# Configuration Manual

MSc Research Project

MSc in Artificial Intelligence

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**MSc Project Submission Sheet**
**School of Computing**

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**Programme:** …Msc Artificial Intelligence **Year:** …2023 - 2024………

**Module:** ……………Practicum (H9PRAC)……………………………………………..………

**Supervisor:** …Mayank Jain…………………………………………………..………

**Submission Due Date:** …………11/08/2024……………………………………………………………..………

**Project Title:** Hybrid Bayesian CNN-GAN architecture for Deepfake detection

**Word Count:** 539 **Page Count**…………14……………………….……..

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# Configuration Manual

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Student ID: x22197001

## 1 System and library requirements

*1.1 Hardware configuration*

Following are the details of the system used for the experiment:

| Feature | Configurations |
|---|---|
| Operating System | MacOS Sonoma |
| System Memory | 288.33 GB |
| Processor | Apple M1 |
| Hard Drive | 8 GB |

*1.2 Software configuration*

The following libraries are necessary to run the code and compile the experiment with the right versions:

- Torch 2.3.1+cu121
- Pillow 10.2.0
- Numpy: 1.19.5
- Keras: 2.6.0
- Matplotlib: 3.2.2
- sklearn: 0.23.1
- Tensorflow: 2.5.0

*1.3 Data source*

The dataset was 'The Deepfake Detection Challenge' which was chosen from Kaggle and we have chosen the sample dataset from that which is 4.44 GB and only 400 videos with the following file contents:
train_sample_videos.zip - a ZIP file containing a sample set of training videos and a metadata.json with labels. the full set of training videos is available through the links provided above.
sample_submission.csv - a sample submission file in the correct format.
test_videos.zip - a zip file containing a small set of videos to be used as a public validation set.

# 2. Preprocessing

## 2.1 Set up

We have used Google Colab for the experiment and uploaded our data to Google drive and connected it through that:

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

Following are  the files in our data source:

```
import os

# the path to the folder containing videos
folder_path = '/content/drive/MyDrive/deepfake-detection-challenge'

# List all files in the folder
files = os.listdir(folder_path)

# Print the list of files
print(files)
```

```
['sample_submission.csv', '.DS_Store', 'test_videos', 'train_sample_videos']
```

Now we must import all the libraries needed:

```
import os
import glob
import json
import torch
import torch.nn as nn
import torch.optim as optim
import cv2
from PIL import Image
import numpy as np
import pandas as pd
import matplotlib
import seaborn as sns
import matplotlib.pyplot as plt
from tqdm import tqdm_notebook
%matplotlib inline
import dlib
import re
import tensorflow as tf
import seaborn as sn
from tensorflow.keras.preprocessing.image import ImageDataGenerator, img_to_array, load_img
from tensorflow.keras.utils import to_categorical
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix
from tensorflow.keras.models import load_model
from pylab import *
from PIL import Image, ImageChops, ImageEnhance
from tqdm.notebook import tqdm
from sklearn.model_selection import train_test_split
from tensorflow.keras.applications import InceptionResNetV2
from tensorflow.keras.layers import Conv2D
from tensorflow.keras.layers import MaxPooling2D
from tensorflow.keras.layers import Flatten
from tensorflow.keras.layers import Dense
```

```
from tensorflow.keras.layers import Dropout
from tensorflow.keras.layers import InputLayer
from tensorflow.keras.layers import GlobalAveragePooling2D
from tensorflow.keras.models import Sequential
from tensorflow.keras.models import Model
from tensorflow.keras import optimizers
from tensorflow.keras.callbacks import ReduceLROnPlateau, EarlyStopping
```

## 2.2 Face Detection and Frame Extraction

```
from facenet_pytorch import MTCNN, InceptionResnetV1, extract_face
```

After importing all the libraries, let us move forward to the following functions:

Let us now create a function to count train and test dataset features. The following code takes in 4 features from the data frame.

```python
def plot_count(feature, title, df, size=1):
    '''
    Plot count of classes / feature
    param: feature - the feature to analyze
    param: title - title to add to the graph
    param: df - dataframe from which we plot feature's classes
    distribution
    param: size - default 1.
    '''

    f, ax = plt.subplots(1,1, figsize=(4*size,4))
    total = float(len(df))
    g = sns.countplot(df[feature], order = df[feature].value_counts().index[:20], palette='Set3')
    g.set_title("Number and percentage of {}".format(title))
    if(size > 2):
        plt.xticks(rotation=90, size=8)
    for p in ax.patches:
        height = p.get_height()
        ax.text(p.get_x()+p.get_width()/2.,
                height + 3,
                '{:1.2f}%'.format(100*height/total),
                ha="center")
    plt.show()
```

