In [ ]:
```
pip install tensorflow
```

In [ ]:
```
pip install sklearn
```

In [ ]:
```
pip install matplotlib
```

In [ ]:
```
pip install keras
```

In [ ]:
```
pip install seaborn
```

In [ ]:
```
pip install pydotplus
```

In [1]:
```
import matplotlib.pyplot as plt
from PIL import Image
import seaborn as sns
import numpy as np
import pandas as pd
import os
from tensorflow.keras.utils import to_categorical
from glob import glob


from sklearn.model_selection import train_test_split
import keras
from keras.models import Sequential
from keras.layers import Dense, Dropout
import tensorflow as tf
from sklearn.preprocessing import StandardScaler
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_repo
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ReduceLROnPlateau
from tensorflow.keras import layers
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten

from sklearn.metrics import confusion_matrix
import itertools
import matplotlib.pyplot as plt

import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
df = pd.read_csv('skinCancer/HAM10000_metadata_Incereased.csv')
df.head(10)
```

Out[2]:

	lesion_id	image_id	dx	dx_type	age	sex	localization
0	HAM_0000118	ISIC_0027419	bkl	histo	80.0	male	scalp
1	HAM_0000118	ISIC_0025030	bkl	histo	80.0	male	scalp
2	HAM_0002730	ISIC_0026769	bkl	histo	80.0	male	scalp
3	HAM_0002730	ISIC_0025661	bkl	histo	80.0	male	scalp
4	HAM_0001466	ISIC_0031633	bkl	histo	75.0	male	ear
5	HAM_0001466	ISIC_0027850	bkl	histo	75.0	male	ear
6	HAM_0002761	ISIC_0029176	bkl	histo	60.0	male	face
7	HAM_0002761	ISIC_0029068	bkl	histo	60.0	male	face
8	HAM_0005132	ISIC_0025837	bkl	histo	70.0	female	back
9	HAM_0005132	ISIC_0025209	bkl	histo	70.0	female	back

In [3]:
```
df.isnull().sum()
```

Out[3]:
```
lesion_id         0
image_id          0
dx                0
dx_type           0
age             119
sex               0
localization      0
dtype: int64
```

In [4]:
```
df.count()
```

Out[4]:
```
lesion_id       49517
image_id        49517
dx              49517
dx_type         49517
age             49398
sex             49517
localization    49517
dtype: int64
```

In [5]:
```
df['age'].fillna(int(df['age'].mean()),inplace=True)
df.isnull().sum()
```

Out[5]:
```
lesion_id       0
image_id        0
dx              0
dx_type         0
age             0
sex             0
localization    0
dtype: int64
```

In [6]:
```
lesion_type_dict = {
    'nv': 'Melanocytic nevi',
    'mel': 'Melanoma',
    'bkl': 'Benign keratosis-like lesions ',
    'bcc': 'Basal cell carcinoma',
    'akiec': 'Actinic keratoses',
    'vasc': 'Vascular lesions',
    'df': 'Dermatofibroma'
}
base_skin_dir = 'skinCancer'

imageid_path_dict = {os.path.splitext(os.path.basename(x))[0]: x
                     for x in glob(os.path.join(base_skin_dir, '*', '*.jpg'))}
```

In [7]:
```
df['path'] = df['image_id'].map(imageid_path_dict.get)
df['cell_type'] = df['dx'].map(lesion_type_dict.get)
df['cell_type_idx'] = pd.Categorical(df['cell_type']).codes
df.head()
```

