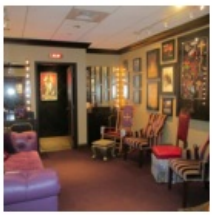
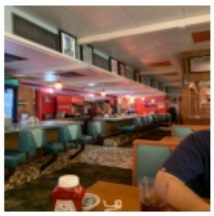
In [ ]:
```
import pandas as pd
import os
from PIL import Image, UnidentifiedImageError
import numpy as np
from concurrent.futures import ThreadPoolExecutor
json_file = 'C:/Users/user/Documents/yelp_photos/photos.json'
df = pd.read_json(json_file, lines=True, nrows=1000)
label_mapping = df[['photo_id', 'label']]
image_folder = 'C:/Users/user/Documents/yelp_photos/photos'
def process_image(row):
    photo_id = row['photo_id']
    label = row['label']
    image_path = os.path.join(image_folder, f"{photo_id}.jpg")
    if not os.path.exists(image_path):
        return None, None
    try:
        img = Image.open(image_path)
        img = img.resize((224, 224))
        img_array = np.array(img) / 255.0
        return img_array, label
    except UnidentifiedImageError:
        return None, None
    except Exception as e:
        print(f"Error loading image for photo_id: {photo_id}. Error: {e}")
        return None, None
images = []
preprocessed_labels = []
with ThreadPoolExecutor() as executor:
    results = list(executor.map(process_image, label_mapping.to_dict('records')))
#Using this to maintain the shape
for img_array, label in results:
    if img_array is not None and label is not None:
        images.append(img_array)
        preprocessed_labels.append(label)
final_df = pd.DataFrame({
    'photo_id': label_mapping['photo_id'].iloc[:len(images)].values,
    'label': preprocessed_labels,
    'image': images
})
print(final_df.head())
```

```
                photo_id    label  \
0  zsvj7vloL4L5jhYyPIuVwg   inside
1  HCUdRJHHm_e0OCTlZetGLg  outside
2  vkr8T0scuJmGVvN2HJelEA    drink
3  pve7D6NUrafHW3EAORubyw     food
4  H52Er-uBg6rNrHcReWTD2w     food

                                               image
0  [[[0.15294117647058825, 0.06666666666666667, 0...
1  [[[0.8313725490196079, 0.8980392156862745, 0.9...
2  [[[0.4980392156862745, 0.28627450980392155, 0....
3  [[[0.12941176470588237, 0.10588235294117647, 0...
4  [[[0.6274509803921569, 0.6627450980392157, 0.7...
```

In [ ]:
```
def plot_sample_images(label, num_images=5):
    sample_images = final_df[final_df['label'] == label]['image'].head(num_images)
    plt.figure(figsize=(10, 5))
    for i, img_array in enumerate(sample_images):
        plt.subplot(1, num_images, i+1)
        plt.imshow(img_array)
        plt.axis('off')
    plt.suptitle(f'Sample Images for Label: {label}')
    plt.show()
# Plot sample images for each label
for label in final_df['label'].unique():
    plot_sample_images(label)
```

Sample Images for Label: inside

Sample Images for Label: outside




Sample Images for Label: drink

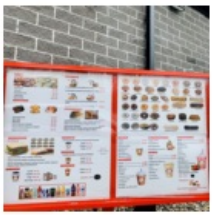



Sample Images for Label: food





Sample Images for Label: menu




Here we have imported and loaded the images from the dataset.

In [ ]:
```
missing_labels = final_df['label'].isnull().sum()
print(f'Missing Labels: {missing_labels}')
missing_images = final_df['image'].isnull().sum()
print(f'Missing Images: {missing_images}')
```

```
Missing Labels: 0
Missing Images: 0
```