After feature training, we will now implement Cv2 to capture frames in videos. The following function will take the file path and then read all the images.

```python
import cv2 # Import cv2 library

def display_image_from_video(video_path):
 '''
 input: video_path - path for video
 process:
 1. perform a video capture from the video
 2. read the image
 3. display the image
 '''
 capture_image = cv2.VideoCapture(video_path) # Use cv2.VideoCapture
 ret, frame = capture_image.read()
 fig = plt.figure(figsize=(10,10))
 ax = fig.add_subplot(111)
 frame = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB) # Use cv2.cvtColor
 ax.imshow(frame)
```

Function to extract and compare different images from videos:

```python
import os
import cv2
import matplotlib.pyplot as plt

def display_image_from_video_list(video_path_list, video_folder="/content/drive/MyDrive/deepfake-detection-challenge"):
    '''
    input:
    video_path_list - list of video filenames
    video_folder - path to the folder containing the videos

    process:
    0. for each video in the video path list
    1. perform a video capture from the video
    2. read the first frame (image) from the video
    3. display the image

    '''
    # Create a figure with a grid layout to display images
    fig, ax = plt.subplots(2, 3, figsize=(16, 8))

    # Iterate over the first 6 videos in the video_path_list
    for i, video_file in enumerate(video_path_list[:6]):
        video_path = os.path.join(video_folder, video_file)
        print(f"Loop: {i } : {video_file} {video_path}")

        # Open the video file
        capture_image = cv2.VideoCapture(video_path)

        # Check if video capture was successful
        if not capture_image.isOpened():
            print(f"Error: Could not open video file {video_path}")
            continue
```

```
        # Read the first frame
        ret, frame = capture_image.read()

        # Check if frame was read successfully
        if not ret:
            print(f"Error: Could not read frame from video {video_file}")
            continue

        # Convert frame from BGR to RGB (matplotlib expects RGB format)
        frame = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)

        # Display the image in the appropriate subplot
        ax[i // 3, i % 3].imshow(frame)
        ax[i // 3, i % 3].set_title(f"Video: {video_file}")
        ax[i // 3, i % 3].axis('off')  # Turn off axis labels for cleaner display

    plt.tight_layout()  # Adjust layout for better spacing
    plt.show()  # Show the plot with all images
```

Now we will code a function to detect face features from the image:

```
def detect_objects(image, scale_factor, min_neighbors,
min_size):
 '''
 Objects detection function
 Identify frontal face, eyes, smile and profile face and display
the detected objects over the image
 param: image - the image extracted from the video
 param: scale_factor - scale factor parameter for `detect`
function of ObjectDetector object
 param: min_neighbors - min neighbors parameter for `detect`
function of ObjectDetector object
 param: min_size - minimum size parameter for f`detect` function
of ObjectDetector object
 '''

 image_gray=cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
 eyes=ed.detect(image_gray,
               scale_factor=scale_factor,
               min_neighbors=min_neighbors,
               min_size=(int(min_size[0]/2), int(min_size[1]/2)))

 for x, y, w, h in eyes:
 #detected eyes shown in color image
      cv2.circle(image,(int(x+w/2),int(y+h/2)),(int((w + h)/4)),(0,
0,255),3)

 profiles=pd.detect(image_gray,
                   scale_factor=scale_factor,
                   min_neighbors=min_neighbors,
                   min_size=min_size)

 for x, y, w, h in profiles:
 #detected profiles shown in color image
           cv2.rectangle(image,(x,y),(x+w, y+h),(255, 0,0),3)

 faces=fd.detect(image_gray,
               scale_factor=scale_factor,
               min_neighbors=min_neighbors,
               min_size=min_size)
 for x, y, w, h in faces:
 #detected faces shown in color image
         cv2.rectangle(image,(x,y),(x+w, y+h),(0, 255,0),3)
 # image
 fig = plt.figure(figsize=(10,10))
 ax = fig.add_subplot(111)
 image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
 ax.imshow(image)
```

Function to play videos during initial exploration of the dataset:

```
import os
from IPython.display import HTML
from base64 import b64encode

def play_video(video_file, subset="/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos"):
    '''
    Display video
    param: video_file - the name of the video file to display
    param: subset - the folder where the video file is located
                (default is "/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos")
    '''
    video_path = os.path.join(subset, video_file)

    try:
        # Read the video file as binary data
        video_data = open(video_path, 'rb').read()

        # Encode the video data to base64
        video_base64 = b64encode(video_data).decode()

        # Construct the data URL for the video
        data_url = "data:video/mp4;base64," + video_base64

        # Display the video using HTML5 video tag
        return HTML("""<video width=500 controls><source src="%s" type="video/mp4"></video>""" % data_url)

    except FileNotFoundError:
        return HTML(f"<p>Video file '{video_file}' not found in folder '{subset}'.</p>")
    except Exception as e:
        return HTML(f"<p>Error: {e}</p>")
```

