuracy: 0.8804
Epoch 98/100
83/83 [==============================] - 5s 65ms/step - loss: 0.0945 - accuracy:
0.8937 - val_loss: 0.0977 - val_accuracy: 0.8877
Epoch 99/100
83/83 [==============================] - 5s 64ms/step - loss: 0.0954 - accuracy:
0.8877 - val_loss: 0.1006 - val_accuracy: 0.8841
Epoch 100/100
83/83 [==============================] - 5s 56ms/step - loss: 0.0943 - accuracy:
0.8925 - val_loss: 0.0989 - val_accuracy: 0.8841
Running time is 494.33 seconds per 100 epoches
Test Accuracy: 0.873
```

[45]:
```
plot_metric(hist_lstm_y3_sgd,'loss')
plot_metric(hist_lstm_y3_sgd,'accuracy')
```



From the above trainings and plots, we can observe-

LSTM with Adam optimizer gives higher accuracy and much shorter computing time than LSTM model with sgd optimizer.

Train losses roughly remained constant with sgd optimizer, likely due to gradient descent with decaying learning rate for the error calculation. [4]

#### 4.0.5 CM3- (iv)

Below is a neural network which which uses a **Simple RNN** architecture followed by **3 hidden layers** with **64**, **32** and **16** units respectively. The activation function used here is **ReLU activation**. For the output layer, **softmax activation function** has been used. The optimizer which we have used is '**Adam**' with a **learning rate of 0.001** and this performs faster than sgd. To prevent overfitting, the regularization method which we have used here is **early stopping** with a **delta value of 0.001**. The model stops training after we see no improvement in the validation loss for 8 epochs. The input layer uses 13 features to determine the output class label. Three separate models have been trained (**100 epochs and 10 batch size**) for the labels 'Confirmed', 'Recovered' and 'Deaths'. The performance of all the three models has been plotted using two graphs - The training and validation loss by epochs The training and validation accuracy by epochs

[46]:
```
model_RNN = Sequential()
model_RNN.add(SimpleRNN(128,input_shape=(13,1),activation='relu'))
model_RNN.add(Dense(64,activation='relu'))
model_RNN.add(Dense(32,activation='relu'))
model_RNN.add(Dense(16,activation='relu'))
model_RNN.add(Dense(3,activation='softmax'))
model_RNN.compile(loss='sparse_categorical_crossentropy',optimizer=keras.
↪optimizers.Adam(learning_rate=0.001) ,metrics=['accuracy'])
```

[47]:
```
es_rnn= EarlyStopping(
    monitor='val_loss',
    patience=8,
    min_delta=0.001,

)
```

[48]:
```
hist_rnn_y1=model_trainer2(model_RNN, y1, X,100 , 10, es_rnn)
```

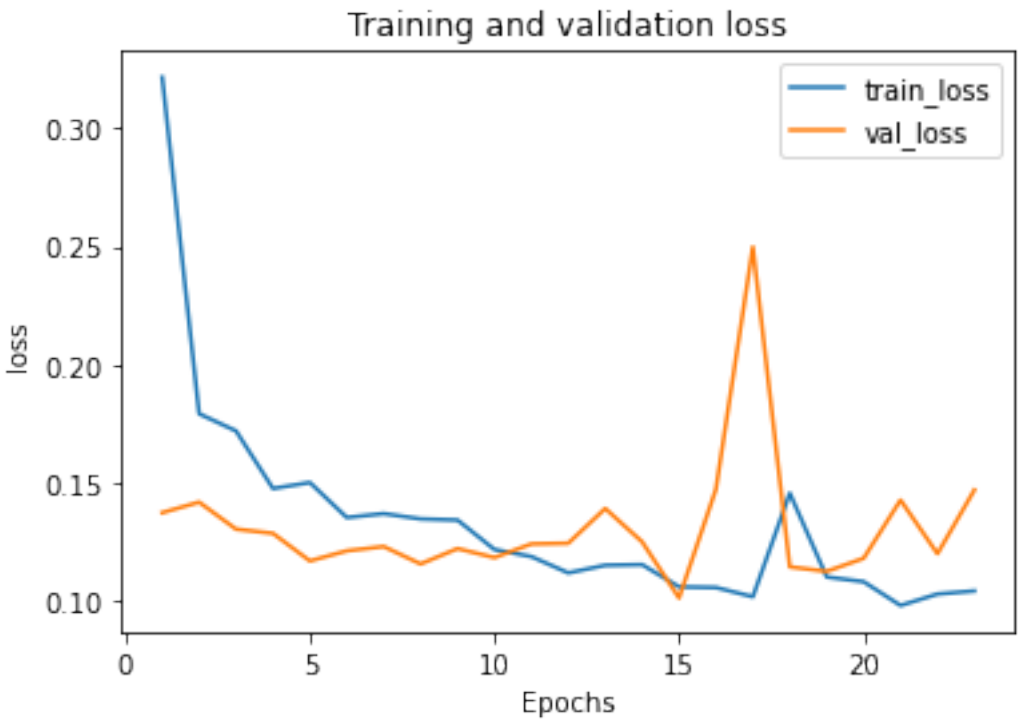
```
Epoch 1/100
 1/83 […] - ETA: 5s - loss: 1.0992 - accuracy:
0.1000

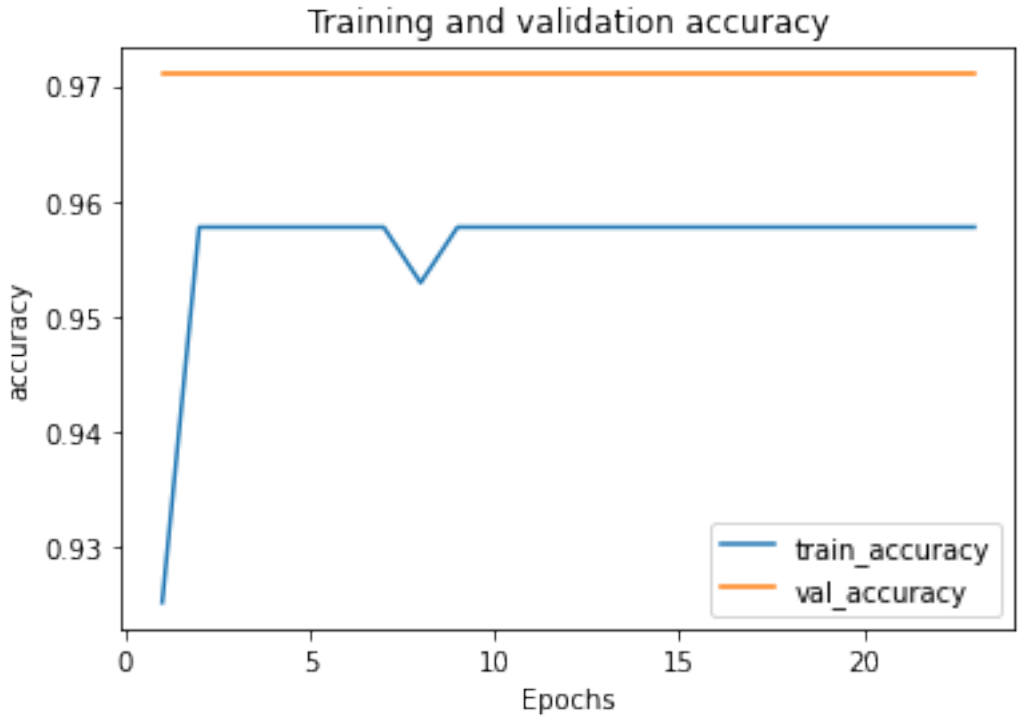
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
```

```
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "
83/83 [==============================] - 5s 60ms/step - loss: 0.5425 - accuracy:
0.8292 - val_loss: 0.1371 - val_accuracy: 0.9710
Epoch 2/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1488 - accuracy:
0.9658 - val_loss: 0.1416 - val_accuracy: 0.9710
Epoch 3/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1536 - accuracy:
0.9605 - val_loss: 0.1301 - val_accuracy: 0.9710
Epoch 4/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1449 - accuracy:
0.9617 - val_loss: 0.1284 - val_accuracy: 0.9710
Epoch 5/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1502 - accuracy:
0.9619 - val_loss: 0.1167 - val_accuracy: 0.9710
Epoch 6/100
83/83 [==============================] - 4s 52ms/step - loss: 0.1175 - accuracy:
0.9638 - val_loss: 0.1210 - val_accuracy: 0.9710
Epoch 7/100
83/83 [==============================] - 4s 52ms/step - loss: 0.1277 - accuracy:
0.9584 - val_loss: 0.1228 - val_accuracy: 0.9710
Epoch 8/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1134 - accuracy:
0.9544 - val_loss: 0.1154 - val_accuracy: 0.9710
Epoch 9/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1598 - accuracy:
0.9460 - val_loss: 0.1219 - val_accuracy: 0.9710
Epoch 10/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1203 - accuracy:
0.9539 - val_loss: 0.1181 - val_accuracy: 0.9710
Epoch 11/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1175 - accuracy:
0.9575 - val_loss: 0.1239 - val_accuracy: 0.9710
Epoch 12/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1201 - accuracy:
0.9577 - val_loss: 0.1242 - val_accuracy: 0.9710
Epoch 13/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1232 - accuracy:
0.9551 - val_loss: 0.1389 - val_accuracy: 0.9710
Epoch 14/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1074 - accuracy:
0.9641 - val_loss: 0.1248 - val_accuracy: 0.9710
Epoch 15/100
83/83 [==============================] - 5s 62ms/step - loss: 0.0978 - accuracy:
0.9593 - val_loss: 0.1010 - val_accuracy: 0.9710
Epoch 16/100
```