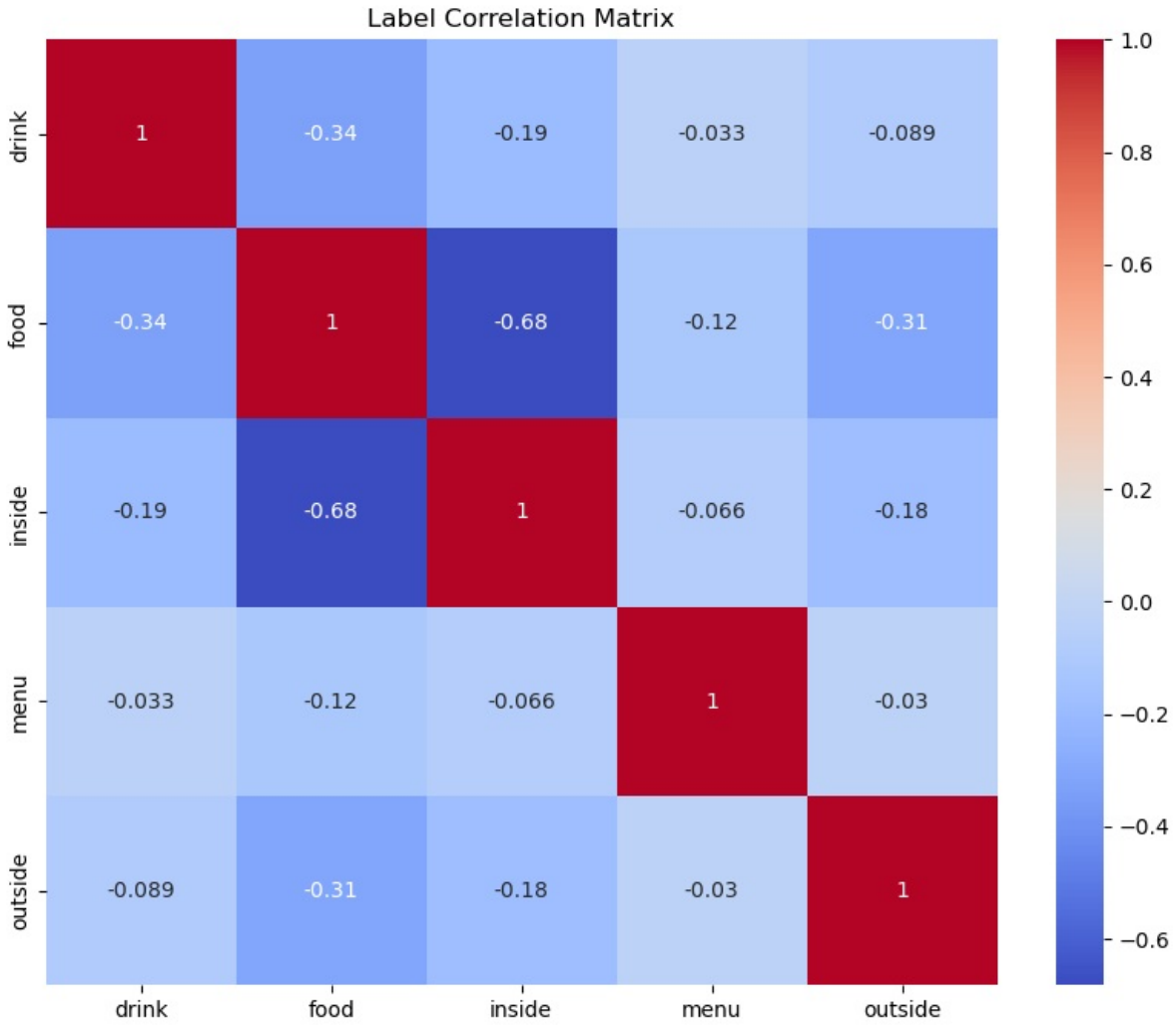
Check if there are any missing images and lables of the images missing.

In [ ]:
```
image_shapes = [img.shape for img in final_df['image']]
unique_shapes = set(image_shapes)
print(f"Unique image shapes: {unique_shapes}")

image_data = np.array([img.flatten() for img in final_df['image']])
mean_pixel_value = np.mean(image_data)
std_pixel_value = np.std(image_data)
print(f"Mean pixel value: {mean_pixel_value}")
print(f"Standard deviation of pixel values: {std_pixel_value}")
```

```
Unique image shapes: {(224, 224, 3)}
Mean pixel value: 0.4575029893988837
Standard deviation of pixel values: 0.30301191848536047
```