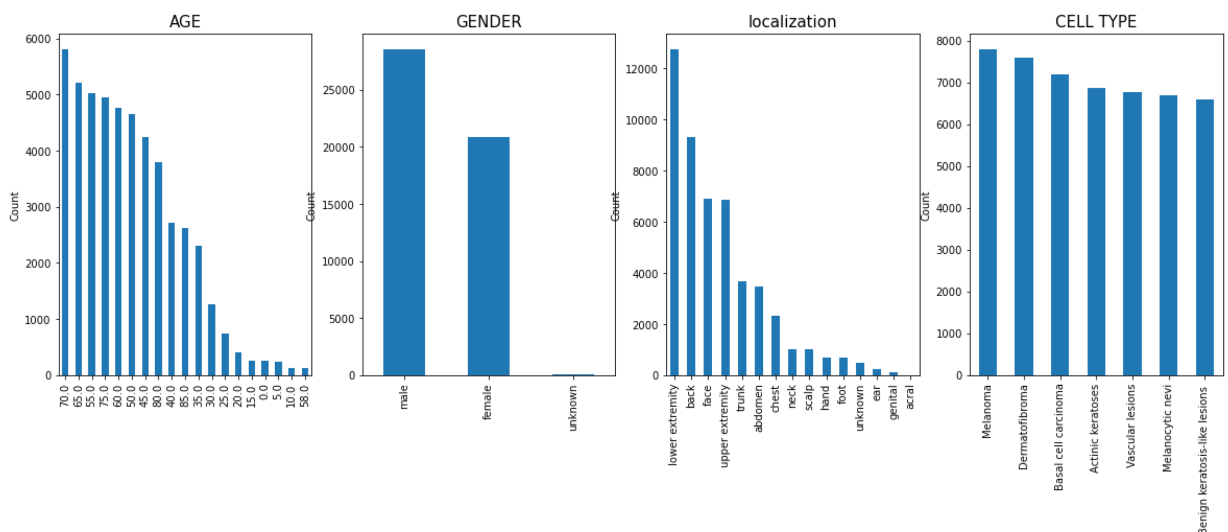
Out[7]:

	lesion_id	image_id	dx	dx_type	age	sex	localization	
0	HAM_0000118	ISIC_0027419	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_
1	HAM_0000118	ISIC_0025030	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_
2	HAM_0002730	ISIC_0026769	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_
3	HAM_0002730	ISIC_0025661	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_
4	HAM_0001466	ISIC_0031633	bkl	histo	75.0	male	ear	skinCancer\HAM10000_images_

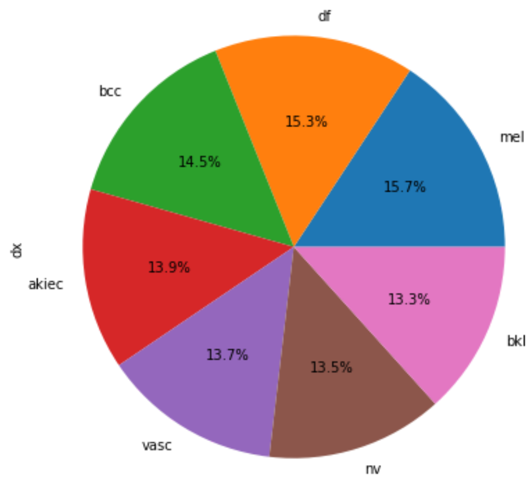
In [8]:
```
df['image'] = df['path'].map(lambda x: np.asarray(Image.open(x).resize((125,100))
```

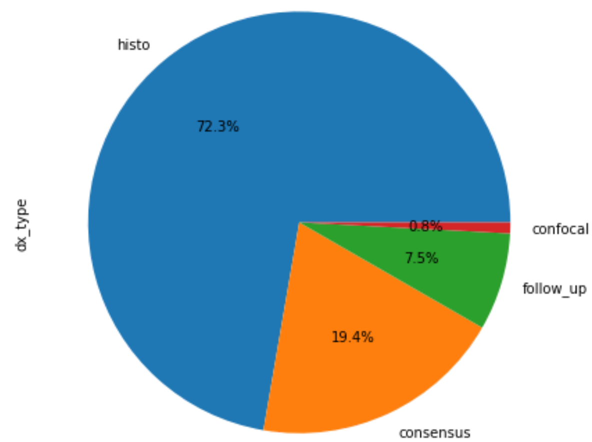
In [9]:
```
plt.figure(figsize=(20,10))
plt.subplots_adjust(left=0.125, bottom=1, right=0.9, top=2, hspace=0.2)
plt.subplot(2,4,1)
plt.title("AGE",fontsize=15)
plt.ylabel("Count")
df['age'].value_counts().plot.bar()

plt.subplot(2,4,2)
plt.title("GENDER",fontsize=15)
plt.ylabel("Count")
df['sex'].value_counts().plot.bar()

plt.subplot(2,4,3)
plt.title("localization",fontsize=15)
plt.ylabel("Count")
plt.xticks(rotation=45)
df['localization'].value_counts().plot.bar()

plt.subplot(2,4,4)
plt.title("CELL TYPE",fontsize=15)
plt.ylabel("Count")
df['cell_type'].value_counts().plot.bar()
```