```
83/83 [==============================] - 5s 55ms/step - loss: 0.1256 - accuracy:
0.9505 - val_loss: 0.1471 - val_accuracy: 0.9710
Epoch 17/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1043 - accuracy:
0.9549 - val_loss: 0.2498 - val_accuracy: 0.9710
Epoch 18/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1552 - accuracy:
0.9628 - val_loss: 0.1142 - val_accuracy: 0.9710
Epoch 19/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1048 - accuracy:
0.9600 - val_loss: 0.1122 - val_accuracy: 0.9710
Epoch 20/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1172 - accuracy:
0.9497 - val_loss: 0.1178 - val_accuracy: 0.9710
Epoch 21/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1027 - accuracy:
0.9534 - val_loss: 0.1425 - val_accuracy: 0.9710
Epoch 22/100
83/83 [==============================] - 5s 55ms/step - loss: 0.0971 - accuracy:
0.9569 - val_loss: 0.1197 - val_accuracy: 0.9710
Epoch 23/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1030 - accuracy:
0.9609 - val_loss: 0.1467 - val_accuracy: 0.9710
Running time is 107.27 seconds per 100 epoches
Test Accuracy: 0.971
```

[49]:
```
plot_metric(hist_rnn_y1,'loss')
plot_metric(hist_rnn_y1,'accuracy')
```


Training and validation loss
train_loss
val_loss
loss
0.30
0.25
0.20
0.15
0.10
0
5
10
15
20
Epochs


Training and validation accuracy
accuracy
0.97
0.96
0.95
0.94
0.93
train_accuracy
val_accuracy
0
5
10
15
20
Epochs

[50]:
```
hist_rnn_y2=model_trainer2(model_RNN, y2, X,100 , 10, es_rnn)
```

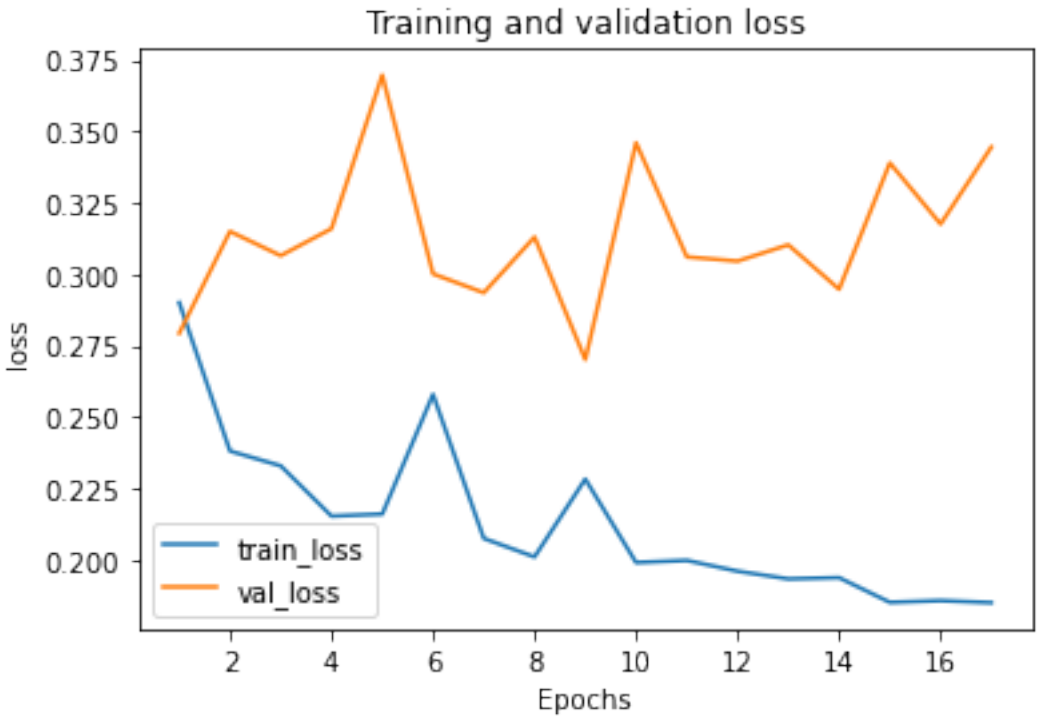
```
Epoch 1/100
 1/83 […] - ETA: 3s - loss: 0.6408 - accuracy:
0.9000

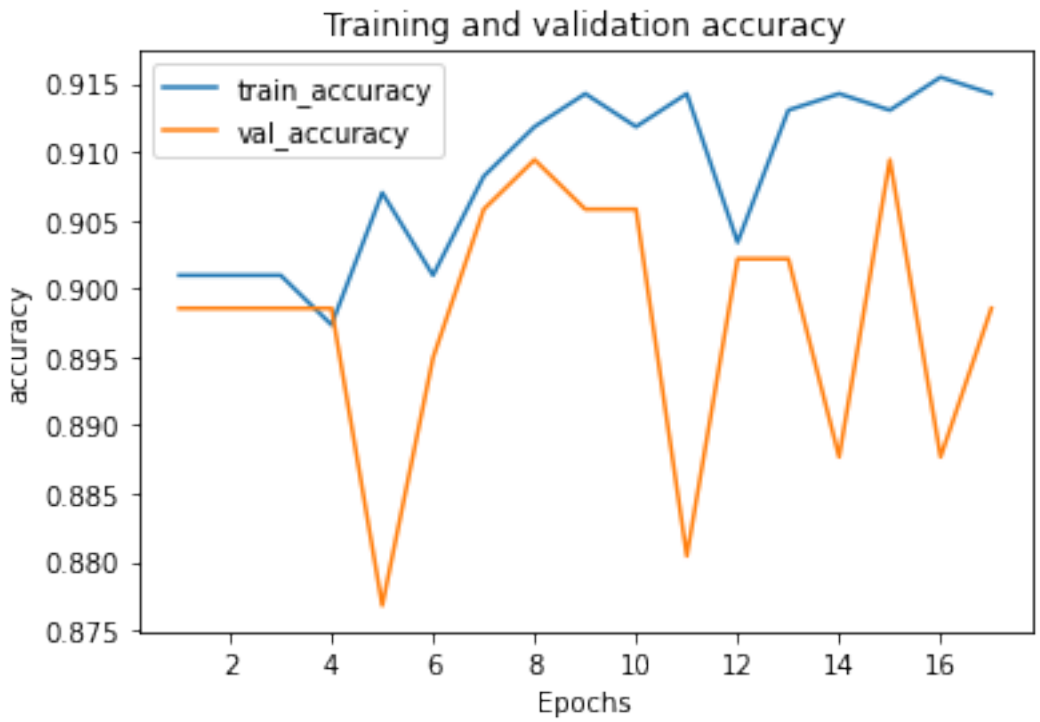
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 55ms/step - loss: 0.2901 - accuracy:
0.9010 - val_loss: 0.2794 - val_accuracy: 0.8986
Epoch 2/100
83/83 [==============================] - 5s 60ms/step - loss: 0.2382 - accuracy:
0.9010 - val_loss: 0.3150 - val_accuracy: 0.8986
Epoch 3/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2330 - accuracy:
0.9010 - val_loss: 0.3065 - val_accuracy: 0.8986
Epoch 4/100
83/83 [==============================] - 5s 56ms/step - loss: 0.2154 - accuracy:
0.8973 - val_loss: 0.3159 - val_accuracy: 0.8986
Epoch 5/100
83/83 [==============================] - 5s 55ms/step - loss: 0.2161 - accuracy:
0.9070 - val_loss: 0.3697 - val_accuracy: 0.8768
Epoch 6/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2580 - accuracy:
0.9010 - val_loss: 0.3001 - val_accuracy: 0.8949
Epoch 7/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2076 - accuracy:
0.9082 - val_loss: 0.2935 - val_accuracy: 0.9058
Epoch 8/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2011 - accuracy:
0.9118 - val_loss: 0.3130 - val_accuracy: 0.9094
Epoch 9/100
83/83 [==============================] - 5s 61ms/step - loss: 0.2284 - accuracy:
0.9143 - val_loss: 0.2702 - val_accuracy: 0.9058
Epoch 10/100
83/83 [==============================] - 5s 56ms/step - loss: 0.1992 - accuracy:
0.9118 - val_loss: 0.3460 - val_accuracy: 0.9058
Epoch 11/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1999 - accuracy:
0.9143 - val_loss: 0.3061 - val_accuracy: 0.8804
Epoch 12/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1961 - accuracy:
0.9034 - val_loss: 0.3046 - val_accuracy: 0.9022
Epoch 13/100
```