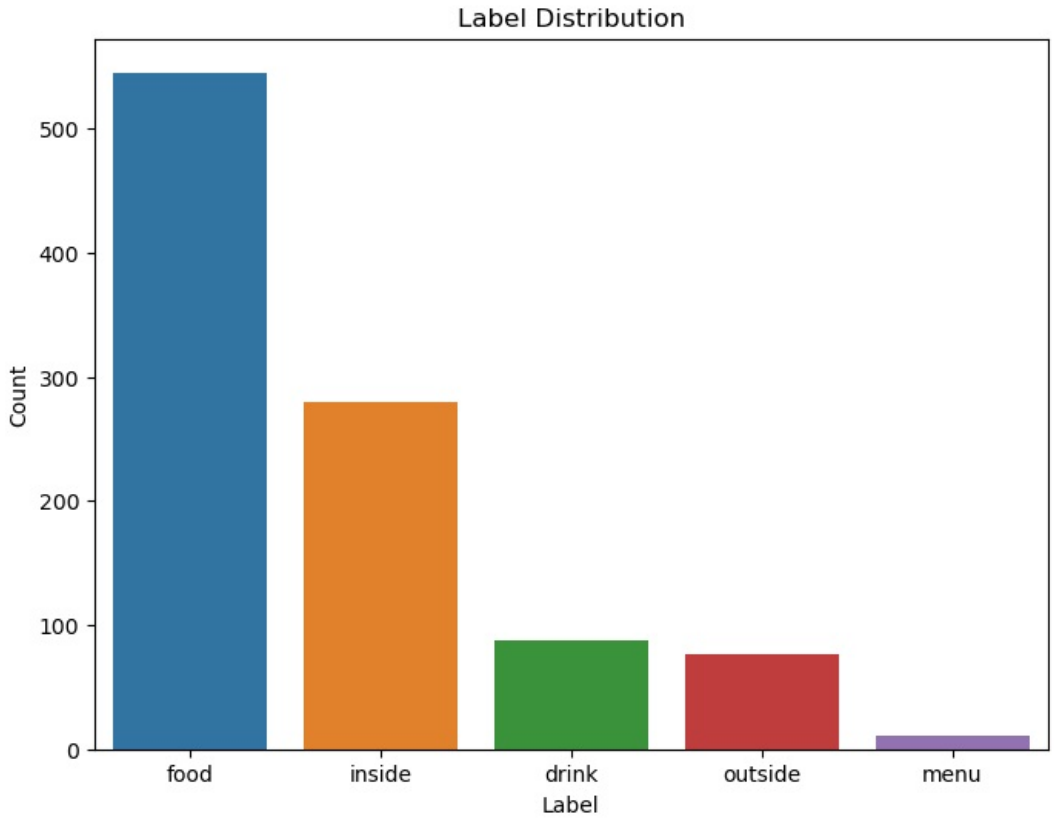
Checking the shape of the images and calculating the mean and the standard deviationof the pixel values.

In [ ]:
```
label_mapping_numerical = pd.get_dummies(final_df['label'])
corr_matrix = label_mapping_numerical.corr()
plt.figure(figsize=(10,8))
sns.heatmap(corr_matrix, annot=True, cmap='coolwarm')
plt.title('Label Correlation Matrix')
plt.show()
```



Plotted the corrrelationnmatrix to gather the info if the multiple image classes are correlated with eachother or not. from the above matrix we can see that features are negetively correlated with eachother saying there is no relation with eachother.

In [ ]:
```
label_distribution = final_df['label'].value_counts()
plt.figure(figsize=(8,6))
sns.barplot(x=label_distribution.index, y=label_distribution.values)
plt.title('Label Distribution')
plt.xlabel('Label')
plt.ylabel('Count')
plt.show()
```

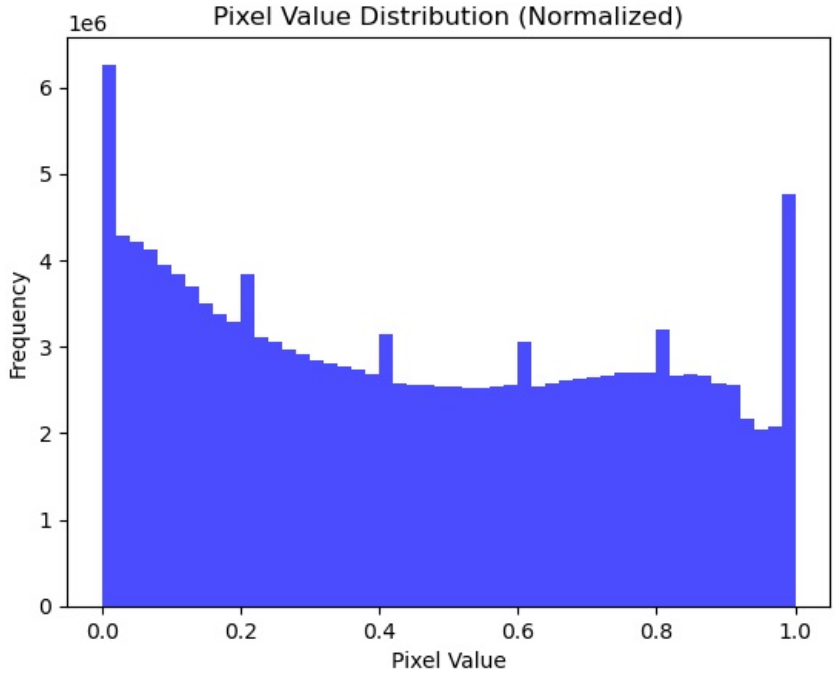


plotted the bar plot to understand the data in each class where the data for food is more compared to others.