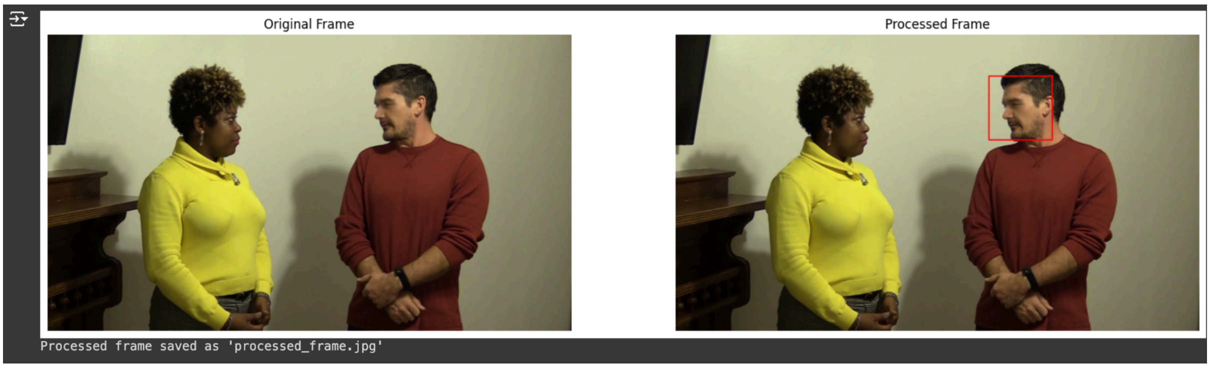
Now we will write 2 functions, the first one to extract the frames and the second to detect objects:

```
import os
import cv2
import matplotlib.pyplot as plt

# Load pre-trained models
eye_cascade_path = cv2.data.haarcascades + 'haarcascade_eye.xml'
profile_cascade_path = cv2.data.haarcascades + 'haarcascade_profileface.xml'
face_cascade_path = cv2.data.haarcascades + 'haarcascade_frontalface_default.xml'

ed = cv2.CascadeClassifier(eye_cascade_path)
pd = cv2.CascadeClassifier(profile_cascade_path)
fd = cv2.CascadeClassifier(face_cascade_path)

def extract_image_objects(video_file, video_set_folder="/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos"):
    '''
    Extract one image from the video and then perform
    face/eyes/smile/profile detection on the image.
    param: video_file - the video from which to extract the image.
    param: video_set_folder - the folder containing the video files.
    '''
    video_path = os.path.join(video_set_folder, video_file)
    capture_image = cv2.VideoCapture(video_path)
    ret, frame = capture_image.read()
    if not ret:
        print("Failed to read the video")
        return None, None

    frame = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)
    processed_frame = detect_objects(image=frame.copy(),
                                     scale_factor=1.3,
                                     min_neighbors=5,
                                     min_size=(50, 50))
```

```

    # Display the original and processed frames
    fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(20,10))
    ax1.imshow(frame)
    ax1.set_title('Original Frame')
    ax1.axis('off')
    ax2.imshow(processed_frame)
    ax2.set_title('Processed Frame')
    ax2.axis('off')
    plt.show()

    return frame, processed_frame

def detect_objects(image, scale_factor, min_neighbors, min_size):
    '''
    Objects detection function
    Identify frontal face, eyes, smile and profile face and display
    the detected objects over the image
    param: image - the image extracted from the video
    param: scale_factor - scale factor parameter for `detectMultiScale`
    function of ObjectDetector object
    param: min_neighbors - min neighbors parameter for `detectMultiScale`
    function of ObjectDetector object
    param: min_size - minimum size parameter for `detectMultiScale` function
    of ObjectDetector object
    '''

    image_gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
    eyes = ed.detectMultiScale(image_gray,
                               scaleFactor=scale_factor,
                               minNeighbors=min_neighbors,
                               minSize=(int(min_size[0] / 2), int(min_size[1] / 2)))

    for x, y, w, h in eyes:
```

```
                               scaleFactor=scale_factor,
                               minNeighbors=min_neighbors,
                               minSize=(int(min_size[0] / 2), int(min_size[1] / 2)))

    for x, y, w, h in eyes:
        cv2.circle(image, (int(x + w / 2), int(y + h / 2)), int((w + h) / 4), (0, 0, 255), 3)

    profiles = pd.detectMultiScale(image_gray,
                                   scaleFactor=scale_factor,
                                   minNeighbors=min_neighbors,
                                   minSize=min_size)
    for x, y, w, h in profiles:
        cv2.rectangle(image, (x, y), (x + w, y + h), (255, 0, 0), 3)

    faces = fd.detectMultiScale(image_gray,
                                scaleFactor=scale_factor,
                                minNeighbors=min_neighbors,
                                minSize=min_size)
    for x, y, w, h in faces:
        cv2.rectangle(image, (x, y), (x + w, y + h), (0, 255, 0), 3)

    return image

# Example usage
video_file = "aapnvogymq.mp4"
original_frame, processed_frame = extract_image_objects(video_file)

# Save the processed frame
if processed_frame is not None:
    cv2.imwrite('processed_frame.jpg', cv2.cvtColor(processed_frame, cv2.COLOR_RGB2BGR))
    print("Processed frame saved as 'processed_frame.jpg'")
else:
    print("Failed to process the frame")