```
83/83 [==============================] - 5s 61ms/step - loss: 0.1934 - accuracy:
0.9130 - val_loss: 0.3103 - val_accuracy: 0.9022
Epoch 14/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1939 - accuracy:
0.9143 - val_loss: 0.2948 - val_accuracy: 0.8877
Epoch 15/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1852 - accuracy:
0.9130 - val_loss: 0.3389 - val_accuracy: 0.9094
Epoch 16/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1858 - accuracy:
0.9155 - val_loss: 0.3175 - val_accuracy: 0.8877
Epoch 17/100
83/83 [==============================] - 5s 61ms/step - loss: 0.1851 - accuracy:
0.9143 - val_loss: 0.3445 - val_accuracy: 0.8986
Running time is 79.61 seconds per 100 epoches
Test Accuracy: 0.909
```

[51]:
```
plot_metric(hist_rnn_y2,'loss')
plot_metric(hist_rnn_y2,'accuracy')
```






[52]:
```
hist_rnn_y3=model_trainer2(model_RNN, y3, X,100 , 10, es_rnn)
```

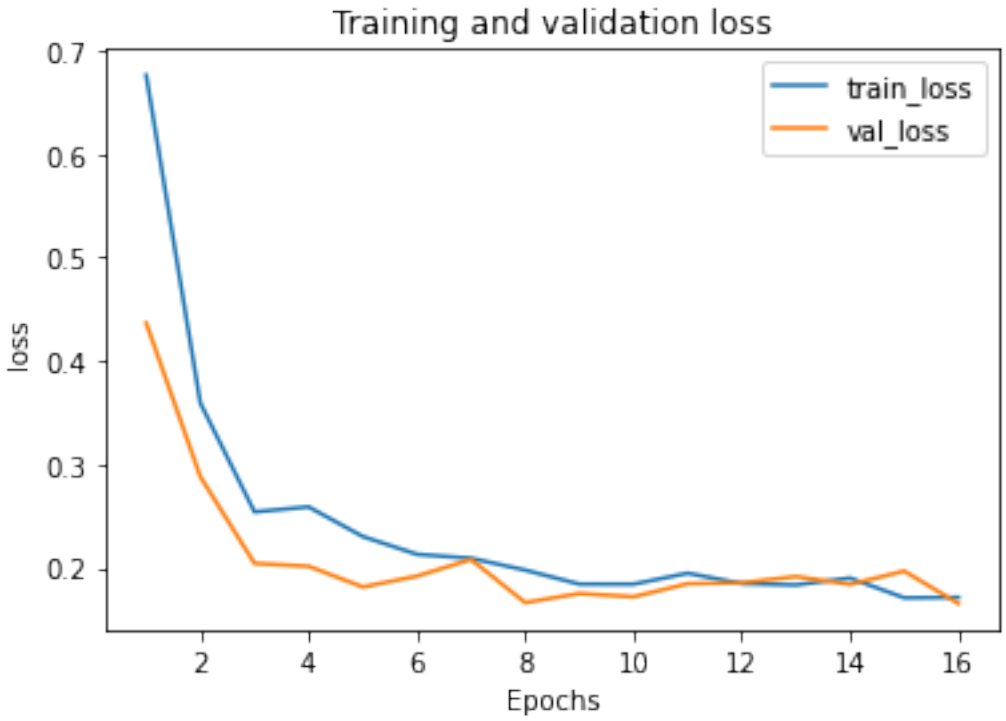
```
Epoch 1/100
 2/83 […] - ETA: 4s - loss: 2.7343 - accuracy:
0.5500

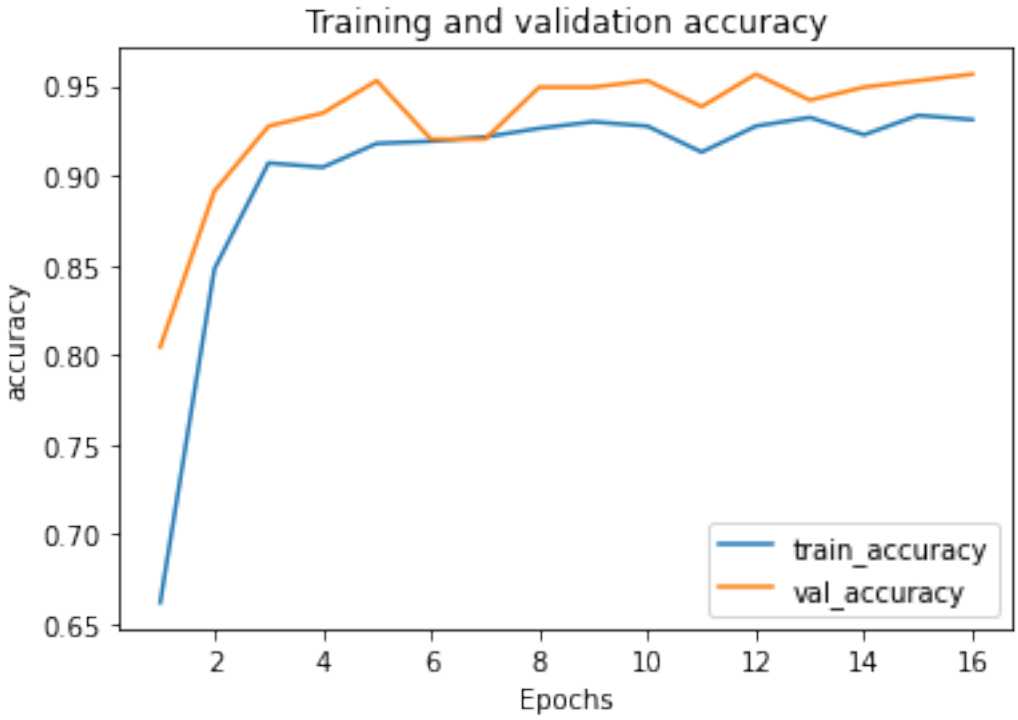
/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

83/83 [==============================] - 5s 55ms/step - loss: 0.6760 - accuracy:
0.6618 - val_loss: 0.4367 - val_accuracy: 0.8043
Epoch 2/100
83/83 [==============================] - 5s 60ms/step - loss: 0.3592 - accuracy:
0.8478 - val_loss: 0.2881 - val_accuracy: 0.8913
Epoch 3/100
83/83 [==============================] - 4s 53ms/step - loss: 0.2542 - accuracy:
0.9070 - val_loss: 0.2044 - val_accuracy: 0.9275
Epoch 4/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2590 - accuracy:
0.9046 - val_loss: 0.2017 - val_accuracy: 0.9348
Epoch 5/100
```