In [ ]:
```
final_df['label'].value_counts()
```

Out[ ]:
```
food       545
inside     280
drink       88
outside     76
menu        11
Name: label, dtype: int64
```

In [ ]:
```
pixel_values = np.concatenate([img.flatten() for img in final_df['image']])
plt.hist(pixel_values, bins=50, color='blue', alpha=0.7)
plt.title('Pixel Value Distribution (Normalized)')
plt.xlabel('Pixel Value')
plt.ylabel('Frequency')
plt.show()
```



In [ ]:
```
final_df['image'].head(5)
```

Out[ ]:
```
0    [[[0.15294117647058825, 0.06666666666666667, 0...
1    [[[0.8313725490196079, 0.8980392156862745, 0.9...
2    [[[0.4980392156862745, 0.28627450980392155, 0....
3    [[[0.12941176470588237, 0.10588235294117647, 0...
4    [[[0.6274509803921569, 0.6627450980392157, 0.7...
Name: image, dtype: object
```

here we have flattened the pixel values of the image for the model training.

In [ ]:
```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import OneHotEncoder
from keras.models import Sequential
from keras.layers import Dense, Flatten, Dropout
from keras.callbacks import EarlyStopping
from sklearn.utils import class_weight
```

In [ ]:
```
X = np.array(images)
y = np.array(preprocessed_labels)
```

In [ ]:
```
encoder = OneHotEncoder(sparse_output=False)
y_encoded= encoder.fit_transform(y.reshape(-1, 1))
```

In [ ]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y_encoded, test_size=0.2, random_state=42)
```

considering 80% of the data for training and the 20% of the data for test.

In [ ]:
```
def create_dnn(input_shape):
    model = Sequential()
    model.add(Flatten(input_shape=input_shape))
    model.add(Dense(128, activation='relu'))
    model.add(Dropout(0.5))
    model.add(Dense(64, activation='relu'))
    model.add(Dropout(0.5))
    model.add(Dense(y_encoded.shape[1], activation='softmax'))
    model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
    return model
```

In [ ]:
```
dnn_model = create_dnn((224, 224, 3))
early_stopping = EarlyStopping(monitor='val_loss', patience=3)
dnn_history = dnn_model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=10, batch_size=32, callb
```

```
c:\Users\user\anaconda3\lib\site-packages\keras\src\layers\reshaping\flatten.py:37: UserWarning: Do not pass an
`input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` obj
ect as the first layer in the model instead.
  super().__init__(**kwargs)
Epoch 1/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 16s 383ms/step - accuracy: 0.3120 - loss: 37.3424 - val_accuracy: 0.2850 - val_loss:
1.5901
Epoch 2/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 207ms/step - accuracy: 0.2962 - loss: 1.6071 - val_accuracy: 0.5700 - val_loss: 1
.5507
Epoch 3/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 193ms/step - accuracy: 0.4972 - loss: 1.5412 - val_accuracy: 0.5700 - val_loss: 1
.5086
Epoch 4/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 197ms/step - accuracy: 0.5058 - loss: 1.9426 - val_accuracy: 0.5700 - val_loss: 1
.4710
Epoch 5/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 198ms/step - accuracy: 0.5320 - loss: 1.4754 - val_accuracy: 0.5700 - val_loss: 1
.4376
Epoch 6/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 194ms/step - accuracy: 0.5374 - loss: 1.4625 - val_accuracy: 0.5700 - val_loss: 1
.4071
Epoch 7/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 198ms/step - accuracy: 0.5453 - loss: 1.4158 - val_accuracy: 0.5700 - val_loss: 1
.3794
Epoch 8/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 205ms/step - accuracy: 0.5382 - loss: 1.3890 - val_accuracy: 0.5700 - val_loss: 1
.3543
Epoch 9/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 6s 227ms/step - accuracy: 0.5307 - loss: 1.3680 - val_accuracy: 0.5700 - val_loss: 1
.3308
Epoch 10/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 5s 197ms/step - accuracy: 0.5381 - loss: 1.3606 - val_accuracy: 0.5700 - val_loss: 1
.3091
```

As we can see as we increase the epochs the loss is decreased and the accuracy got up to 53% which is descent.

In [ ]:
```
from sklearn.metrics import roc_curve, auc
import matplotlib.pyplot as plt
dnn_predictions = dnn_model.predict(X_test)
dnn_fpr, dnn_tpr, _ = roc_curve(y_test.ravel(), dnn_predictions.ravel())
dnn_auc = auc(dnn_fpr, dnn_tpr)
```

```
  File "C:\Users\user\AppData\Local\Temp\ipykernel_3464\489144834.py", line 1
    k0mnfrom sklearn.metrics import roc_curve, auc
             ^
SyntaxError: invalid syntax
```

In [ ]:
```python
def create_cnn(input_shape):
    model = Sequential()
    model.add(Conv2D(32, (3, 3), activation='relu', input_shape=input_shape))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Conv2D(64, (3, 3), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Flatten())
    model.add(Dense(128, activation='relu'))
    model.add(Dropout(0.5))
    model.add(Dense(y_encoded.shape[1], activation='softmax'))  # Use softmax for multi-class
    model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
    return model
```

In [ ]:
```python
# Create and train the CNN
cnn_model = create_cnn((224, 224, 3))
cnn_history = cnn_model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=10, batch_size=32, callb
```

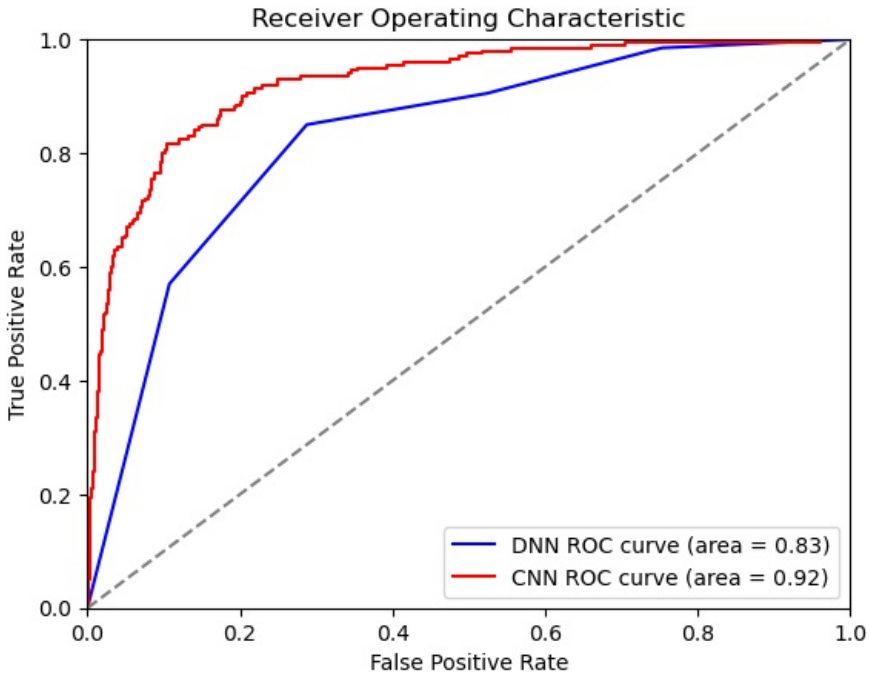
```
c:\Users\user\anaconda3\lib\site-packages\keras\src\layers\convolutional\base_conv.py:107: UserWarning: Do not
pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(sha
pe)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Epoch 1/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 27s 933ms/step - accuracy: 0.4011 - loss: 5.9475 - val_accuracy: 0.7000 - val_loss:
0.9589
Epoch 2/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 19s 758ms/step - accuracy: 0.6530 - loss: 0.9892 - val_accuracy: 0.7050 - val_loss:
0.8511
Epoch 3/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 20s 752ms/step - accuracy: 0.7315 - loss: 0.7884 - val_accuracy: 0.7200 - val_loss:
0.7773
Epoch 4/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 20s 774ms/step - accuracy: 0.8168 - loss: 0.5585 - val_accuracy: 0.7200 - val_loss:
0.8344
Epoch 5/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 19s 741ms/step - accuracy: 0.8688 - loss: 0.3958 - val_accuracy: 0.7300 - val_loss:
0.7822
Epoch 6/10
25/25 ━━━━━━━━━━━━━━━━━━━━ 19s 750ms/step - accuracy: 0.9205 - loss: 0.2751 - val_accuracy: 0.7000 - val_loss:
0.8401
```

As we know CNN is good for image data whivh we can already notice from the bove accuracy which is 92% got up from 40% in first wpoch and the loss has decreased significantly comoared to DNN.

In [ ]:
```python
cnn_predictions = cnn_model.predict(X_test)
cnn_fpr, cnn_tpr, _ = roc_curve(y_test.ravel(), cnn_predictions.ravel())
cnn_auc = auc(cnn_fpr, cnn_tpr)
```

```
7/7 ━━━━━━━━━━━━━━━━━━━━ 2s 219ms/step
```

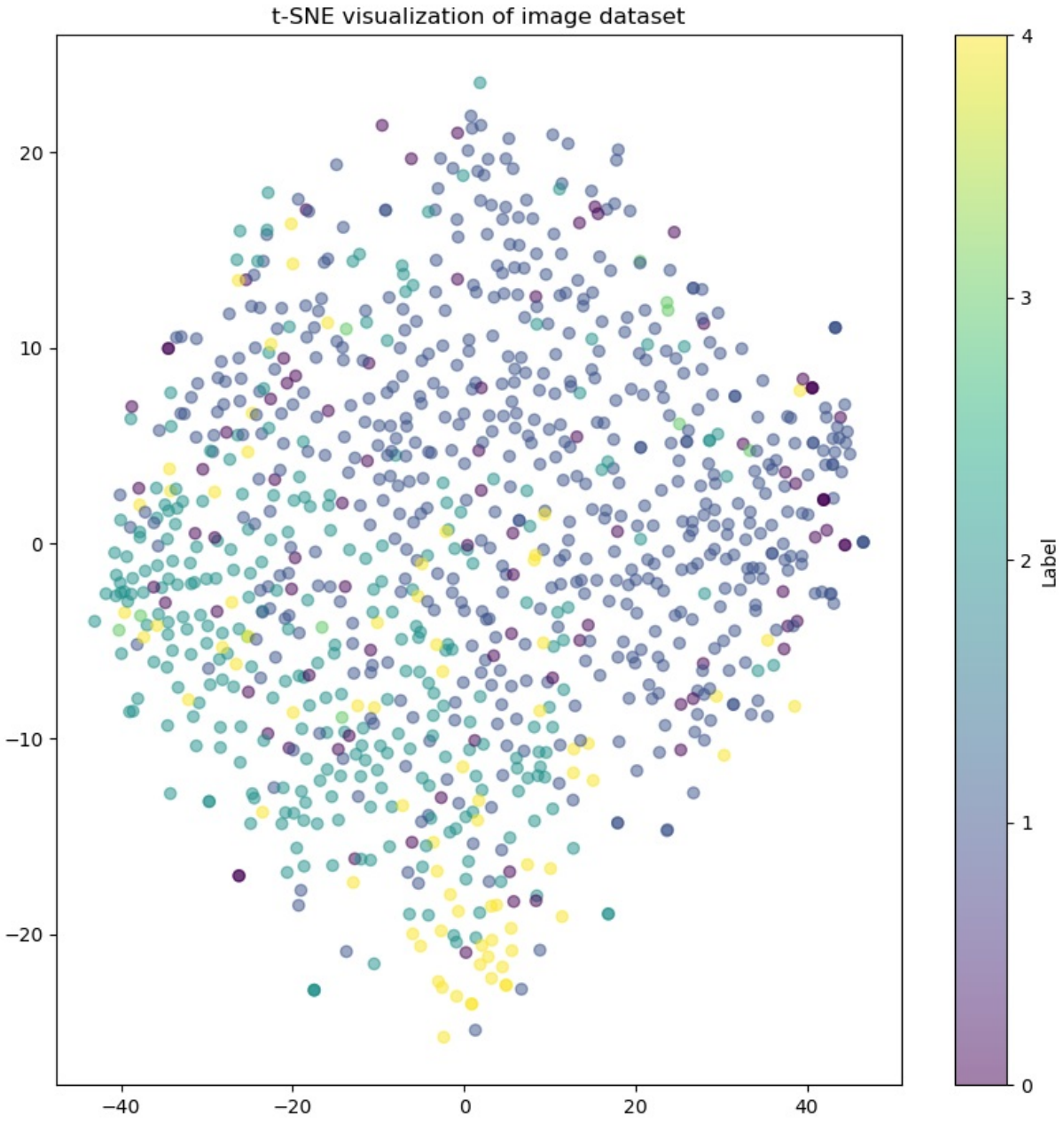
In [ ]:
```python
plt.figure()
plt.plot(dnn_fpr, dnn_tpr, color='blue', label='DNN ROC curve (area = {:.2f})'.format(dnn_auc))
plt.plot(cnn_fpr, cnn_tpr, color='red', label='CNN ROC curve (area = {:.2f})'.format(cnn_auc))
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.0])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc='lower right')
plt.show()
```



We can see form the ROC that CNN in red is predicting good compared to that of the DNN. CNN curve is close to top left corner close 1 i.e., 92 where as DNN is 83.

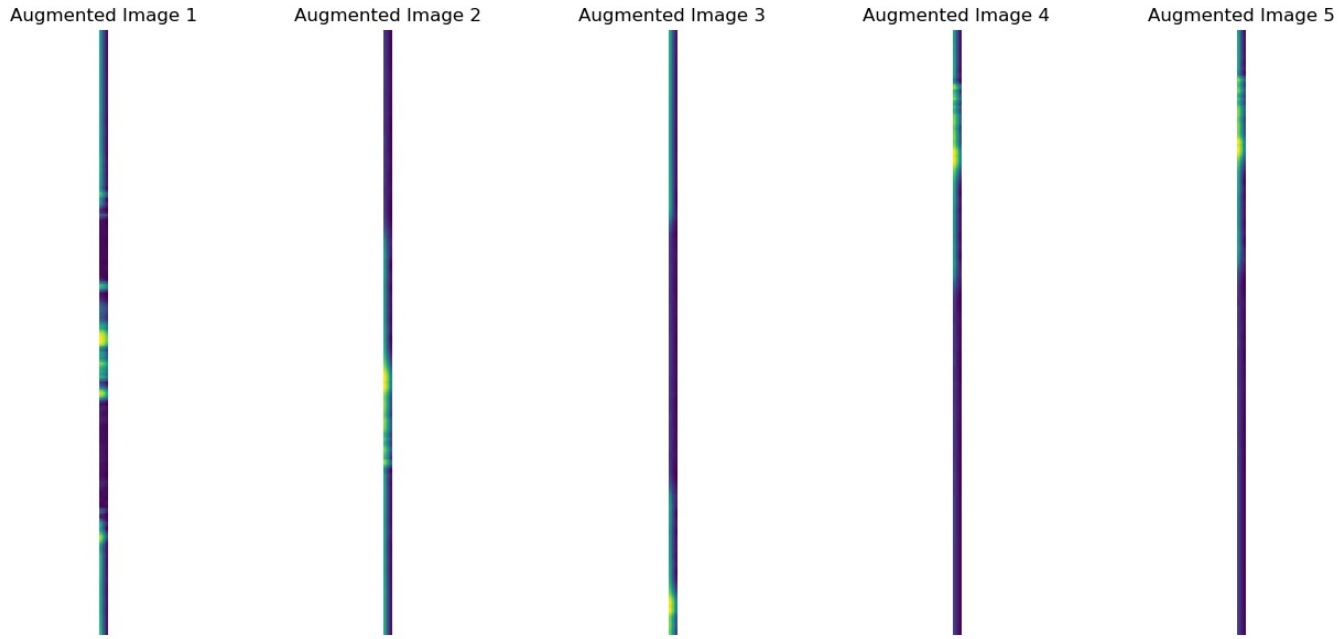
In [ ]:

```
from sklearn.decomposition import PCA
from sklearn.manifold import TSNE

images = np.array(final_df['image'].tolist())
flattened_images =images.reshape(images.shape[0], -1)

pca = PCA(n_components=50)
pca_result = pca.fit_transform(flattened_images)

tsne = TSNE(n_components=2, random_state=42)
tsne_result = tsne.fit_transform(pca_result)
plt.figure(figsize=(10, 10))
plt.scatter(tsne_result[:, 0], tsne_result[:, 1], c=final_df['label'].astype('category').cat.codes, cmap='viridi
plt.title('t-SNE visualization of image dataset')
plt.colorbar(ticks=range(len(final_df['label'].unique())), label='Label')
plt.show()
```



In [ ]:

```python
# Augmentation Analysis
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import matplotlib.pyplot as plt
datagen = ImageDataGenerator(
    rotation_range=20,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.2,
    zoom_range=0.2,
    horizontal_flip=True,
    fill_mode='nearest')
sample_image = np.expand_dims(images[0], axis=0)
augmented_images = datagen.flow(sample_image, batch_size=1)
plt.figure(figsize=(15, 6))
for i in range(5):
    plt.subplot(1, 5, i + 1)
    img = augmented_images[0][0][i]
    plt.imshow(img)
    plt.title(f'Augmented Image {i + 1}')
    plt.axis('off')
plt.tight_layout()
plt.show()
```



In [ ]:
```
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.optimizers import Adam
from sklearn.model_selection import RandomizedSearchCV
from sklearn.base import BaseEstimator

from tensorflow.keras.layers import Flatten
class KerasDNN(BaseEstimator):
    def __init__(self, learning_rate=0.01, neurons=32, epochs=2, batch_size=5):
        self.learning_rate = learning_rate
        self.neurons = neurons
        self.epochs = epochs
        self.batch_size = batch_size
        self.model = None
    def create_model(self):
        model = Sequential()
        model.add(Dense(self.neurons, input_shape=(224, 224, 3), activation='relu'))
        model.add(Flatten())
        model.add(Dense(self.neurons, activation='relu'))
        model.add(Dense(5, activation='softmax'))
        model.compile(optimizer=Adam(learning_rate=self.learning_rate),
                      loss='categorical_crossentropy',
                      metrics=['accuracy'])
        return model
    def fit(self, X, y):
        self.model = self.create_model()
        self.model.fit(X, y, epochs=self.epochs, batch_size=self.batch_size, verbose=0)
    def predict(self, X):
        return self.model.predict(X)
    def score(self, X, y):
        _, accuracy = self.model.evaluate(X, y, verbose=0)
        return accuracy
dnn_model = KerasDNN()
param_grid = {
    'learning_rate': [0.1, 0.01],
    'neurons': [16,32],
    'batch_size': [2,3],
    'epochs': [1,2]
}
random_search = RandomizedSearchCV(estimator=dnn_model, param_distributions=param_grid, n_iter=2, cv=2)
random_search_result = random_search.fit(X_train, y_train)
print("Best DNN Hyperparameters: ", random_search_result.best_params_)
```

