Report on Face Alignment System with Lip/Eye Color Modification

1. Introduction

Facial analysis has become a cornerstone in various applications, from biometrics to augmented reality. Face alignment, or precisely locating facial landmarks in images, is one of the most important tasks in facial analysis. For tasks like face recognition, expression analysis, and facial feature manipulation, these landmarks are crucial locations. This report describes our all-inclusive method for creating, deploying, and assessing a face alignment system, along with a side project to adjust the image's lips, eyes, and/or other features. Our system is designed to meet the needs specified in the coursework assignment, with an emphasis on achieving simplicity, robustness, and accuracy.

2. Design and Implementation

2.1 Face Alignment System

Our face alignment system encompasses the following components:

- ***Data Loading and Preprocessing:*** We painstakingly loaded the landmark points and training images. Images were preprocessed by normalising pixel values to fall within the range [0, 1] in order to guarantee consistency and compatibility.
- ***Model Architecture:*** We used the pre-trained VGG16 model as our foundational architecture, utilising the strength of transfer learning. On top of the VGG16 base, custom layers were added to allow regression for landmark coordinate prediction.
- ***Training:*** We optimised our model's parameters during the training phase in order to minimise a unique mean squared error loss function. To strike a balance between convergence stability and computational efficiency, this iterative process was run over 20 epochs with a moderate batch size of 32.
- **Evaluation:** After training, we conducted a thorough analysis of our model's performance using a different set of test images. The accuracy and generalisation capabilities of the predicted landmarks were evaluated by comparing them with ground truth landmarks.

2.2 Lip/Eye Color Modification System

In addition to face alignment, our system incorporates a straightforward yet effective method for modifying lip and eye colour:

- **Lip Colour Modification:** We developed a mechanism to fill the lip region with a specified colour by identifying it using landmark points. This allows for subtle or dramatic changes to the lip colour.

- **Eye Colour Modification:** Our system offers flexibility in manipulating the colour of the eyes by first identifying the eye region using landmark points, then applying the desired colour transformation. This process is similar to lip colour modification.

3. Results

3.1 Face Alignment Performance

In terms of accuracy and resilience, our face alignment system performed admirably. The model was able to precisely localise facial landmarks on the test set, as evidenced by its average loss of 10.08, despite the inherent complexity of facial images. The system's ability to capture facial geometry is demonstrated visually in Figure 1, which shows the predicted landmarks superimposed on test images.

3.2 Changes to Lip and Eye Colour

Our face alignment system was able to smoothly integrate the lip and eye colour modification module, giving users an easy way to change the colours of their lips and eyes in pictures. The ability of the system to modify the colour of the lips and eyes while maintaining the facial structure and context is demonstrated in Figure 2.

4. Discussion

4.1 Face Alignment System Evaluation

Our face alignment system's evaluation produced encouraging results, highlighting its accuracy and resilience when processing a range of facial images. Nonetheless, difficulties continued to arise in situations with extreme positions, occlusions, and unconventional lighting, underscoring the need for further development and refinement. Techniques like model regularisation and data augmentation could improve the system's performance in difficult situations.

4.2 Lip/Eye Color Modification

Our face alignment system was enhanced by the addition of a useful tool that allowed users to manipulate facial features cosmetically. This was the lip and eye colour modification system. Although the system worked very well in standard conditions, it may not work as well when there are intricate facial expressions, occlusions, or artefacts present.

5. Failure Cases Analysis

Although our system performed well overall, there were some failure cases that were mainly caused by difficult image conditions and built-in biases. Failure scenarios are depicted in Figure 3, emphasising the system's vulnerability to occlusions, extreme poses, and lighting changes. By locating and examining these failure cases, we are able to gather important information about possible improvements to the system and areas that require more research.

6. Conclusion

Conclusively, our all-inclusive facial alignment system, enhanced by the addition of lip and eye colour modification functionalities, signifies a noteworthy advancement in facial analysis and manipulation. By means of methodical planning, execution, and assessment, we have proven the system's ability to precisely identify facial features and apply cosmetic modifications to the hues of lips and eyes. Although the performance of our system is promising, further research and development are necessary to address underlying issues and improve its resilience and adaptability.

Figure Captions

Figure 1: Predicted facial landmarks overlaid on test images, demonstrating the system's accuracy and robustness.

Figure 2: Example of modified image showcasing altered lip and eye colours, illustrating the system's cosmetic manipulation capabilities.

Figure 3: Failure cases highlighting system limitations and biases, providing insights for future enhancements.