```
83/83 [==============================] - 5s 60ms/step - loss: 0.2304 - accuracy:
0.9179 - val_loss: 0.1817 - val_accuracy: 0.9529
Epoch 6/100
83/83 [==============================] - 4s 53ms/step - loss: 0.2132 - accuracy:
0.9191 - val_loss: 0.1921 - val_accuracy: 0.9203
Epoch 7/100
83/83 [==============================] - 4s 54ms/step - loss: 0.2093 - accuracy:
0.9215 - val_loss: 0.2082 - val_accuracy: 0.9203
Epoch 8/100
83/83 [==============================] - 5s 55ms/step - loss: 0.1979 - accuracy:
0.9263 - val_loss: 0.1665 - val_accuracy: 0.9493
Epoch 9/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1844 - accuracy:
0.9300 - val_loss: 0.1753 - val_accuracy: 0.9493
Epoch 10/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1844 - accuracy:
0.9275 - val_loss: 0.1722 - val_accuracy: 0.9529
Epoch 11/100
83/83 [==============================] - 4s 53ms/step - loss: 0.1949 - accuracy:
0.9130 - val_loss: 0.1848 - val_accuracy: 0.9384
Epoch 12/100
83/83 [==============================] - 5s 59ms/step - loss: 0.1849 - accuracy:
0.9275 - val_loss: 0.1857 - val_accuracy: 0.9565
Epoch 13/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1836 - accuracy:
0.9324 - val_loss: 0.1917 - val_accuracy: 0.9420
Epoch 14/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1903 - accuracy:
0.9227 - val_loss: 0.1842 - val_accuracy: 0.9493
Epoch 15/100
83/83 [==============================] - 4s 54ms/step - loss: 0.1712 - accuracy:
0.9336 - val_loss: 0.1970 - val_accuracy: 0.9529
Epoch 16/100
83/83 [==============================] - 5s 60ms/step - loss: 0.1716 - accuracy:
0.9312 - val_loss: 0.1657 - val_accuracy: 0.9565
Running time is 73.85 seconds per 100 epoches
Test Accuracy: 0.946
```

[53]:
```
plot_metric(hist_rnn_y3,'loss')
plot_metric(hist_rnn_y3,'accuracy')
```


Training and validation loss
train_loss
val_loss
loss
Epochs
0.7
0.6
0.5
0.4
0.3
0.2
2
4
6
8
10
12
14
16


Training and validation accuracy
train_accuracy
val_accuracy
accuracy
Epochs
0.95
0.90
0.85
0.80
0.75
0.70
0.65
2
4
6
8
10
12
14
16

# 5 CM4

To summarize, the models which we have used for this dataset are: 1. a Deep NNet with 2 hidden layers (CM2) 2. a Deep NNet with 7 hidden layers 3. a LSTM based NNet with Adam optimizer 4. a LSTM based NNet with SGD optimizer 5. a RNN based NNet For each of the models, two graphs have been plotted to understand more about their performance. The graphs include training and validation losses and accuracies with the no. of epochs. Also, the test accuracies in each case have been calculated and printed at the end of each model training details. The metrics have been copied into the table shown below. We get low performance and the test accuracies for models 1 and 5. Using LSTM (models 3 and 4), we get the best performance. Out of 3 and 4, we can see that model 4 performs even slightly better.

| | Test Accuracy | Validation Loss |
|---|---|---|
| CM2 | | |
| Model 1: DNN with 2 hidden layers | | |
| Confirmed | 0.971 | 0.1251 |
| Deaths | 0.906 | 0.2481 |
| Recovered | 0.641 | 0.1632 |
| | | |
| CM3 | | |
| Model 2: DNN with hidden layers | | |
| Confirmed | 0.971 | 0.1167 |
| Deaths | 0.906 | 0.2489 |
| Recovered | 0.928 | 0.2047 |
| | | |
| Model 3: LSTM with Adam optimizer | | |
| Confirmed | 0.971 | 0.0283 |
| Deaths | 0.909 | 0.077 |
| Recovered | 0.941 | 0.1072 |
| | | |
| Model 4: LSTM with SGD optimizer | | |
| Confirmed | 0.971 | 0.0288 |
| Deaths | 0.906 | 0.0932 |
| Recovered | 0.873 | 0.0989 |
| | | |
| Model 5: RNN based NNet | | |
| Confirmed | 0.971 | 0.1467 |
| Deaths | 0.909 | 0.3445 |
| Recovered | 0.946 | 0.1657 |

#CM5 Kaggle

Kaggle Group - Group 100

Kaggle url- https://www.kaggle.com/c/ece657as21-asg3

Group members- Amy Bhatia, Mengxuan Shi

[ ]:
```
# load dkmacovid test data
df_test = pd.read_csv('dkmacovid_kaggletest_features.csv')
# remove comma from dataframe in 'Resident Population 2020 Census' and␣
 ↪'Population Density 2020 Census'
df_test = df_test.replace(',','', regex=True)
# convert string to numeric data
df_test['Resident Population 2020 Census'] = df_test['Resident Population 2020␣
 ↪Census'].astype(float)
df_test['Population Density 2020 Census'] = df_test['Population Density 2020␣
 ↪Census'].astype(float)
features=['Day','State ID','Lat','Long_','Active', 'Incident_Rate',␣
 ↪'Total_Test_Results', 'Case_Fatality_Ratio', 'Testing_Rate', 'Resident␣
 ↪Population 2020 Census', 'Population Density 2020 Census', 'Density Rank␣
 ↪2020 Census', 'SexRatio']

df_test.head()
df_test_z= df_test.loc[:,features]

# df_z= df.loc[:,features]
df_test_z.iloc[:,:]=std_scaler.fit_transform(df_test_z.iloc[:,:])
X_kaggle= df_test_z.loc[:,features]
df_test_z.head()
X_kaggle = X_kaggle.values.reshape(X_kaggle.shape[0], 13,1)
```

[ ]:
```
# REPLACE MODEL NAME AND Y1 2 3 FOR OTHER MODELS AND LABELS
model_trainer(model_LSTM, y1, X,100 )
y1_predict = model_LSTM.predict_classes(X_kaggle)
```

```
Epoch 1/100
 3/26 [==>…] - ETA: 1s - loss: 0.2474 - accuracy:
0.6667

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

26/26 [==============================] - 2s 66ms/step - loss: 0.2145 - accuracy:
0.7029 - val_loss: 0.1960 - val_accuracy: 0.7283
Epoch 2/100
```

```
26/26 [==============================] - 2s 64ms/step - loss: 0.1727 - accuracy:
0.7585 - val_loss: 0.1707 - val_accuracy: 0.7609
Epoch 3/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1500 - accuracy:
0.7995 - val_loss: 0.1593 - val_accuracy: 0.7754
Epoch 4/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1409 - accuracy:
0.8056 - val_loss: 0.1495 - val_accuracy: 0.7971
Epoch 5/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1201 - accuracy:
0.8430 - val_loss: 0.1194 - val_accuracy: 0.8406
Epoch 6/100
26/26 [==============================] - 2s 59ms/step - loss: 0.0983 - accuracy:
0.8804 - val_loss: 0.1036 - val_accuracy: 0.8623
Epoch 7/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0942 - accuracy:
0.8804 - val_loss: 0.0883 - val_accuracy: 0.8877
Epoch 8/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0774 - accuracy:
0.9070 - val_loss: 0.0800 - val_accuracy: 0.8986
Epoch 9/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0683 - accuracy:
0.9215 - val_loss: 0.0683 - val_accuracy: 0.9203
Epoch 10/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0653 - accuracy:
0.9263 - val_loss: 0.0670 - val_accuracy: 0.9203
Epoch 11/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0645 - accuracy:
0.9275 - val_loss: 0.0656 - val_accuracy: 0.9239
Epoch 12/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0638 - accuracy:
0.9300 - val_loss: 0.0642 - val_accuracy: 0.9239
Epoch 13/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0628 - accuracy:
0.9312 - val_loss: 0.0633 - val_accuracy: 0.9275
Epoch 14/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0609 - accuracy:
0.9348 - val_loss: 0.0627 - val_accuracy: 0.9275
Epoch 15/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0580 - accuracy:
0.9372 - val_loss: 0.0601 - val_accuracy: 0.9312
Epoch 16/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0573 - accuracy:
0.9384 - val_loss: 0.0641 - val_accuracy: 0.9203
Epoch 17/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0536 - accuracy:
0.9420 - val_loss: 0.0424 - val_accuracy: 0.9565
Epoch 18/100
```

```
26/26 [==============================] - 2s 63ms/step - loss: 0.0460 - accuracy:
0.9553 - val_loss: 0.0344 - val_accuracy: 0.9710
Epoch 19/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0445 - accuracy:
0.9577 - val_loss: 0.0341 - val_accuracy: 0.9710
Epoch 20/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0443 - accuracy:
0.9577 - val_loss: 0.0339 - val_accuracy: 0.9710
Epoch 21/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0441 - accuracy:
0.9577 - val_loss: 0.0338 - val_accuracy: 0.9710
Epoch 22/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0440 - accuracy:
0.9577 - val_loss: 0.0336 - val_accuracy: 0.9710
Epoch 23/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0438 - accuracy:
0.9577 - val_loss: 0.0335 - val_accuracy: 0.9710
Epoch 24/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0437 - accuracy:
0.9577 - val_loss: 0.0334 - val_accuracy: 0.9710
Epoch 25/100
26/26 [==============================] - 2s 59ms/step - loss: 0.0436 - accuracy:
0.9577 - val_loss: 0.0333 - val_accuracy: 0.9710
Epoch 26/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0435 - accuracy:
0.9577 - val_loss: 0.0332 - val_accuracy: 0.9710
Epoch 27/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0434 - accuracy:
0.9577 - val_loss: 0.0331 - val_accuracy: 0.9710
Epoch 28/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0433 - accuracy:
0.9577 - val_loss: 0.0330 - val_accuracy: 0.9710
Epoch 29/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0432 - accuracy:
0.9577 - val_loss: 0.0329 - val_accuracy: 0.9710
Epoch 30/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0431 - accuracy:
0.9577 - val_loss: 0.0328 - val_accuracy: 0.9710
Epoch 31/100
26/26 [==============================] - 1s 58ms/step - loss: 0.0430 - accuracy:
0.9577 - val_loss: 0.0327 - val_accuracy: 0.9710
Epoch 32/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0429 - accuracy:
0.9577 - val_loss: 0.0326 - val_accuracy: 0.9710
Epoch 33/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0428 - accuracy:
0.9577 - val_loss: 0.0326 - val_accuracy: 0.9710
Epoch 34/100
```

