Final Report: Facial Recognition for Age and Gender estimation

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1. Introduction

Facial recognition for age and gender estimation is an essential task in various applications such as biometrics, personalized marketing, and demographic analysis. This project compares two different approaches:

1. **Combined Model**: A single Convolutional Neural Network (CNN) with dual outputs for gender classification and age estimation.
2. **Separate Models**: Independent CNNs optimized specifically for each task.

The goal is to evaluate the trade-offs between computational efficiency and task-specific accuracy.

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2. Dataset

Source: UTKFace dataset.

Details:

- Includes labeled images with attributes for age and gender.
- Diversity in ethnicity, lighting, and age ranges.

Preprocessing:

- Resized all images to 128×128 \model-2: 200x200.
- Normalized pixel values to the range [0, 1].
- Applied data augmentation (e.g., flips, shifts) to enhance robustness.

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3. Methodology

Model 1: Combined Model

A single CNN handles both tasks simultaneously, sharing feature extraction layers. Outputs:

- Gender: Binary classification using sigmoid activation.
- Age: Regression using ReLU activation.

```
inputs = Input((input_shape))
conv_1 = Conv2D(32, kernel_size=(3, 3), activation='relu')(inputs)
max_1 = MaxPooling2D(pool_size=(2, 2))(conv_1)
conv_2 = Conv2D(64, kernel_size=(3, 3), activation='relu')(max_1)
max_2 = MaxPooling2D(pool_size=(2, 2))(conv_2)
conv_3 = Conv2D(128, kernel_size=(3, 3), activation='relu')(max_2)
max_3 = MaxPooling2D(pool_size=(2, 2))(conv_3)
conv_4 = Conv2D(256, kernel_size=(3, 3), activation='relu')(max_3)
max_4 = MaxPooling2D(pool_size=(2, 2))(conv_4)

flatten = Flatten()(max_4)

# fully connected layers
dense_1 = Dense(256, activation='relu')(flatten)
dense_2 = Dense(256, activation='relu')(flatten)

dropout_1 = Dropout(0.3)(dense_1)
dropout_2 = Dropout(0.3)(dense_2)

output_1 = Dense(1, activation='sigmoid', name='gender_out')(dropout_1)
output_2 = Dense(1, activation='relu', name='age_out')(dropout_2)

model = Model(inputs=[inputs], outputs=[output_1, output_2])

model.compile(loss=['binary_crossentropy', 'mae'],
              optimizer='adam', metrics=[['accuracy'], ['mae']])
```

Model 2: Separate Models

Two independent CNNs were built, each optimized for one task:

- **Age Estimation Model**: Outputs continuous age values.
- **Gender Classification Model**: Outputs binary gender values.

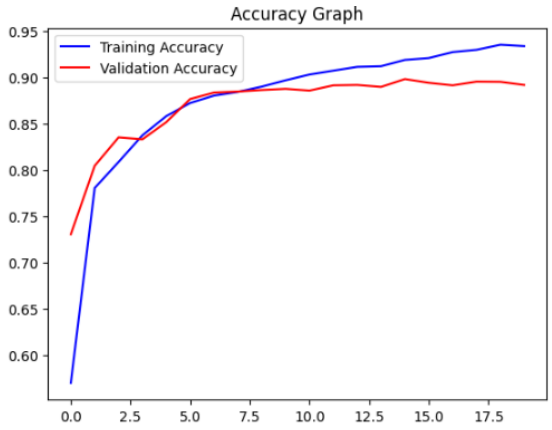
```
agemodel = Sequential()
agemodel.add(Conv2D(32, (3,3), activation='relu', input_shape=(200, 200, 3)))
agemodel.add(MaxPooling2D((2,2)))
agemodel.add(Conv2D(64, (3,3), activation='relu'))
agemodel.add(MaxPooling2D((2,2)))
agemodel.add(Conv2D(128, (3,3), activation='relu'))
agemodel.add(MaxPooling2D((2,2)))
agemodel.add(Flatten())
agemodel.add(Dense(64, activation='relu'))
agemodel.add(Dropout(0.5))
agemodel.add(Dense(1, activation='relu'))

agemodel.compile(loss='mean_squared_error',
            optimizer=optimizers.Adam(learning_rate=0.0001))

genmodel = Sequential()
genmodel.add(Conv2D(32, (3,3), activation='relu', input_shape=(200, 200, 3)))
genmodel.add(MaxPooling2D((2,2)))
genmodel.add(Conv2D(64, (3,3), activation='relu'))
genmodel.add(MaxPooling2D((2,2)))
genmodel.add(Conv2D(128, (3,3), activation='relu'))
genmodel.add(MaxPooling2D((2,2)))
genmodel.add(Flatten())
genmodel.add(Dense(64, activation='relu'))
genmodel.add(Dropout(0.5))
genmodel.add(Dense(1, activation='sigmoid'))

genmodel.compile(loss='binary_crossentropy',
            optimizer=optimizers.Adam(learning_rate=0.0001),
            metrics=['accuracy'])
```

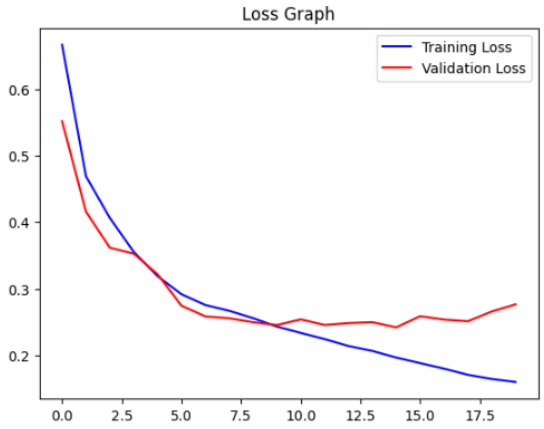
4. Metrics and Results

Metric	Combined Model	Separate Models
Gender Accuracy	~93%	~87.8%
Age Estimation (MAE)	~7 years	~17 years
Training Time	Faster	Slower
Inference Time	Faster	Slower

5. Visualizations

Model 2





6. Deployment

```python
def process_and_predict(file):
    im = Image.open(file)
    width, height = im.size
    if width == height:
        im = im.resize((200,200), Image.Resampling.LANCZOS)
    else:
        if width > height:
            left = width/2 - height/2
            right = width/2 + height/2
            top = 0
            bottom = height
            im = im.crop((left,top,right,bottom))
            im = im.resize((200,200), Image.Resampling.LANCZOS)
        else:
            left = 0
            right = width
            top = 0
            bottom = width
            im = im.crop((left,top,right,bottom))
            im = im.resize((200,200), Image.Resampling.LANCZOS)

    ar = np.asarray(im)
    ar = ar.astype('float32')
    ar /= 255.0
    ar = ar.reshape(-1, 200, 200, 3)

    age = agemodel.predict(ar)
    gender = np.round(genmodel.predict(ar))
    if gender == 0:
        gender = 'male'
    elif gender == 1:
        gender = 'female'

    print('Age:', int(age), '\n Gender:', gender)
    return im.resize((300,300), Image.Resampling.LANCZOS)
```

```
Age: 17
 Gender: male
C:\Users\zhara\AppData\Local\Temp\ipykernel_20596\2624513457.py:34: Deprecatio
ement from your array before performing this operation. (Deprecated NumPy 1.25
  print('Age:', int(age), '\n Gender:', gender)
```

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