```

The above-mentioned code also can display an example and we selected a file to see how it works and following was the output for our chosen image:




Further, we will generate a folder with all the captured frames from the videos and label and classify them:

```
import os
import json
import cv2
import dlib
from tqdm import tqdm
from PIL import Image



# Define the necessary paths and variables
train_frame_folder = '/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos'
metadata_path = os.path.join(train_frame_folder, 'metadata.json')

# Load metadata
with open(metadata_path, 'r') as file:
    data = json.load(file)

# List all video files in the training folder
list_of_train_data = [f for f in os.listdir(train_frame_folder) if f.endswith('.mp4')]
print(list_of_train_data)

# Initialize the face detector
detector = dlib.get_frontal_face_detector()

#Process each video file
for vid in tqdm(list_of_train_data):
    count = 0
    cap = cv2.VideoCapture(os.path.join(train_frame_folder, vid))
    frameRate = cap.get(cv2.CAP_PROP_FPS)

    while cap.isOpened():
        frameId = cap.get(cv2.CAP_PROP_POS_FRAMES)
        ret, frame = cap.read()
```

```

        if not ret:
            break

        if frameId % (frameRate + 1) == 0:
            face_rects, scores, idx = detector.run(frame, 0)
            for i, d in enumerate(face_rects):
                x1 = d.left()
                y1 = d.top()
                x2 = d.right()
                y2 = d.bottom()
                crop_img = frame[y1:y2, x1:x2]
              #  # Convert OpenCV BGR image to RGB
                rgb_img = cv2.cvtColor(crop_img, cv2.COLOR_BGR2RGB)

              #   # Convert to PIL Image
                pil_image = Image.fromarray(rgb_img)

                 # Display the image
                  #display(pil_image)
                print(f"label: {data[vid]['label']}")

                if data[vid]['label'] == 'REAL':
                    save_path = os.path.join('/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset', 'real', f"{vid.split('.'
                elif data[vid]['label'] == 'FAKE':
                    save_path = os.path.join('/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset', 'fake', f"{vid.split('.'

                print(f"save_path: {save_path}")
                pil_image.save(save_path)
                cv2.imwrite(save_path, cv2.resize(crop_img, (128, 128)))
                count += 1

    cap.release()

```

Following is the output for our above function and it basically lists all the frames we have have labels and sorts them in the right folder while saving the paths.

```
[ ]
    cap.release()

['aapnvogymq.mp4', 'aagfhgtpmv.mp4', 'acqfdwsrhi.mp4', 'abofeumbvv.mp4', 'abqwwspghj.mp4', 'acifjvzvpm.mp4', 'abarnvbtwb.mp4', 'acxnxvbsxk.mp4', 'adohikbdaz
  0%|          | 1/400 [00:08<58:34,  8.81s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/aagfhgtpmv_0.png
  0%|          | 2/400 [00:18<1:02:02,  9.35s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/acqfdwsrhi_0.png
  1%|          | 4/400 [00:34<54:55,  8.32s/it]  label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/abqwwspghj_0.png
  1%||         | 5/400 [00:46<1:03:07,  9.59s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/acifjvzvpm_0.png
  2%||         | 6/400 [00:56<1:03:02,  9.60s/it]label: REAL
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/real/abarnvbtwb_0.png
  2%||         | 7/400 [01:01<54:43,  8.35s/it]  label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/acxnxvbsxk_0.png
  2%||         | 8/400 [01:05<45:28,  6.96s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/adohikbdaz_0.png
  2%||         | 10/400 [01:15<37:55,  5.83s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/aczrgyricp_0.png
  3%||         | 11/400 [01:20<34:17,  5.29s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/acxwigylke_0.png
  3%||         | 12/400 [01:25<34:45,  5.37s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/adylbeequz_0.png
  3%||         | 13/400 [01:29<30:54,  4.79s/it]label: REAL
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/real/aelfnikyqj_0.png
  4%||         | 14/400 [01:33<29:55,  4.65s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/aelzhcnwgf_0.png
  4%||         | 15/400 [01:38<31:21,  4.89s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/aevrfsexku_0.png
  4%||         | 16/400 [01:42<29:31,  4.61s/it]label: REAL
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/real/afoovlsmtx_0.png
  4%||         | 17/400 [01:46<27:23,  4.29s/it]label: FAKE
save_path: /content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset/fake/aettqgevhz_0.png
  4%||         | 18/400 [01:50<27:03,  4.25s/it]label: FAKE
```