```
26/26 [==============================] - 2s 69ms/step - loss: 0.0428 - accuracy:
0.9577 - val_loss: 0.0325 - val_accuracy: 0.9710
Epoch 35/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0427 - accuracy:
0.9577 - val_loss: 0.0324 - val_accuracy: 0.9710
Epoch 36/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0426 - accuracy:
0.9577 - val_loss: 0.0323 - val_accuracy: 0.9710
Epoch 37/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0426 - accuracy:
0.9577 - val_loss: 0.0323 - val_accuracy: 0.9710
Epoch 38/100
26/26 [==============================] - 2s 58ms/step - loss: 0.0425 - accuracy:
0.9577 - val_loss: 0.0322 - val_accuracy: 0.9710
Epoch 39/100
26/26 [==============================] - 2s 58ms/step - loss: 0.0424 - accuracy:
0.9577 - val_loss: 0.0322 - val_accuracy: 0.9710
Epoch 40/100
26/26 [==============================] - 2s 67ms/step - loss: 0.0424 - accuracy:
0.9577 - val_loss: 0.0321 - val_accuracy: 0.9710
Epoch 41/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0423 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9710
Epoch 42/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0423 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9710
Epoch 43/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0422 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9710
Epoch 44/100
26/26 [==============================] - 2s 67ms/step - loss: 0.0422 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9710
Epoch 45/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0421 - accuracy:
0.9577 - val_loss: 0.0318 - val_accuracy: 0.9710
Epoch 46/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0420 - accuracy:
0.9577 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 47/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0420 - accuracy:
0.9577 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 48/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0419 - accuracy:
0.9577 - val_loss: 0.0316 - val_accuracy: 0.9710
Epoch 49/100
26/26 [==============================] - 2s 67ms/step - loss: 0.0419 - accuracy:
0.9577 - val_loss: 0.0316 - val_accuracy: 0.9710
Epoch 50/100
```

```
26/26 [==============================] - 2s 59ms/step - loss: 0.0418 - accuracy:
0.9577 - val_loss: 0.0315 - val_accuracy: 0.9710
Epoch 51/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0418 - accuracy:
0.9577 - val_loss: 0.0315 - val_accuracy: 0.9710
Epoch 52/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0417 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 53/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0417 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 54/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0416 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 55/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0415 - accuracy:
0.9577 - val_loss: 0.0313 - val_accuracy: 0.9710
Epoch 56/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0415 - accuracy:
0.9577 - val_loss: 0.0313 - val_accuracy: 0.9710
Epoch 57/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0414 - accuracy:
0.9577 - val_loss: 0.0313 - val_accuracy: 0.9710
Epoch 58/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0413 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 59/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0413 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 60/100
26/26 [==============================] - 2s 82ms/step - loss: 0.0412 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 61/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0412 - accuracy:
0.9577 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 62/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0411 - accuracy:
0.9589 - val_loss: 0.0314 - val_accuracy: 0.9710
Epoch 63/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0411 - accuracy:
0.9589 - val_loss: 0.0315 - val_accuracy: 0.9710
Epoch 64/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0410 - accuracy:
0.9589 - val_loss: 0.0315 - val_accuracy: 0.9710
Epoch 65/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0410 - accuracy:
0.9589 - val_loss: 0.0315 - val_accuracy: 0.9710
Epoch 66/100
```

```
26/26 [==============================] - 2s 65ms/step - loss: 0.0409 - accuracy:
0.9589 - val_loss: 0.0316 - val_accuracy: 0.9710
Epoch 67/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0409 - accuracy:
0.9577 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 68/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0408 - accuracy:
0.9589 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 69/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0408 - accuracy:
0.9577 - val_loss: 0.0317 - val_accuracy: 0.9710
Epoch 70/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0407 - accuracy:
0.9577 - val_loss: 0.0318 - val_accuracy: 0.9710
Epoch 71/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0407 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 72/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0406 - accuracy:
0.9565 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 73/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0406 - accuracy:
0.9565 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 74/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0405 - accuracy:
0.9565 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 75/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0405 - accuracy:
0.9577 - val_loss: 0.0321 - val_accuracy: 0.9674
Epoch 76/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0404 - accuracy:
0.9589 - val_loss: 0.0321 - val_accuracy: 0.9674
Epoch 77/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0404 - accuracy:
0.9577 - val_loss: 0.0323 - val_accuracy: 0.9674
Epoch 78/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0404 - accuracy:
0.9577 - val_loss: 0.0321 - val_accuracy: 0.9674
Epoch 79/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0404 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 80/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0403 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 81/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0402 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 82/100
```

```
26/26 [==============================] - 2s 63ms/step - loss: 0.0402 - accuracy:
0.9565 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 83/100
26/26 [==============================] - 2s 69ms/step - loss: 0.0402 - accuracy:
0.9577 - val_loss: 0.0322 - val_accuracy: 0.9674
Epoch 84/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0401 - accuracy:
0.9577 - val_loss: 0.0321 - val_accuracy: 0.9674
Epoch 85/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0402 - accuracy:
0.9565 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 86/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0400 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 87/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0400 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 88/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0400 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 89/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0399 - accuracy:
0.9577 - val_loss: 0.0320 - val_accuracy: 0.9674
Epoch 90/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0399 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 91/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0399 - accuracy:
0.9589 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 92/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0399 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 93/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0399 - accuracy:
0.9577 - val_loss: 0.0319 - val_accuracy: 0.9674
Epoch 94/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0397 - accuracy:
0.9589 - val_loss: 0.0318 - val_accuracy: 0.9674
Epoch 95/100
26/26 [==============================] - 2s 68ms/step - loss: 0.0397 - accuracy:
0.9577 - val_loss: 0.0316 - val_accuracy: 0.9674
Epoch 96/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0397 - accuracy:
0.9589 - val_loss: 0.0315 - val_accuracy: 0.9674
Epoch 97/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0397 - accuracy:
0.9577 - val_loss: 0.0315 - val_accuracy: 0.9674
Epoch 98/100
```

```
26/26 [==============================] - 2s 62ms/step - loss: 0.0396 - accuracy:
0.9589 - val_loss: 0.0316 - val_accuracy: 0.9674
Epoch 99/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0397 - accuracy:
0.9577 - val_loss: 0.0316 - val_accuracy: 0.9674
Epoch 100/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0396 - accuracy:
0.9589 - val_loss: 0.0315 - val_accuracy: 0.9674
Running time is 162.76 seconds per 100 epoches

/usr/local/lib/python3.7/dist-packages/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after
2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if
your model does multi-class classification   (e.g. if it uses a `softmax` last-
layer activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model
does binary classification   (e.g. if it uses a `sigmoid` last-layer
activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