Out[9]: <AxesSubplot:title={'center':'CELL TYPE'}, ylabel='Count'>



In [10]:
```
plt.figure(figsize=(15,10))
plt.subplot(1,2,1)
df['dx'].value_counts().plot.pie(autopct="%1.1f%%")
plt.subplot(1,2,2)
df['dx_type'].value_counts().plot.pie(autopct="%1.1f%%")
plt.show()
```





In [11]:
```
features=df.drop(columns=['cell_type_idx','image_id'],axis=1)
target=df['cell_type_idx']
features.head()
```

Out[11]:

	lesion_id	dx	dx_type	age	sex	localization	
0	HAM_0000118	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_part_1\ISIC_002
1	HAM_0000118	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_part_1\ISIC_002
2	HAM_0002730	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_part_1\ISIC_002
3	HAM_0002730	bkl	histo	80.0	male	scalp	skinCancer\HAM10000_images_part_1\ISIC_002
4	HAM_0001466	bkl	histo	75.0	male	ear	skinCancer\HAM10000_images_part_2\ISIC_003

In [12]:
```
x_train_o, x_test_o, y_train_o, y_test_o = train_test_split(features, target, tes
tf.unique(x_train_o.cell_type.values)
```

Out[12]:
```
Unique(y=<tf.Tensor: shape=(7,), dtype=string, numpy=
array([b'Actinic keratoses', b'Basal cell carcinoma', b'Dermatofibroma',
       b'Melanoma', b'Benign keratosis-like lesions ',
       b'Melanocytic nevi', b'Vascular lesions'], dtype=object)>, idx=<tf.Tenso
r: shape=(37137,), dtype=int32, numpy=array([0, 1, 1, ..., 1, 1, 6])>)
```

In [13]:
```
x_train = np.asarray(x_train_o['image'].tolist())
x_test = np.asarray(x_test_o['image'].tolist())

x_train_mean = np.mean(x_train)
x_train_std = np.std(x_train)


x_test_mean = np.mean(x_test)
x_test_std = np.std(x_test)

x_train = (x_train - x_train_mean)/x_train_std
x_test = (x_test - x_test_mean)/x_test_std
```

In [14]:
```
# Perform one-hot encoding on the labels
y_train = to_categorical(y_train_o, num_classes = 7)
y_test = to_categorical(y_test_o, num_classes = 7)
y_test
```

Out[14]:
```
array([[0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 1.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 1.],
       [0., 0., 0., ..., 0., 0., 0.]], dtype=float32)
```

In [15]:
```
y_test[1]
```

Out[15]:
```
array([0., 0., 0., 1., 0., 0., 0.], dtype=float32)
```

In [16]:
```
y_train
```

Out[16]:
```
array([[1., 0., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       ...,
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 1., 0., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 1.]], dtype=float32)
```

In [17]:
```
y_test_o.value_counts()
```

Out[17]:
```
5    1924
3    1907
1    1750
0    1730
6    1697
2    1689
4    1683
Name: cell_type_idx, dtype: int64
```

In [18]:
```
# x_train, x_validate, y_train, y_validate = train_test_split(x_train, y_train, t


# Reshape image in 3 dimensions (height = 100, width = 125 , canal = 3)
x_train = x_train.reshape(x_train_o.shape[0], *(100, 125, 3))
x_test = x_test.reshape(x_test_o.shape[0], *(100, 125, 3))
```