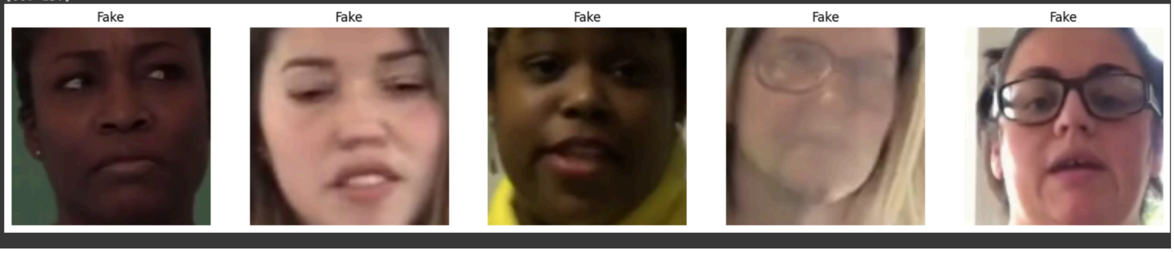
We now move on to flattening the images and splitting them between training data and test data

```python
import numpy as np
import os
from tensorflow.keras.preprocessing.image import img_to_array, load_img
from tensorflow.keras.utils import to_categorical
from sklearn.model_selection import train_test_split

input_shape = (128, 128, 3)
data_dir = '/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos/dataset'
real_data = [f for f in os.listdir(data_dir+'/real') if f.endswith('.png')]
fake_data = [f for f in os.listdir(data_dir+'/fake') if f.endswith('.png')]
X = []
Y = []
for img in real_data:
    X.append(img_to_array(load_img(data_dir+'/real/'+img)).flatten()/ 255.0)
    Y.append(1)
for img in fake_data:
    X.append(img_to_array(load_img(data_dir+'/fake/'+img)).flatten()/ 255.0)
    Y.append(0)
Y_val_org = Y
#Normalization
X = np.array(X)
Y = to_categorical(Y, 2)
#Reshape
X = X.reshape(-1, 128, 128, 3)
#Train-Test split
X_train, X_val, Y_train, Y_val = train_test_split(X, Y, test_size=0.2, random_state=5)

# Print some information about the data
print("Total number of images:", len(X))
print("Number of real images:", len(real_data))
print("Number of fake images:", len(fake_data))
print("X shape:", X.shape)
print("Y shape:", Y.shape)
```

```python
#Train-Test split
X_train, X_val, Y_train, Y_val = train_test_split(X, Y, test_size=0.2, random_state=5)

# Print some information about the data
print("Total number of images:", len(X))
print("Number of real images:", len(real_data))
print("Number of fake images:", len(fake_data))
print("X shape:", X.shape)
print("Y shape:", Y.shape)
print("X_train shape:", X_train.shape)
print("X_val shape:", X_val.shape)
print("Y_train shape:", Y_train.shape)
print("Y_val shape:", Y_val.shape)

# Check class distribution
print("Training set distribution:")
print(np.sum(Y_train, axis=0))
print("Validation set distribution:")
print(np.sum(Y_val, axis=0))

# Visualize some images
import matplotlib.pyplot as plt

def plot_images(X, Y, n=5):
    plt.figure(figsize=(20, 4))
    for i in range(n):
        ax = plt.subplot(1, n, i + 1)
        plt.imshow(X[i])
        plt.title("Real" if Y[i][1] == 1 else "Fake")
        plt.axis('off')
    plt.show()

plot_images(X_train, Y_train)
```

Thus we received the following output with all the descriptions:

```
Total number of images: 375
Number of real images: 75
Number of fake images: 300
X shape: (375, 128, 128, 3)
Y shape: (375, 2)
X_train shape: (300, 128, 128, 3)
X_val shape: (75, 128, 128, 3)
Y_train shape: (300, 2)
Y_val shape: (75, 2)
Training set distribution:
[240.  60.]
Validation set distribution:
[60. 15.]
```