[ ]:
```
# REPLACE MODEL NAME AND Y1 2 3 FOR OTHER MODELS AND LABELS
model_trainer(model_LSTM, y2, X,100 )
y2_predict = model_LSTM.predict_classes(X_kaggle)
```

```
Epoch 1/100

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

26/26 [==============================] - 2s 65ms/step - loss: 0.0900 - accuracy:
0.9010 - val_loss: 0.0929 - val_accuracy: 0.8986
Epoch 2/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0899 - accuracy:
0.8998 - val_loss: 0.0927 - val_accuracy: 0.8986
Epoch 3/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0897 - accuracy:
0.9010 - val_loss: 0.0927 - val_accuracy: 0.8986
Epoch 4/100
26/26 [==============================] - 2s 59ms/step - loss: 0.0897 - accuracy:
0.8998 - val_loss: 0.0926 - val_accuracy: 0.8986
Epoch 5/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0896 - accuracy:
0.9010 - val_loss: 0.0926 - val_accuracy: 0.8986
Epoch 6/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0896 - accuracy:
0.9010 - val_loss: 0.0925 - val_accuracy: 0.8986
Epoch 7/100
```

```
26/26 [==============================] - 2s 63ms/step - loss: 0.0895 - accuracy:
0.9010 - val_loss: 0.0925 - val_accuracy: 0.8986
Epoch 8/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0894 - accuracy:
0.9010 - val_loss: 0.0926 - val_accuracy: 0.8986
Epoch 9/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0894 - accuracy:
0.9010 - val_loss: 0.0925 - val_accuracy: 0.8986
Epoch 10/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0893 - accuracy:
0.9010 - val_loss: 0.0924 - val_accuracy: 0.8986
Epoch 11/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0892 - accuracy:
0.9010 - val_loss: 0.0925 - val_accuracy: 0.8986
Epoch 12/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0890 - accuracy:
0.9010 - val_loss: 0.0929 - val_accuracy: 0.8986
Epoch 13/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0891 - accuracy:
0.9010 - val_loss: 0.0973 - val_accuracy: 0.8841
Epoch 14/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0887 - accuracy:
0.8998 - val_loss: 0.0937 - val_accuracy: 0.8913
Epoch 15/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0894 - accuracy:
0.8973 - val_loss: 0.1032 - val_accuracy: 0.8732
Epoch 16/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0889 - accuracy:
0.8998 - val_loss: 0.1001 - val_accuracy: 0.8768
Epoch 17/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0867 - accuracy:
0.9034 - val_loss: 0.1011 - val_accuracy: 0.8768
Epoch 18/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0886 - accuracy:
0.8998 - val_loss: 0.0985 - val_accuracy: 0.8841
Epoch 19/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0889 - accuracy:
0.8998 - val_loss: 0.0943 - val_accuracy: 0.8913
Epoch 20/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0876 - accuracy:
0.9010 - val_loss: 0.0957 - val_accuracy: 0.8877
Epoch 21/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0876 - accuracy:
0.9010 - val_loss: 0.1044 - val_accuracy: 0.8696
Epoch 22/100
26/26 [==============================] - 2s 59ms/step - loss: 0.0867 - accuracy:
0.9034 - val_loss: 0.0960 - val_accuracy: 0.8841
Epoch 23/100
```

```
26/26 [==============================] - 2s 63ms/step - loss: 0.0873 - accuracy:
0.9010 - val_loss: 0.1007 - val_accuracy: 0.8768
Epoch 24/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0872 - accuracy:
0.9022 - val_loss: 0.0941 - val_accuracy: 0.8949
Epoch 25/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0862 - accuracy:
0.9034 - val_loss: 0.1017 - val_accuracy: 0.8732
Epoch 26/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0884 - accuracy:
0.8998 - val_loss: 0.0937 - val_accuracy: 0.8913
Epoch 27/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0868 - accuracy:
0.9022 - val_loss: 0.0992 - val_accuracy: 0.8768
Epoch 28/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0872 - accuracy:
0.9010 - val_loss: 0.1023 - val_accuracy: 0.8768
Epoch 29/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0885 - accuracy:
0.8998 - val_loss: 0.0997 - val_accuracy: 0.8804
Epoch 30/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0863 - accuracy:
0.9010 - val_loss: 0.0977 - val_accuracy: 0.8841
Epoch 31/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0859 - accuracy:
0.9046 - val_loss: 0.1004 - val_accuracy: 0.8804
Epoch 32/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0880 - accuracy:
0.9010 - val_loss: 0.0997 - val_accuracy: 0.8804
Epoch 33/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0863 - accuracy:
0.9034 - val_loss: 0.1021 - val_accuracy: 0.8768
Epoch 34/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0882 - accuracy:
0.8998 - val_loss: 0.0967 - val_accuracy: 0.8841
Epoch 35/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0855 - accuracy:
0.9034 - val_loss: 0.1008 - val_accuracy: 0.8768
Epoch 36/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0877 - accuracy:
0.9010 - val_loss: 0.0988 - val_accuracy: 0.8804
Epoch 37/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0865 - accuracy:
0.9046 - val_loss: 0.0936 - val_accuracy: 0.8913
Epoch 38/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0886 - accuracy:
0.8998 - val_loss: 0.1003 - val_accuracy: 0.8768
Epoch 39/100
```

```
26/26 [==============================] - 2s 63ms/step - loss: 0.0859 - accuracy:
0.9034 - val_loss: 0.0988 - val_accuracy: 0.8804
Epoch 40/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0866 - accuracy:
0.9034 - val_loss: 0.1003 - val_accuracy: 0.8768
Epoch 41/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0876 - accuracy:
0.9022 - val_loss: 0.0975 - val_accuracy: 0.8804
Epoch 42/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0852 - accuracy:
0.9058 - val_loss: 0.0956 - val_accuracy: 0.8877
Epoch 43/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0855 - accuracy:
0.9058 - val_loss: 0.0942 - val_accuracy: 0.8913
Epoch 44/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0872 - accuracy:
0.9022 - val_loss: 0.0992 - val_accuracy: 0.8768
Epoch 45/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0855 - accuracy:
0.9058 - val_loss: 0.0952 - val_accuracy: 0.8841
Epoch 46/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0856 - accuracy:
0.9046 - val_loss: 0.0945 - val_accuracy: 0.8877
Epoch 47/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0858 - accuracy:
0.9046 - val_loss: 0.0951 - val_accuracy: 0.8877
Epoch 48/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0869 - accuracy:
0.9022 - val_loss: 0.0976 - val_accuracy: 0.8841
Epoch 49/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0859 - accuracy:
0.9034 - val_loss: 0.1003 - val_accuracy: 0.8804
Epoch 50/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0863 - accuracy:
0.9034 - val_loss: 0.0988 - val_accuracy: 0.8804
Epoch 51/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0860 - accuracy:
0.9034 - val_loss: 0.0953 - val_accuracy: 0.8841
Epoch 52/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0854 - accuracy:
0.9046 - val_loss: 0.0948 - val_accuracy: 0.8877
Epoch 53/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0850 - accuracy:
0.9058 - val_loss: 0.0951 - val_accuracy: 0.8841
Epoch 54/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0850 - accuracy:
0.9058 - val_loss: 0.0934 - val_accuracy: 0.8913
Epoch 55/100
```

```
26/26 [==============================] - 2s 66ms/step - loss: 0.0857 - accuracy:
0.9034 - val_loss: 0.0959 - val_accuracy: 0.8841
Epoch 56/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0856 - accuracy:
0.9034 - val_loss: 0.0939 - val_accuracy: 0.8913
Epoch 57/100
26/26 [==============================] - 2s 69ms/step - loss: 0.0863 - accuracy:
0.9034 - val_loss: 0.0935 - val_accuracy: 0.8877
Epoch 58/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0871 - accuracy:
0.9022 - val_loss: 0.0996 - val_accuracy: 0.8804
Epoch 59/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0861 - accuracy:
0.9034 - val_loss: 0.0958 - val_accuracy: 0.8804
Epoch 60/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0873 - accuracy:
0.8998 - val_loss: 0.0957 - val_accuracy: 0.8877
Epoch 61/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0855 - accuracy:
0.9034 - val_loss: 0.0929 - val_accuracy: 0.8949
Epoch 62/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0866 - accuracy:
0.9034 - val_loss: 0.0968 - val_accuracy: 0.8841
Epoch 63/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0855 - accuracy:
0.9034 - val_loss: 0.0989 - val_accuracy: 0.8804
Epoch 64/100
26/26 [==============================] - 2s 60ms/step - loss: 0.0852 - accuracy:
0.9046 - val_loss: 0.1004 - val_accuracy: 0.8768
Epoch 65/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0850 - accuracy:
0.9046 - val_loss: 0.1011 - val_accuracy: 0.8768
Epoch 66/100
26/26 [==============================] - 2s 68ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.1003 - val_accuracy: 0.8768
Epoch 67/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.1028 - val_accuracy: 0.8732
Epoch 68/100
26/26 [==============================] - 2s 59ms/step - loss: 0.0858 - accuracy:
0.9034 - val_loss: 0.0980 - val_accuracy: 0.8804
Epoch 69/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0882 - accuracy:
0.8986 - val_loss: 0.1031 - val_accuracy: 0.8732
Epoch 70/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0859 - accuracy:
0.9022 - val_loss: 0.0978 - val_accuracy: 0.8804
Epoch 71/100
```

```
26/26 [==============================] - 2s 65ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.0981 - val_accuracy: 0.8804
Epoch 72/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0852 - accuracy:
0.9046 - val_loss: 0.0977 - val_accuracy: 0.8804
Epoch 73/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.0999 - val_accuracy: 0.8804
Epoch 74/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.0987 - val_accuracy: 0.8804
Epoch 75/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.0990 - val_accuracy: 0.8804
Epoch 76/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0850 - accuracy:
0.9046 - val_loss: 0.0990 - val_accuracy: 0.8804
Epoch 77/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.0992 - val_accuracy: 0.8768
Epoch 78/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0852 - accuracy:
0.9034 - val_loss: 0.1036 - val_accuracy: 0.8732
Epoch 79/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0850 - accuracy:
0.9046 - val_loss: 0.0985 - val_accuracy: 0.8804
Epoch 80/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0851 - accuracy:
0.9046 - val_loss: 0.0972 - val_accuracy: 0.8841
Epoch 81/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0880 - accuracy:
0.8986 - val_loss: 0.1034 - val_accuracy: 0.8732
Epoch 82/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0873 - accuracy:
0.8998 - val_loss: 0.1031 - val_accuracy: 0.8732
Epoch 83/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0860 - accuracy:
0.9022 - val_loss: 0.1026 - val_accuracy: 0.8732
Epoch 84/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0856 - accuracy:
0.9034 - val_loss: 0.0967 - val_accuracy: 0.8841
Epoch 85/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.0984 - val_accuracy: 0.8804
Epoch 86/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.0986 - val_accuracy: 0.8804
Epoch 87/100
```