In [19]:
```
x_train = x_train.reshape(x_train.shape[0],125*100*3)
x_test = x_test.reshape(x_test.shape[0],125*100*3)
print(x_train.shape)
print(x_test.shape)
```

```
(37137, 37500)
(12380, 37500)
```

In [20]:
```
print(x_train)
```

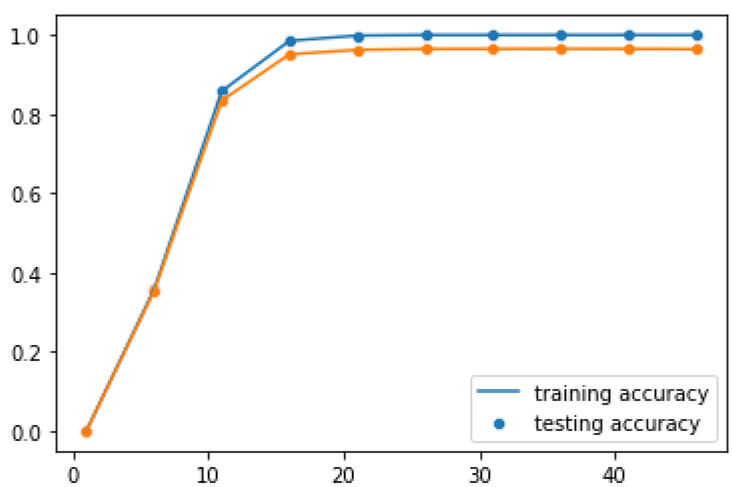
```
[[ 0.67592044 -0.3525907   0.07794885 ...  0.96294681  0.12578657
   0.31713748]
 [-0.04164547 -0.85488684 -1.54853389 ...  0.1736243  -0.6874548
  -1.14191321]
 [ 0.07794885 -1.33326412 -1.45285844 ...  0.60416385 -0.23299638
  -0.16123979]
 ...
 [-2.93582799 -3.31852981 -2.79231481 ... -3.17501663 -3.41420527
  -3.03150345]
 [ 0.53240726 -0.63961707 -0.71137366 ...  0.19754317 -1.02231889
  -1.14191321]
 [ 0.93902794 -0.30475297  0.19754317 ...  0.65200158 -0.63961707
  -0.23299638]]
```

Decision Tree

In [24]:
```
depth = range(1,51,5)
testing_accuracy = []
training_accuracy = []
score = 0

for i in depth:
    tree = DecisionTreeClassifier(max_depth = i, criterion = 'entropy')
    tree.fit(x_train, y_train)

    y_predict_train = tree.predict(x_train)
    training_accuracy.append(accuracy_score(y_train, y_predict_train))

    y_predict_test = tree.predict(x_test)
    acc_score = accuracy_score(y_test,y_predict_test)
    testing_accuracy.append(acc_score)

    print(i)

    if score < acc_score:
        score = acc_score
        best_depth = i

sns.lineplot(depth, training_accuracy)
sns.scatterplot(depth, training_accuracy)
sns.lineplot(depth, testing_accuracy)
sns.scatterplot(depth, testing_accuracy)
plt.legend(['training accuracy', 'testing accuracy'])
```

```
1
6
11
16
21
26
31
36
41
46
```

Out[24]:
```
<matplotlib.legend.Legend at 0x14e31eaed90>
```



In [25]:
```
print('This is the best depth for Decision Tree Classifier: ', best_depth, '\nAcc
result = confusion_matrix(y_test.argmax(axis=1), y_predict_test.argmax(axis=1),)
print("Confusion Matrix:","\n", result)
report = classification_report(y_test.argmax(axis=1), y_predict_test.argmax(axis=
print("Classification Report:" , "\n", report)
```