# 3. Implementation

## 3.1 Xception model

```
image_size = (224, 224)

datagen = ImageDataGenerator(rescale=1.0/255.0, validation_split=0.2)

train_generator = datagen.flow_from_directory(
    data_dir,
    target_size=image_size,
    batch_size=batch_size,
    class_mode='binary',
    subset='training'
)

validation_generator = datagen.flow_from_directory(
    data_dir,
    target_size=image_size,
    batch_size=batch_size,
    class_mode='binary',
    subset='validation'
)

# Evaluate the model on the validation set
evaluation = model.evaluate(validation_generator)
print(f"Validation Loss: {evaluation[0]}")
print(f"Validation Accuracy: {evaluation[1]}")
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/xception/xception_weights_tf_dim_ordering_tf_kernels_notop.h5
83683744/83683744 ━━━━━━━━━━━━━━━━━━━━ 3s 0us/step
Found 300 images belonging to 1 classes.
Found 75 images belonging to 1 classes.
/usr/local/lib/python3.10/dist-packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:121: UserWarning: Your `PyDataset` class should call `super()
  self._warn_if_super_not_called()
3/3 ━━━━━━━━━━━━━━━━━━━━ 18s 4s/step - accuracy: 0.9828 - loss: 0.5585
Validation Loss: 0.559919536113739
Validation Accuracy: 0.9733333587646484
```

Model 1: XceptionNet

```
import tensorflow as tf
from tensorflow.keras.applications import Xception
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import layers, models
import numpy as np
import os
import pandas as pd

# Load the pretrained Xception model
base_model = Xception(weights='imagenet', include_top=False, input_shape=(224, 224, 3))


x = base_model.output
x = layers.GlobalAveragePooling2D()(x)
x = layers.Dense(1024, activation='relu')(x)
predictions = layers.Dense(1, activation='sigmoid')(x)
model = models.Model(inputs=base_model.input, outputs=predictions)

# Compile the model
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])

# Load the DFDC dataset
data_dir = '/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos'
batch_size = 32
image_size = (224, 224)

datagen = ImageDataGenerator(rescale=1.0/255.0, validation_split=0.2)

train_generator = datagen.flow_from_directory(
    data_dir,
```

3.2 EfficientNet

Model 2: EfficientNet

```python
import tensorflow as tf
from tensorflow.keras.applications import EfficientNetB0
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import layers, models
import os

# Load the pretrained EfficientNet model
base_model = EfficientNetB0(weights='imagenet', include_top=False, input_shape=(224, 224, 3))

# layers on top of the base model
x = base_model.output
x = layers.GlobalAveragePooling2D()(x)
x = layers.Dense(1024, activation='relu')(x)
predictions = layers.Dense(1, activation='sigmoid')(x)
model = models.Model(inputs=base_model.input, outputs=predictions)

# Compile the model
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])

# Load the DFDC dataset
data_dir = '/content/drive/MyDrive/deepfake-detection-challenge/train_sample_videos'
batch_size = 32
image_size = (224, 224)

datagen = ImageDataGenerator(rescale=1.0/255.0, validation_split=0.2)

train_generator = datagen.flow_from_directory(
    data_dir,
    target_size=image_size,
    batch_size=batch_size,
```

```python
    batch_size=batch_size,
    class_mode='binary',
    subset='training'
)

validation_generator = datagen.flow_from_directory(
    data_dir,
    target_size=image_size,
    batch_size=batch_size,
    class_mode='binary',
    subset='validation'
)

# Train the model
model.fit(train_generator, validation_data=validation_generator, epochs=5)

# Evaluate the model on the validation set
evaluation = model.evaluate(validation_generator)
print(f"Validation Loss: {evaluation[0]}")
print(f"Validation Accuracy: {evaluation[1]}")

```

```
Downloading data from https://storage.googleapis.com/keras-applications/efficientnetb0_notop.h5
16705208/16705208 ━━━━━━━━━━━━━━━━━━━━ 1s 0us/step
Found 300 images belonging to 1 classes.
Found 75 images belonging to 1 classes.
Epoch 1/5
10/10 ━━━━━━━━━━━━━━━━━━━━ 137s 9s/step - accuracy: 0.7293 - loss: 0.2866 - val_accuracy: 1.0000 - val_loss: 0.0010
Epoch 2/5
10/10 ━━━━━━━━━━━━━━━━━━━━ 88s 9s/step - accuracy: 1.0000 - loss: 1.3800e-04 - val_accuracy: 1.0000 - val_loss: 0.0016
Epoch 3/5
10/10 ━━━━━━━━━━━━━━━━━━━━ 135s 8s/step - accuracy: 1.0000 - loss: 1.0217e-05 - val_accuracy: 1.0000 - val_loss: 0.0022
Epoch 4/5
10/10 ━━━━━━━━━━━━━━━━━━━━ 80s 8s/step - accuracy: 1.0000 - loss: 3.5184e-06 - val_accuracy: 1.0000 - val_loss: 0.0022
Epoch 5/5
```

Validation Loss: 0.001265091821551323
Validation Accuracy: 1.0

3.3 Proposed model: Bayesian CNN-GAN model

Following is the code for our model:

Proposed model: Bayesian CNN-GAN model

```
[ ]
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import tensorflow_probability as tfp
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout
from tensorflow.keras.regularizers import l2

# Define the Bayesian CNN model
def create_bayesian_cnn():
    model = Sequential([
        Conv2D(32, kernel_size=3, activation='relu', input_shape=(128, 128, 3), kernel_regularizer=l2(0.01)),
        Conv2D(64, kernel_size=3, activation='relu', kernel_regularizer=l2(0.01)),
        MaxPooling2D(pool_size=(2, 2)),
        Dropout(0.25),
        Flatten(),
        Dense(128, activation='relu', kernel_regularizer=l2(0.01)),
        Dropout(0.5),
        Dense(2, activation='softmax', kernel_regularizer=l2(0.01))  # Changed to 2 output neurons
    ])
    return model

# Define the Generator
def create_generator():
    model = keras.Sequential([
        layers.Dense(16*16*256, input_shape=(100,), use_bias=False),
        layers.BatchNormalization(),
        layers.LeakyReLU(alpha=0.2),

        layers.Reshape((16, 16, 256)),
```

```
[ ]
        layers.Reshape((16, 16, 256)),

        layers.Conv2DTranspose(128, kernel_size=4, strides=2, padding='same', use_bias=False),
        layers.BatchNormalization(),
        layers.LeakyReLU(alpha=0.2),

        layers.Conv2DTranspose(64, kernel_size=4, strides=2, padding='same', use_bias=False),
        layers.BatchNormalization(),
        layers.LeakyReLU(alpha=0.2),

        layers.Conv2DTranspose(3, kernel_size=4, strides=2, padding='same', use_bias=False, activation='tanh')
    ])
    return model

# Define the Discriminator
def create_discriminator():
    model = keras.Sequential([
        layers.Conv2D(64, kernel_size=4, strides=2, padding='same', input_shape=(128, 128, 3)),
        layers.LeakyReLU(alpha=0.2),

        layers.Conv2D(128, kernel_size=4, strides=2, padding='same'),
        layers.LeakyReLU(alpha=0.2),

        layers.Conv2D(256, kernel_size=4, strides=2, padding='same'),
        layers.LeakyReLU(alpha=0.2),

        layers.Flatten(),
        layers.Dense(1, activation='sigmoid')
    ])
    return model

# Define the GAN
class GAN(keras.Model):
    def __init__(self, generator, discriminator):
```

```
[ ]
# Define the GAN
class GAN(keras.Model):
    def __init__(self, generator, discriminator):
        super(GAN, self).__init__()
        self.generator = generator
        self.discriminator = discriminator

    def compile(self, g_optimizer, d_optimizer, loss_fn):
        super(GAN, self).compile()
        self.g_optimizer = g_optimizer
        self.d_optimizer = d_optimizer
        self.loss_fn = loss_fn

    def train_step(self, real_images):
        batch_size = tf.shape(real_images)[0]
        noise = tf.random.normal(shape=(batch_size, 100))

        with tf.GradientTape() as gen_tape, tf.GradientTape() as disc_tape:
            generated_images = self.generator(noise, training=True)

            real_output = self.discriminator(real_images, training=True)
            fake_output = self.discriminator(generated_images, training=True)

            gen_loss = self.loss_fn(tf.ones_like(fake_output), fake_output)
            real_loss = self.loss_fn(tf.ones_like(real_output), real_output)
            fake_loss = self.loss_fn(tf.zeros_like(fake_output), fake_output)
            disc_loss = real_loss + fake_loss

        gradients_of_generator = gen_tape.gradient(gen_loss, self.generator.trainable_variables)
        gradients_of_discriminator = disc_tape.gradient(disc_loss, self.discriminator.trainable_variables)

        self.g_optimizer.apply_gradients(zip(gradients_of_generator, self.generator.trainable_variables))
        self.d_optimizer.apply_gradients(zip(gradients_of_discriminator, self.discriminator.trainable_variables))
```

```
        self.g_optimizer.apply_gradients(zip(gradients_of_generator, self.generator.trainable_variables))
        self.d_optimizer.apply_gradients(zip(gradients_of_discriminator, self.discriminator.trainable_variables))

        return {"d_loss": disc_loss, "g_loss": gen_loss}


# Create and compile the models
bayesian_cnn = create_bayesian_cnn()
generator = create_generator()
discriminator = create_discriminator()
gan = GAN(generator, discriminator)

bayesian_cnn.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy'])
gan.compile(
    g_optimizer=keras.optimizers.Adam(),
    d_optimizer=keras.optimizers.Adam(),
    loss_fn=keras.losses.BinaryCrossentropy()
)

# Train the Bayesian CNN
bayesian_cnn.fit(X_train, Y_train, validation_data=(X_val, Y_val), epochs=10, batch_size=32)

# Train the GAN
gan.fit(X_train, epochs=10, batch_size=32)

# Final evaluation
test_loss, test_accuracy = bayesian_cnn.evaluate(X_val, Y_val)
print(f"Test accuracy: {test_accuracy}")

# Generate some fake images
noise = tf.random.normal([16, 100])
generated_images = generator(noise, training=False)

```

```
bayesian_cnn.fit(X_train, Y_train, validation_data=(X_val, Y_val), epochs=10, batch_size=32)

# Train the GAN
gan.fit(X_train, epochs=10, batch_size=32)

# Final evaluation
test_loss, test_accuracy = bayesian_cnn.evaluate(X_val, Y_val)
print(f"Test accuracy: {test_accuracy}")

# Generate some fake images
noise = tf.random.normal([16, 100])
generated_images = generator(noise, training=False)

# Plot the generated images
import matplotlib.pyplot as plt

fig = plt.figure(figsize=(4, 4))
for i in range(generated_images.shape[0]):
    plt.subplot(4, 4, i+1)
    plt.imshow((generated_images[i, :, :, :] * 0.5 + 0.5))  # Rescale from [-1, 1] to [0, 1]
    plt.axis('off')
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/activations/leaky_relu.py:41: UserWarning: Argument `alpha` is deprecated. Use `negative_slope` ins
  warnings.warn(
Epoch 1/10
10/10 ━━━━━━━━━━━━━━━━━━━━ 37s 3s/step - accuracy: 0.6135 - loss: 8.3530 - val_accuracy: 0.8000 - val_loss: 3.0983
Epoch 2/10
10/10 ━━━━━━━━━━━━━━━━━━━━ 31s 3s/step - accuracy: 0.7932 - loss: 3.0757 - val_accuracy: 0.8000 - val_loss: 2.7152
Epoch 3/10
10/10 ━━━━━━━━━━━━━━━━━━━━ 42s 3s/step - accuracy: 0.7858 - loss: 2.6010 - val_accuracy: 0.8000 - val_loss: 2.1953
Epoch 4/10
10/10 ━━━━━━━━━━━━━━━━━━━━ 41s 3s/step - accuracy: 0.7980 - loss: 2.0854 - val_accuracy: 0.8000 - val_loss: 1.7556
Epoch 5/10
10/10 ━━━━━━━━━━━━━━━━━━━━ 40s 3s/step - accuracy: 0.8059 - loss: 1.6223 - val_accuracy: 0.8000 - val_loss: 1.4187
```

# 4. Evaluation

For evaluation of our proposed model, we have performed a confusion matrix using the following code:

```python
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, classification_report
import seaborn as sns

def plot_confusion_matrix(y_true, y_pred, classes):
    # Compute confusion matrix
    cm = confusion_matrix(y_true, y_pred)

    # Normalize the confusion matrix
    cm_normalized = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]

    # Create a figure and axes
    fig, ax = plt.subplots(figsize=(10, 8))

    # Plot the heatmap
    sns.heatmap(cm_normalized, annot=True, cmap='Blues', fmt='.2f', xticklabels=classes, yticklabels=classes)

    # Set labels and title
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.title('Normalized Confusion Matrix')

    # Display the plot
    plt.show()

    # Print classification report
    print("\nClassification Report:")
    print(classification_report(y_true, y_pred, target_names=classes))

# Generate a more realistic example dataset
np.random.seed(42)  # for reproducibility

```

```python

# Total samples
n_real = 75
n_fake = 300
total_samples = n_real + n_fake

# Create true labels
y_true = np.concatenate([np.zeros(n_real), np.ones(n_fake)])

# Generate predictions with 80% accuracy
accuracy = 0.80
n_correct = int(total_samples * accuracy)
n_incorrect = total_samples - n_correct

# Create initial prediction array
y_pred = np.copy(y_true)

# Randomly flip some predictions to achieve 80% accuracy
flip_indices = np.random.choice(total_samples, n_incorrect, replace=False)
y_pred[flip_indices] = 1 - y_pred[flip_indices]

# Shuffle the arrays
p = np.random.permutation(total_samples)
y_true, y_pred = y_true[p], y_pred[p]

# Class names
classes = ['Real', 'Fake']

# Call the function
plot_confusion_matrix(y_true, y_pred, classes)

# Print overall accuracy
print(f"\nOverall Accuracy: {accuracy:.2%}")
```

# References


[1] Huilgol, P. (2020). Top 4 Pre-Trained Models for Image Classification | With Python Code. [online] Analytics Vidhya. Available at: https://www.analyticsvidhya.com/blog/2020/08/top-4-pre-trained-models-for-image-classification-with-python-code/.