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26/26 [==============================] - 2s 63ms/step - loss: 0.0847 - accuracy:
0.9046 - val_loss: 0.0970 - val_accuracy: 0.8841
Epoch 88/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.0987 - val_accuracy: 0.8804
Epoch 89/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0847 - accuracy:
0.9046 - val_loss: 0.0984 - val_accuracy: 0.8804
Epoch 90/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.0991 - val_accuracy: 0.8804
Epoch 91/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0856 - accuracy:
0.9034 - val_loss: 0.1030 - val_accuracy: 0.8732
Epoch 92/100
26/26 [==============================] - 2s 63ms/step - loss: 0.0852 - accuracy:
0.9046 - val_loss: 0.1033 - val_accuracy: 0.8732
Epoch 93/100
26/26 [==============================] - 2s 67ms/step - loss: 0.0850 - accuracy:
0.9046 - val_loss: 0.1007 - val_accuracy: 0.8768
Epoch 94/100
26/26 [==============================] - 2s 66ms/step - loss: 0.0848 - accuracy:
0.9046 - val_loss: 0.1017 - val_accuracy: 0.8732
Epoch 95/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0849 - accuracy:
0.9046 - val_loss: 0.1017 - val_accuracy: 0.8732
Epoch 96/100
26/26 [==============================] - 2s 61ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.1008 - val_accuracy: 0.8768
Epoch 97/100
26/26 [==============================] - 2s 62ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.1017 - val_accuracy: 0.8732
Epoch 98/100
26/26 [==============================] - 2s 64ms/step - loss: 0.0846 - accuracy:
0.9046 - val_loss: 0.0997 - val_accuracy: 0.8768
Epoch 99/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0849 - accuracy:
0.9046 - val_loss: 0.1000 - val_accuracy: 0.8768
Epoch 100/100
26/26 [==============================] - 2s 65ms/step - loss: 0.0847 - accuracy:
0.9046 - val_loss: 0.1013 - val_accuracy: 0.8768
Running time is 201.96 seconds per 100 epoches

/usr/local/lib/python3.7/dist-packages/keras/engine/sequential.py:450:
UserWarning: `model.predict_classes()` is deprecated and will be removed after
2021-01-01. Please use instead:* `np.argmax(model.predict(x), axis=-1)`,   if
your model does multi-class classification   (e.g. if it uses a `softmax` last-
layer activation).* `(model.predict(x) > 0.5).astype("int32")`,   if your model
```

```
does binary classification   (e.g. if it uses a `sigmoid` last-layer
activation).
  warnings.warn('`model.predict_classes()` is deprecated and '
```

[ ]:
```
# REPLACE MODEL NAME AND Y1 2 3 FOR OTHER MODELS AND LABELS
model_trainer(model_LSTM, y3, X,100 )
y3_predict = model_LSTM.predict_classes(X_kaggle)
```

```
Epoch 1/100

/usr/local/lib/python3.7/dist-
packages/tensorflow/python/data/ops/dataset_ops.py:3704: UserWarning: Even
though the `tf.config.experimental_run_functions_eagerly` option is set, this
option does not apply to tf.data functions. To force eager execution of tf.data
functions, please use `tf.data.experimental.enable.debug_mode()`.
  "Even though the `tf.config.experimental_run_functions_eagerly` "

26/26 [==============================] - 2s 65ms/step - loss: 0.3017 - accuracy:
0.6461 - val_loss: 0.2893 - val_accuracy: 0.6630
Epoch 2/100
26/26 [==============================] - 2s 65ms/step - loss: 0.2869 - accuracy:
0.6606 - val_loss: 0.2750 - val_accuracy: 0.6667
Epoch 3/100
26/26 [==============================] - 2s 62ms/step - loss: 0.2731 - accuracy:
0.6739 - val_loss: 0.2571 - val_accuracy: 0.6957
Epoch 4/100
26/26 [==============================] - 2s 59ms/step - loss: 0.2464 - accuracy:
0.6896 - val_loss: 0.2051 - val_accuracy: 0.7464
Epoch 5/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1966 - accuracy:
0.7597 - val_loss: 0.1871 - val_accuracy: 0.7717
Epoch 6/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1687 - accuracy:
0.7923 - val_loss: 0.1675 - val_accuracy: 0.7899
Epoch 7/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1543 - accuracy:
0.8128 - val_loss: 0.1567 - val_accuracy: 0.8080
Epoch 8/100
26/26 [==============================] - 2s 65ms/step - loss: 0.1388 - accuracy:
0.8345 - val_loss: 0.1550 - val_accuracy: 0.8152
Epoch 9/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1312 - accuracy:
0.8478 - val_loss: 0.1571 - val_accuracy: 0.8152
Epoch 10/100
26/26 [==============================] - 2s 59ms/step - loss: 0.1301 - accuracy:
0.8466 - val_loss: 0.1548 - val_accuracy: 0.8080
Epoch 11/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1282 - accuracy:
0.8539 - val_loss: 0.1523 - val_accuracy: 0.8188
```

```
Epoch 12/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1271 - accuracy:
0.8502 - val_loss: 0.1487 - val_accuracy: 0.8225
Epoch 13/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1257 - accuracy:
0.8551 - val_loss: 0.1474 - val_accuracy: 0.8261
Epoch 14/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1248 - accuracy:
0.8575 - val_loss: 0.1477 - val_accuracy: 0.8297
Epoch 15/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1231 - accuracy:
0.8623 - val_loss: 0.1466 - val_accuracy: 0.8333
Epoch 16/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1221 - accuracy:
0.8635 - val_loss: 0.1464 - val_accuracy: 0.8297
Epoch 17/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1218 - accuracy:
0.8647 - val_loss: 0.1482 - val_accuracy: 0.8152
Epoch 18/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1217 - accuracy:
0.8659 - val_loss: 0.1470 - val_accuracy: 0.8225
Epoch 19/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1216 - accuracy:
0.8647 - val_loss: 0.1490 - val_accuracy: 0.8225
Epoch 20/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1202 - accuracy:
0.8647 - val_loss: 0.1497 - val_accuracy: 0.8188
Epoch 21/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1200 - accuracy:
0.8684 - val_loss: 0.1488 - val_accuracy: 0.8152
Epoch 22/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1200 - accuracy:
0.8671 - val_loss: 0.1478 - val_accuracy: 0.8261
Epoch 23/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1199 - accuracy:
0.8659 - val_loss: 0.1509 - val_accuracy: 0.8116
Epoch 24/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1190 - accuracy:
0.8684 - val_loss: 0.1495 - val_accuracy: 0.8225
Epoch 25/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1190 - accuracy:
0.8671 - val_loss: 0.1539 - val_accuracy: 0.8188
Epoch 26/100
26/26 [==============================] - 2s 66ms/step - loss: 0.1187 - accuracy:
0.8671 - val_loss: 0.1472 - val_accuracy: 0.8225
Epoch 27/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1186 - accuracy:
0.8684 - val_loss: 0.1497 - val_accuracy: 0.8188
```

```
Epoch 28/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1186 - accuracy:
0.8659 - val_loss: 0.1494 - val_accuracy: 0.8261
Epoch 29/100
26/26 [==============================] - 2s 67ms/step - loss: 0.1188 - accuracy:
0.8671 - val_loss: 0.1505 - val_accuracy: 0.8188
Epoch 30/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1179 - accuracy:
0.8684 - val_loss: 0.1499 - val_accuracy: 0.8225
Epoch 31/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1182 - accuracy:
0.8684 - val_loss: 0.1508 - val_accuracy: 0.8188
Epoch 32/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1179 - accuracy:
0.8659 - val_loss: 0.1505 - val_accuracy: 0.8188
Epoch 33/100
26/26 [==============================] - 2s 65ms/step - loss: 0.1175 - accuracy:
0.8696 - val_loss: 0.1502 - val_accuracy: 0.8225
Epoch 34/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1177 - accuracy:
0.8684 - val_loss: 0.1519 - val_accuracy: 0.8116
Epoch 35/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1177 - accuracy:
0.8696 - val_loss: 0.1511 - val_accuracy: 0.8188
Epoch 36/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1169 - accuracy:
0.8696 - val_loss: 0.1492 - val_accuracy: 0.8188
Epoch 37/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1169 - accuracy:
0.8696 - val_loss: 0.1533 - val_accuracy: 0.8116
Epoch 38/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1169 - accuracy:
0.8696 - val_loss: 0.1553 - val_accuracy: 0.8080
Epoch 39/100
26/26 [==============================] - 2s 66ms/step - loss: 0.1169 - accuracy:
0.8708 - val_loss: 0.1549 - val_accuracy: 0.8080
Epoch 40/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1166 - accuracy:
0.8696 - val_loss: 0.1518 - val_accuracy: 0.8188
Epoch 41/100
26/26 [==============================] - 2s 65ms/step - loss: 0.1168 - accuracy:
0.8696 - val_loss: 0.1503 - val_accuracy: 0.8188
Epoch 42/100
26/26 [==============================] - 2s 69ms/step - loss: 0.1165 - accuracy:
0.8696 - val_loss: 0.1524 - val_accuracy: 0.8188
Epoch 43/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1168 - accuracy:
0.8684 - val_loss: 0.1497 - val_accuracy: 0.8188
```

```
Epoch 44/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1160 - accuracy:
0.8708 - val_loss: 0.1506 - val_accuracy: 0.8116
Epoch 45/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1164 - accuracy:
0.8708 - val_loss: 0.1491 - val_accuracy: 0.8225
Epoch 46/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1161 - accuracy:
0.8696 - val_loss: 0.1492 - val_accuracy: 0.8188
Epoch 47/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1163 - accuracy:
0.8696 - val_loss: 0.1512 - val_accuracy: 0.8188
Epoch 48/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1154 - accuracy:
0.8720 - val_loss: 0.1542 - val_accuracy: 0.8116
Epoch 49/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1161 - accuracy:
0.8708 - val_loss: 0.1546 - val_accuracy: 0.8152
Epoch 50/100
26/26 [==============================] - 2s 59ms/step - loss: 0.1160 - accuracy:
0.8684 - val_loss: 0.1529 - val_accuracy: 0.8152
Epoch 51/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1153 - accuracy:
0.8708 - val_loss: 0.1496 - val_accuracy: 0.8188
Epoch 52/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1152 - accuracy:
0.8708 - val_loss: 0.1524 - val_accuracy: 0.8080
Epoch 53/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1155 - accuracy:
0.8696 - val_loss: 0.1505 - val_accuracy: 0.8188
Epoch 54/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1151 - accuracy:
0.8696 - val_loss: 0.1515 - val_accuracy: 0.8152
Epoch 55/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1149 - accuracy:
0.8684 - val_loss: 0.1545 - val_accuracy: 0.8080
Epoch 56/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1149 - accuracy:
0.8671 - val_loss: 0.1495 - val_accuracy: 0.8188
Epoch 57/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1152 - accuracy:
0.8696 - val_loss: 0.1521 - val_accuracy: 0.8152
Epoch 58/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1147 - accuracy:
0.8708 - val_loss: 0.1501 - val_accuracy: 0.8188
Epoch 59/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1149 - accuracy:
0.8671 - val_loss: 0.1514 - val_accuracy: 0.8152
```

```
Epoch 60/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1149 - accuracy:
0.8696 - val_loss: 0.1500 - val_accuracy: 0.8188
Epoch 61/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1145 - accuracy:
0.8708 - val_loss: 0.1494 - val_accuracy: 0.8225
Epoch 62/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1148 - accuracy:
0.8684 - val_loss: 0.1505 - val_accuracy: 0.8188
Epoch 63/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1146 - accuracy:
0.8696 - val_loss: 0.1504 - val_accuracy: 0.8188
Epoch 64/100
26/26 [==============================] - 2s 59ms/step - loss: 0.1141 - accuracy:
0.8696 - val_loss: 0.1522 - val_accuracy: 0.8152
Epoch 65/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1141 - accuracy:
0.8696 - val_loss: 0.1514 - val_accuracy: 0.8152
Epoch 66/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1141 - accuracy:
0.8708 - val_loss: 0.1509 - val_accuracy: 0.8116
Epoch 67/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1142 - accuracy:
0.8696 - val_loss: 0.1509 - val_accuracy: 0.8188
Epoch 68/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1138 - accuracy:
0.8708 - val_loss: 0.1543 - val_accuracy: 0.8116
Epoch 69/100
26/26 [==============================] - 2s 59ms/step - loss: 0.1140 - accuracy:
0.8708 - val_loss: 0.1505 - val_accuracy: 0.8225
Epoch 70/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1138 - accuracy:
0.8720 - val_loss: 0.1517 - val_accuracy: 0.8152
Epoch 71/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1135 - accuracy:
0.8720 - val_loss: 0.1507 - val_accuracy: 0.8152
Epoch 72/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1141 - accuracy:
0.8708 - val_loss: 0.1503 - val_accuracy: 0.8225
Epoch 73/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1136 - accuracy:
0.8720 - val_loss: 0.1519 - val_accuracy: 0.8188
Epoch 74/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1139 - accuracy:
0.8708 - val_loss: 0.1529 - val_accuracy: 0.8116
Epoch 75/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1136 - accuracy:
0.8708 - val_loss: 0.1497 - val_accuracy: 0.8188
```

```
Epoch 76/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1134 - accuracy:
0.8708 - val_loss: 0.1540 - val_accuracy: 0.8116
Epoch 77/100
26/26 [==============================] - 2s 64ms/step - loss: 0.1135 - accuracy:
0.8708 - val_loss: 0.1517 - val_accuracy: 0.8188
Epoch 78/100
26/26 [==============================] - 2s 66ms/step - loss: 0.1133 - accuracy:
0.8708 - val_loss: 0.1538 - val_accuracy: 0.8116
Epoch 79/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1137 - accuracy:
0.8696 - val_loss: 0.1511 - val_accuracy: 0.8188
Epoch 80/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1131 - accuracy:
0.8720 - val_loss: 0.1515 - val_accuracy: 0.8188
Epoch 81/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1133 - accuracy:
0.8708 - val_loss: 0.1498 - val_accuracy: 0.8225
Epoch 82/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1128 - accuracy:
0.8732 - val_loss: 0.1511 - val_accuracy: 0.8188
Epoch 83/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1129 - accuracy:
0.8720 - val_loss: 0.1527 - val_accuracy: 0.8188
Epoch 84/100
26/26 [==============================] - 2s 65ms/step - loss: 0.1131 - accuracy:
0.8708 - val_loss: 0.1511 - val_accuracy: 0.8188
Epoch 85/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1130 - accuracy:
0.8720 - val_loss: 0.1519 - val_accuracy: 0.8188
Epoch 86/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1128 - accuracy:
0.8720 - val_loss: 0.1510 - val_accuracy: 0.8188
Epoch 87/100
26/26 [==============================] - 2s 61ms/step - loss: 0.1128 - accuracy:
0.8732 - val_loss: 0.1514 - val_accuracy: 0.8188
Epoch 88/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1132 - accuracy:
0.8696 - val_loss: 0.1501 - val_accuracy: 0.8188
Epoch 89/100
26/26 [==============================] - 2s 62ms/step - loss: 0.1126 - accuracy:
0.8720 - val_loss: 0.1496 - val_accuracy: 0.8188
Epoch 90/100
26/26 [==============================] - 2s 63ms/step - loss: 0.1126 - accuracy:
0.8708 - val_loss: 0.1515 - val_accuracy: 0.8152
Epoch 91/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1127 - accuracy:
0.8696 - val_loss: 0.1499 - val_accuracy: 0.8225
```

```
Epoch 92/100
26/26 [==============================] - 2s 60ms/step - loss: 0.1126 - accuracy:
0.8720 - val_loss: 0.1506 - val_accuracy: 0.8225
Epoch 93/100
21/26 [======================>...] - ETA: 0s - loss: 0.1124 - accuracy:
0.8705
```

[ ]:
```
import datetime
now = datetime.datetime.now()
time_string=now.strftime("%Y-%m-%d %H:%M")

Confirmed= pd.DataFrame(data= y1_predict, columns=['Confirmed']).astype(int)
Deaths= pd.DataFrame(data= y2_predict, columns=['Deaths']).astype(int)
Recovered= pd.DataFrame(data= y3_predict, columns=['Recovered']).astype(int)

ID = pd.DataFrame(df_test['Id'],columns=['Id'])
df_result=pd.concat([ID,Confirmed,Deaths,Recovered], axis=1)
df_result.to_csv('Kaggle_Decision_'+time_string+'.csv', index=False)
```

## 6 References


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[3] https://machinelearningmastery.com/timedistributed-layer-for-long-short-term-memory-networks-in-python/

[4] https://stats.stackexchange.com/questions/324896/training-loss-increases-with-time