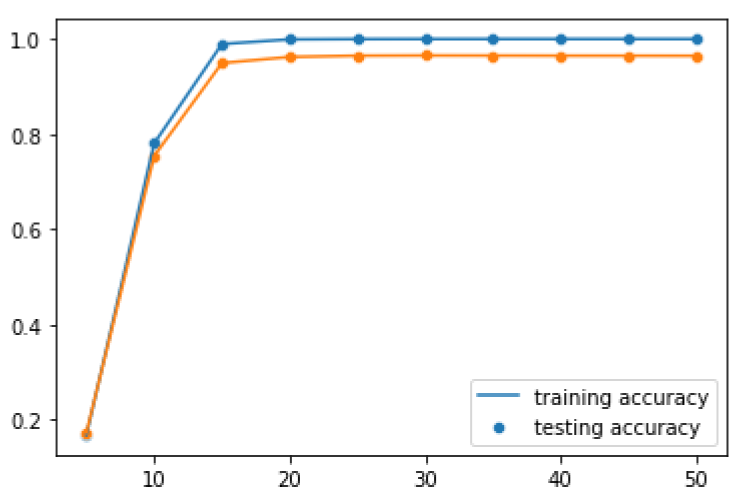
```
This is the best depth for Decision Tree Classifier:  36
Accuracy score is:  0.9651050080775444
Confusion Matrix:
 [[1702    0    7    0   21    0    0]
 [   0 1736    0    0   11    0    3]
 [   0    0 1689    0    0    0    0]
 [   0    0    0 1907    0    0    0]
 [  22   41  126    7 1284  176   27]
 [   0    0    2    0    0 1922    0]
 [   0    0    0    0    0    0 1697]]
Classification Report:
               precision    recall  f1-score   support

           0       0.99      0.98      0.99      1730
           1       0.98      0.99      0.98      1750
           2       0.93      1.00      0.96      1689
           3       1.00      1.00      1.00      1907
           4       0.98      0.76      0.86      1683
           5       0.92      1.00      0.96      1924
           6       0.98      1.00      0.99      1697

    accuracy                           0.96     12380
   macro avg       0.97      0.96      0.96     12380
weighted avg       0.97      0.96      0.96     12380
```

Random Forest

In [26]:
```
#random Forest
depth = range(5,51,5)
testing_accuracy = []
training_accuracy = []
score = 0

for i in depth:
    tree = RandomForestClassifier(max_depth = i, criterion = 'gini', random_state
    tree.fit(x_train, y_train)

    y_predict_train = tree.predict(x_train)
    training_accuracy.append(accuracy_score(y_train, y_predict_train))

    y_predict_test = tree.predict(x_test)
    acc_score = accuracy_score(y_test,y_predict_test)
    testing_accuracy.append(acc_score)

    print(i)

    if score < acc_score:
        score = acc_score
        best_depth = i

sns.lineplot(depth, training_accuracy)
sns.scatterplot(depth, training_accuracy)
sns.lineplot(depth, testing_accuracy)
sns.scatterplot(depth, testing_accuracy)
plt.legend(['training accuracy', 'testing accuracy'])
```

```
5
10
15
20
25
30
35
40
45
50
```

Out[26]: <matplotlib.legend.Legend at 0x14e31f2f880>



In [27]:
```
print('This is the best depth for Decision Tree Classifier: ', best_depth, '\nAcc
result = confusion_matrix(y_test.argmax(axis=1), y_predict_test.argmax(axis=1),)
print("Confusion Matrix:","\n", result)
report = classification_report(y_test.argmax(axis=1), y_predict_test.argmax(axis=
print("Classification Report:" , "\n", report)
```

```
This is the best depth for Decision Tree Classifier:  30
Accuracy score is:  0.9652665589660743
Confusion Matrix:
 [[1730    0    0    0    0    0    0]
 [   0 1750    0    0    0    0    0]
 [   0    0 1689    0    0    0    0]
 [   0    0    0 1907    0    0    0]
 [ 398    3   15    0 1245   22    0]
 [   0    0    0    0    0 1924    0]
 [   0    0    0    0    0    0 1697]]
Classification Report:
               precision    recall  f1-score   support

           0       0.81      1.00      0.90      1730
           1       1.00      1.00      1.00      1750
           2       0.99      1.00      1.00      1689
           3       1.00      1.00      1.00      1907
           4       1.00      0.74      0.85      1683
           5       0.99      1.00      0.99      1924
           6       1.00      1.00      1.00      1697

    accuracy                           0.96     12380
   macro avg       0.97      0.96      0.96     12380
weighted avg       0.97      0.96      0.96     12380
```