```
c:\Users\user\anaconda3\lib\site-packages\keras\src\layers\core\dense.py:87: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Best DNN Hyperparameters:  {'neurons': 16, 'learning_rate': 0.1, 'epochs': 2, 'batch_size': 2}
```

In [ ]:
```
print("Best Accuracy: ", round(random_search_result.best_score_,2))
```

```
Best Accuracy:  0.54
```

After tuning the best accuracy for the DNN model is 54% which is expected.

In [ ]:
```
def create_cnn(learning_rate=0.001, filters=32, kernel_size=(3, 3)):
    model = Sequential()
    model.add(Conv2D(filters, kernel_size, activation='relu', input_shape=(224, 224, 3)))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Flatten())
```

```
    model.add(Dense(64, activation='relu'))
    model.add(Dense(5, activation='softmax'))
    model.compile(optimizer=Adam(learning_rate=learning_rate),
                  loss='categorical_crossentropy',
                  metrics=['accuracy'])
    return model
```

In [ ]:
```
from sklearn.base import BaseEstimator
class KerasCNN(BaseEstimator):
    def __init__(self, learning_rate=0.001, filters=32, kernel_size=(3, 3), epochs=1, batch_size=2):
        self.learning_rate = learning_rate
        self.filters = filters
        self.kernel_size = kernel_size
        self.epochs = epochs
        self.batch_size = batch_size
        self.model = None
    def create_model(self):
        return create_cnn(self.learning_rate, self.filters, self.kernel_size)
    def fit(self, X, y):
        self.model = self.create_model()
        self.model.fit(X, y, epochs=self.epochs, batch_size=self.batch_size, verbose=0)
    def predict(self, X):
        return self.model.predict(X)
    def score(self, X, y):
        _, accuracy = self.model.evaluate(X, y, verbose=0)
        return accuracy
```

We used keras base estimator for hyper parameter tuning, set the learning rate, epochs, batch size.

In [ ]:
```
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense
from tensorflow.keras.optimizers import Adam
```

In [ ]:
```
from sklearn.model_selection import RandomizedSearchCV
cnn_model = KerasCNN()
param_grid = {
    'learning_rate': [0.01, 0.001],
    'filters': [16, 32],
    'kernel_size': [(3, 3)],
    'epochs': [1],
    'batch_size': [2]
}
random_search = RandomizedSearchCV(estimator=cnn_model, param_distributions=param_grid, n_iter=2, cv=2)
random_search_result = random_search.fit(X_train, y_train)
print("Best CNN Hyperparameters: ", random_search_result.best_params_)
```

```
c:\Users\user\anaconda3\lib\site-packages\keras\src\layers\convolutional\base_conv.py:107: UserWarning: Do not
pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(sha
pe)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Best CNN Hyperparameters:  {'learning_rate': 0.001, 'kernel_size': (3, 3), 'filters': 16, 'epochs': 1, 'batch_s
ize': 2}
Best CNN Accuracy: 0.6075000166893005
```

In [ ]:
```
print("Best CNN Accuracy:",round(random_search_result.best_score_,2))
```

```
Best CNN Accuracy: 0.61
```

The Accuracy reduced to 60% as the epoch was only one and batch size 2,The accuracy can be increased if these two are increased.

Inferences:

1. **DNN**

- DNN performed descent on the image data where the best accuracy after tuning is 54% and ROC is aroung 84 which suggests that model is performing descent with image data on DNN.

1. **CNN**

- Considering the CNN model is performng good with accuracy aroung 90% where we trained the model for six epochs.
- loss is decreased significantly as the epochs are increased and accuracy is increased more.
- ROC came around 92 which is good and the cureve is more towards to left corner close to one whcih suggests that model prediction is good.

- Considering the above two models CNN performs well with the image data rather than DNN where the accuracy is very low. CNN accuracy is high.
- We also plotted augmented image to increase the size and diversity of the data leading to much improved robust model.
- Risk of overfitting is also reduced with Augmented image.
- We also used T-sne to understand the higher dimension data better and visualised it.