KNN

In [*]:
```
k = range(1,102,3)
testing_accuracy = []
training_accuracy = []
score = 0

for i in k:
    knn = KNeighborsClassifier(n_neighbors = i)
    knn.fit(x_train, y_train)

    y_predict_train = knn.predict(x_train)
    training_accuracy.append(accuracy_score(y_train, y_predict_train))

    y_predict_test = knn.predict(x_test)
    acc_score = accuracy_score(y_test,y_predict_test)
    testing_accuracy.append(acc_score)

    print(i)

    if score < acc_score:
        score = acc_score
        best_k = i


sns.lineplot(k, training_accuracy)
sns.scatterplot(k, training_accuracy)
sns.lineplot(k, testing_accuracy)
sns.scatterplot(k, testing_accuracy)
plt.legend(['training accuracy', 'testing accuracy'])
```

In [*]:
```
print('This is the best depth for Decision Tree Classifier: ', best_depth, '\nAcc
result = confusion_matrix(y_test.argmax(axis=1), y_predict_test.argmax(axis=1),)
print("Confusion Matrix:","\n", result)
report = classification_report(y_test.argmax(axis=1), y_predict_test.argmax(axis=
print("Classification Report:" , "\n", report)
```

In [*]:
```
x_train.shape
```

MLP

In [ ]:
```
# define the keras model
model = Sequential()

model.add(Dense(units= 64, kernel_initializer = 'uniform', activation = 'relu', i
model.add(Dense(units= 128, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dense(units= 64, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dense(units= 32, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dense(units = 7, kernel_initializer = 'uniform', activation = 'softmax'
model.summary()
```

In [ ]:
```
# compile the keras model
model.compile(optimizer = "Adam", loss = 'categorical_crossentropy', metrics = ['

# fit the keras model on the dataset
history = model.fit(x_train, y_train, batch_size = 20, epochs = 25)
```

In [ ]:
```
accuracy = model.evaluate(x_test, y_test, verbose=1)[1]
print("Test: accuracy = ",accuracy*100,"%")
```

CNN

In [ ]:
```
x_train = x_train.reshape(x_train.shape[0], 125,100,3)
x_test = x_test.reshape(x_test.shape[0], 125, 100, 3)
print(x_train.shape)
print(x_test.shape)
```

In [ ]:
```
input_shape = (125, 100, 3)
num_classes = 7

model = Sequential()
model.add(Conv2D(32, kernel_size=(3, 3),activation='relu',padding = 'Same',input_
model.add(Conv2D(32,kernel_size=(3, 3), activation='relu',padding = 'Same'))
model.add(MaxPooling2D(pool_size = (2, 2)))
model.add(Dropout(0.16))

model.add(Conv2D(64, (3, 3), activation='relu',padding = 'same'))
model.add(Conv2D(64, (3, 3), activation='relu',padding = 'Same'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.20))

model.add(Flatten())
model.add(Dense(256, activation='relu'))
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.3))
model.add(Dense(num_classes, activation='softmax'))
model.summary()
```

In [ ]:
```
model.compile(optimizer= "Adam",
            loss='categorical_crossentropy',
            metrics=['accuracy'])

learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy',
                                            patience=4,
                                            verbose=1,
                                            factor=0.5,
                                            min_lr=0.00001)
```

In [ ]:
```
#x_train, x_validate, y_train, y_validate = train_test_split(x_train, y_train, te


# Reshape image in 3 dimensions (height = 100, width = 125 , canal = 3)
x_train = x_train.reshape(x_train.shape[0], *(100, 125, 3))
x_test = x_test.reshape(x_test.shape[0], *(100, 125, 3))
#x_validate = x_validate.reshape(x_validate.shape[0], *(100, 125, 3))



model.fit(x_train, y_train, batch_size = 100, epochs = 20)
```

In [ ]:
```
test_loss, test_acc = model.evaluate(x_test, y_test)
print("Test Accuracy: ",test_acc*100,"%")
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]: