NEWS BROADCAST ANALYSIS

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1 Shot detection

A score is calculated for each frame using either the sum of absolute differences method or the histogram differences method. Given the mean μ and standard deviation σ of all the scores, a threshold is chosen as

$$\text{threshold} = \mu + k \times \sigma$$

where k is an integer. A shot is a series of frames taken by continuously by one camera. A shot change is declared when the value of the score becomes greater than the threshold and then becomes smaller than the threshold (similar to a peak above the threshold line).

Sum of absolute differences

A score is assigned to each frame by calculating the sum of the absolute differences between consecutive frames for every pixel. This value is then normalized by the size of the frame. When the score of a frame is greater than the threshold, a shot change is declared. This method works quite well with simple videos but it is not robust against movements and changes in lighting.

Histogram differences

Each frame is converted into a gray-scale image. A histogram with 256 bins, representing all the possible values of a pixel, is created for each frame. Then, a score is assigned by calculating the sum of the absolute differences between histograms of consecutive frames. This method is more robust against small changes in a frame.

Performance

Let C be the number of correctly identified cuts, M be the number of cuts that are not identified, and F be the number of falsely identified cuts. To evaluate how well the algorithm is detecting the shots, the recall (V), precision (P) and F_1 scores for each clip are calculated. They are defined as below.

$$\begin{aligned} V &= \frac{C}{C+M} \quad \text{(probability that a shot change is detected)} \\ P &= \frac{C}{C+F} \quad \text{(probability that a detected shot change is an actual shot change)} \\ F_1 &= \frac{2 \times P \times V}{P+V} \end{aligned} \tag{1}$$

Figure 1: Sum of absolute differences scores of clip 1

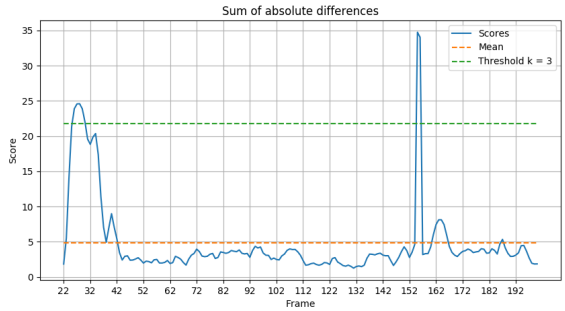


Figure 2: Histogram differences scores of clip 1

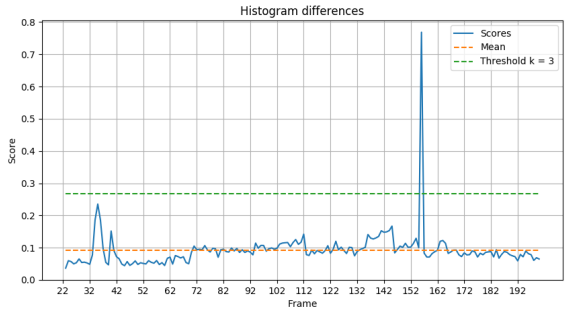


Figure 3: Sum of absolute differences scores of clip 2

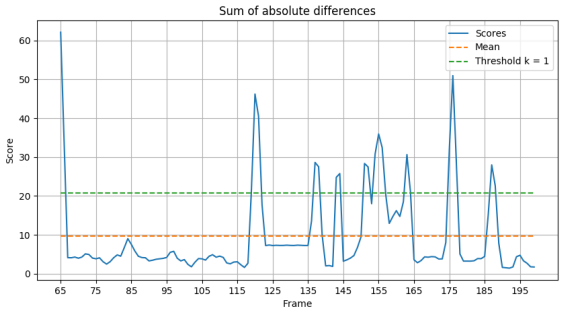


Figure 4: Histogram differences scores of clip 2

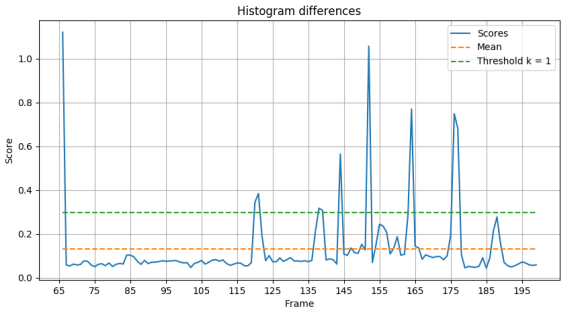


Figure 5: Sum of absolute differences scores of clip 3

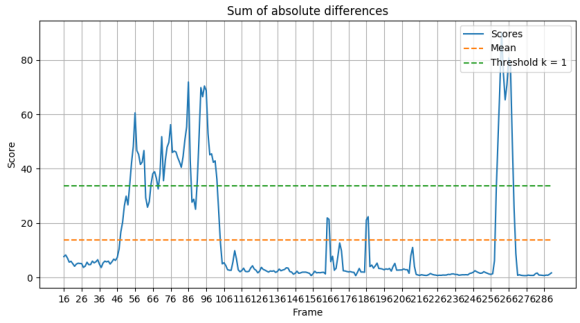


Figure 6: Histogram differences scores of clip 3

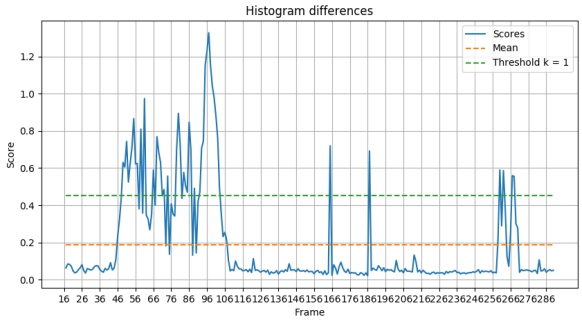


Table 1 and Table 2 shows the respective scores for both methods. On average, the histogram differences (HD) method achieve a higher score across all three metrics comparing to sum of absolute differences (SAD) method. For example, the transition from frame 164 (Figure 7) to frame 165 (Figure 8) is not detected by the latter but it is by the former. HD performs especially better in the montage section in clip 3, where there are frequent shot changes. Also, we see that SAD scored frame 22 to frame 32 in clip 1 quite high when the man was only moving to the left of the frame.

Table 1: Shot detection performance with sum of absolute differences

Clip	Correct (C)	Missed (M)	Falsely detected (F)	Recall (V)	Precision (P)	F_1
1	1	0	1	1	0.5	0.6667
2	7	0	2	1	0.7778	0.8750
3	5	16	0	0.2381	1	0.3846

Table 2: Shot detection performance with histogram differences

Clip	Correct (C)	Missed (M)	Falsely detected (F)	Recall (V)	Precision (P)	F_1
1	1	0	0	1	1	1
2	6	1	1	0.8571	0.8571	0.8571
3	15	6	1	0.7142	0.9375	0.8118

Figure 7: Frame 164 of clip 3

Figure 8: Frame 165 of clip 3

The relevant code is in `shot.py`. To get the graphs of shot detection, run the command below.

```
python3 run.py shot_detection -t <type> -i <path to frames>
```

To add shot numbers into frames, run the command below. The shot number will appear on the bottom left corner of each frame.

```
python3 run.py add_shot_numbe -i <input directory> -o <output directory>
-k <k for thresholding>
```

2 Logo detection

Template matching is an object detection algorithm which is translation invariant but not scale or rotation invariant. As we are detecting the news company's logo, we can assume that the target of detection will be in a known orientation. Due to the possibility that there may be multiple occurrences of the logo in a frame, we cannot simply match SIFT features between the logo template and a frame. Template matching is run on templates of different sizes because the size of the logo in a frame is unknown. Then, a score is calculated for all the matches by normalized cross-correlation. The normalized version is chosen because brighter patches will not have a higher score. Also, the score obtained will be in the range [0, 1] and this makes choosing a threshold more intuitive. As the logo in the template and the one in the frame might be slightly different, possibly due to the differences in resolutions or styles, a looser threshold is first used to filter out the irrelevant matches.

For each match, if its score is greater than the loose threshold, it is kept. Then, the algorithm checks if that particular match is a slight translation of a match we have already decided to keep. If it is, the match is discarded. This prevents having multiple boxes around one logo. Afterwards, SIFT descriptors are calculated for the remaining matches and a score is calculated using feature matching and Lowe's ratio test with the logo template. If a match's score is above a different threshold, it is declared as a match of the template and a box is put around the match.

Initially, I only did one pass with either normalized cross-correlation or SIFT feature matching. However, this led to fairly poor results, with the algorithm often unable to detect multiple logos and including many irrelevant matches. Therefore, the two passes approach, first with a looser threshold using normalized cross-correlation and then with another threshold with SIFT feature matching, is used. SIFT is scale and rotation invariant. Therefore, it will not penalize logos that have slight size differences to the template. This is good because even if we have multiple scales, they might not be an exact match in size. As can be seen in Figure 10, the algorithm can detect multiple logos. In hindsight, it would have been more efficient to scale down the images to multiple scales instead of scaling down the

templates. This is because sliding the template across the image takes much longer than resizing every frame to different scales.

Figure 9: Logo detection on frame 104 of clip 1

Figure 10: Logo detection on frame 52 of clip 1

The relevant code is in `logo.py`. To run logo detection, run the command below.

```
python3 run.py logo_detection -i <input directory> -o <output directory>
-d <logo path> -t <min threshold for NCC>
```

3 Face detection and tracking

There are 260 images in the female and male classes respectively. Each image is accompanied by a `.mat` file specifying the coordinates of the left eye, right eye, nose and mouth. The following rules are used to crop the images in order to obtain the faces.

$$\begin{aligned} start_x &= left\ eye_x - 0.5 \times (right\ eye_x - left\ eye_x) \\ end_x &= right\ eye_x + 0.5 \times (right\ eye_x - left\ eye_x) \\ start_y &= eyes_y - (mouth_y - eyes_y) \\ end_y &= mouth_y + (mouth_y - eyes_y) \end{aligned} \tag{2}$$

The relevant code for face cropping is in `crop_images()` in `face.py`.

The initial attempt to detect faces is to use skin detection - trying to filter out skin in images. Figure 11 and Figure 12 show the color distributions of faces in RGB and HSV color spaces. The HSV color space has narrower distributions, especially with hue. Although this method works sometimes as seen in Figure 13, it is not successful in general. It fails to detect a large area of the face of the man on the right in Figure 14 and includs a lot of the background.This model is especially poor when other things in the frame are very similar to human skin tone.

Figure 11: RGB distribution of fe male training images

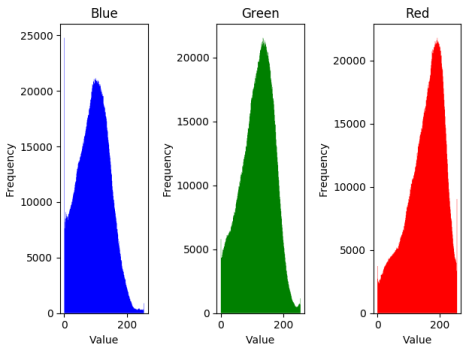


Figure 12: HSV distribution of female training images

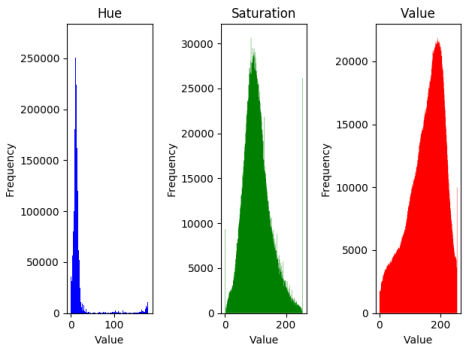


Figure 13: HSV colour detection on frame 160 of clip 1

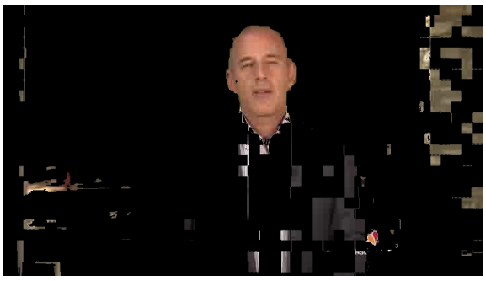


Figure 14: HSV colour detection on frame 50 of clip 1

The relevant code for HSV face detection is in `visualize_distributions()` and `face_detection_hsv()` in `face.py`.

I ended up using `cv2.CascadeClassifier` for detecting faces. The full name of this classifier is Haar feature-based cascade classifier for object detection. It is a OpenCV pre-trained classifier for face stored in an XML file. It works fairly well. It has no trouble detecting multiple people in a frame or people of colour, like in Figure 15. However, it is usually unable to detect faces turned to the side. The detector was unable to detect the person on the left in any of the frames he appeared in that particular position in Figure 16.

After obtaining the faces in a frame, for each face in the current frame, the SIFT descriptors are found. Then, they are matched to the SIFT descriptors of all the faces in the previous frame using feature matching and Lowe's ratio test. Then, a score is obtained from the number of matches. If the score is above a set threshold, the algorithm declares that the face we are looking at is found in the previous frame and we will display the index assigned to that particular face in the previous frame. If the face is not found, we assign a new index to the face. The index of each face is labelled on top of the box.

Figure 15: Face detection on frame 69 of clip 2

Figure 16: Face detection on frame 110 of clip 1

4 Gender classification

90% of the images (234 images from each class) are used for training, whereas the other 10% (26 images from each class) are used for testing the accuracy of the model. The accuracy is defined as the percent of correctly identified faces, not SIFT descriptors, in the cases of support-vector machine and neural network.

SVM

The SIFT descriptors of the training images are passed into the SVM model for training. A radial basis function kernel is used. Then, for each detected face in a frame, the SIFT descriptors are extracted and fed to the trained SVM model. A prediction for each descriptor is obtained. If more descriptors are predicted as female than male, the image is classified as female. If more descriptors are predicted as male than female, the image is classified as male. If there are equal number of descriptors being predicted as both female and male, the image is then classified as unknown.

Neural network

The same as SVM, except with a neural network model instead. The model uses a binary crossentropy loss, adam for optimization, and accuracy as the metric. The neural network used is shown in Figure 17.

CNN

All the training and testing images are padded with black borders to obtain a square shape and then resized to be 72 pixels by 72 pixels. The training images are then passed to the CNN model shown in Figure 18 for training. The model uses a binary crossentropy loss, stochastic gradient descent for optimization, and accuracy as the metric. Each detected face is padded to obtain a square shape. Then, the image is resized to be 72 pixels by 72 pixels. The resized image is then passed to the trained CNN model and a category prediction is obtained.

Figure 17: Neural network model

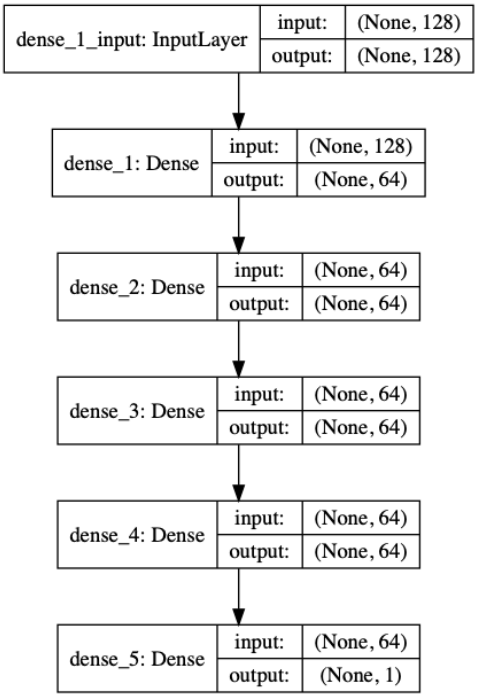
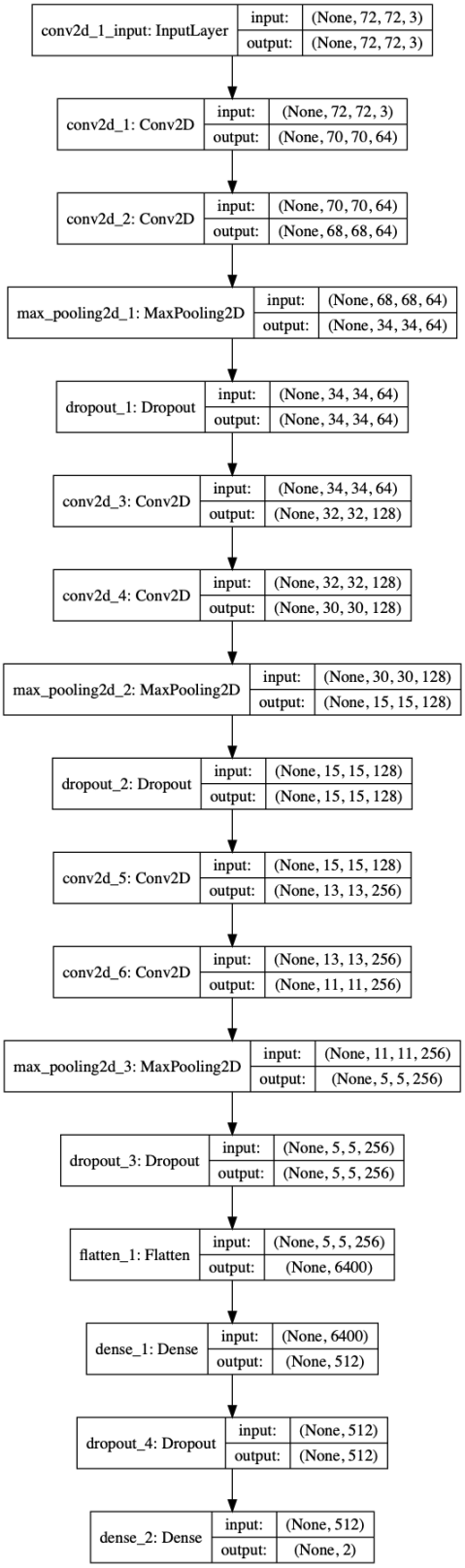


Figure 18: CNN model



The relevant code for training any of the three models is in `train_model()` in `face.py`. To train a gender classification model, run the command below.

```
python3 run.py train -m <model path after training>
-c <classification model (SVM, NN_SIFT, or CNN)>
```

The relevant code for face detection (including gender classification and face tracking) is in `face_detection()` in `face.py`. Run the command below.

```
python3 run.py face_detection -i <input directory> -o <output directory>
-c <classification model (SVM, NN_SIFT, or CNN)> -m <trained model path>
-s <min size for face detection>
```

Performance

Table 3 shows the test accuracies of the three models. As expected, CNN performed poorly, achieving an accuracy that is equivalent to random guesses, due to the very small training data size of 468. It consistently classify all the faces as either female and male.

Table 3: Gender classification performance

Model	Description	Accuracy on test set
SVM	Using SIFT descriptors of faces	100.00%
Neural network	Using SIFT descriptors of faces	92.30%
CNN	Using cropped and resized faces	50.00%

5 Make video

The relevant code for combining all the frames to a video is in `make_video()` in `utils.py`. To do logo detection, face detection, face tracking and gender classification and make a video, run the command below.

```
python3 run.py run_all -i <input directory> -o <output directory>
-d <logo path> -t <min threshold for NCC> -m <trained model path>
-c <classification model (SVM, NN_SIFT, or CNN)> -v <name of output video>
-f <frame per second> -s <min size for face detection>
```

6 References

Video shot boundary detection based on color histogram

Wikipedia - Shot transition detection

Shot detection using pixel wise difference with adaptive threshold and color histogram method in compressed and uncompressed video

7 Code

Listing 1: shot.py

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

def add_shot_number(input_dir, output_dir, shots):
    """
    Add shot number using the shot changes specified in variable shots.
    """
    print("add_shot_number")
    if not os.path.isdir(output_dir):
        os.mkdir(output_dir)

    exts = [".jpg", ".png"]
    img_names = [img for img in os.listdir(input_dir) if img.endswith(tuple(exts))]
    # Sort images by name in ascending order
    img_names.sort(key=lambda img: int("".join(filter(str.isdigit, img))))

    i = 0
    shot = 0
    for filename in img_names:
        image_num = int("".join(filter(str.isdigit, filename)))
        img = cv2.imread(os.path.join(input_dir, filename))
        if i < len(shots) and image_num == shots[i]:
            shot += 1
            i += 1
        # Add shot number to frame
        text = str(shot)
        # Get width and height of the text box
        text_width, text_height = cv2.getTextSize(text, cv2.FONT_HERSHEY_PLAIN, fontScale
            ↪ =1.5, thickness=2)[0]
        # Set the text start position
        text_x = 10
        text_y = img.shape[0] - 10
        box_coords = ((text_x, text_y + 2), (text_x + text_width - 2, text_y -
            ↪ text_height - 4))
        cv2.rectangle(img, box_coords[0], box_coords[1], (255, 255, 255), cv2.FILLED)
        cv2.putText(img, text, (text_x, text_y), cv2.FONT_HERSHEY_PLAIN, fontScale=1.5,
            ↪ color=(0, 0, 0), thickness=2)
        # Save frame
        cv2.imwrite(os.path.join(output_dir, filename), img)
        # cv2.imshow("A box!", img)
        # cv2.waitKey(0)

def shot_detection(input_dir, method, k):
    """
    Get graphs of scores of shot changes using the method specify in method.
    Method should be either SAD2 or HD.
    """
    scores = []
    exts = [".jpg", ".png"]
    img_names = [img for img in os.listdir(input_dir) if img.endswith(tuple(exts))]
    # Sort images by name in ascending order
    img_names.sort(key=lambda img: int("".join(filter(str.isdigit, img))))
    start_idx = int(img_names[0][:img_names[0].find(".jpg")])
    end_idx = int(img_names[-1][:img_names[-1].find(".jpg")])
```

```
54
55      # Sum of absolute differences
56      if method == "SAD2":
57          prev_img = None
58          for i in range(len(img_names)):
59              # Default type is numpy.uint64
60              curr_img = cv2.imread(os.path.join(input_dir, img_names[i])).astype(np.int64)
61              if i == 0:
62                  r, c, d = curr_img.shape
63                  next_img = cv2.imread(os.path.join(input_dir, img_names[i + 1])).astype(np.
                        ↪ int64)
64                  score = np.sum(np.abs(curr_img - next_img))
65              elif i == len(img_names) - 1:
66                  score = np.sum(np.abs(curr_img - prev_img))
67              else:
68                  next_img = cv2.imread(os.path.join(input_dir, img_names[i + 1])).astype(np.
                        ↪ int64)
69                  score = 0.5 * np.sum(np.abs(curr_img - prev_img)) + 0.5 * np.sum(np.abs(
                        ↪ curr_img - next_img))
70              scores.append(score)
71              prev_img = curr_img
72          x = np.arange(start_idx, end_idx + 1)
73          scores = np.array(scores) / (r * c * d)
74          title = "Sum of absolute differences"
75          new_filename = "output/" + input_dir.name + "_score_sad2.png"
76
77      # Histogram differences
78      elif method == "HD":
79          prev_histogram = None
80          for i in range(len(img_names)):
81              # Default type is numpy.uint8
82              curr_img = cv2.imread(os.path.join(input_dir, img_names[i]))
83              # Default type is numpy.uint8
84              curr_img_g = cv2.cvtColor(curr_img, cv2.COLOR_BGR2GRAY).astype(np.int16)
85              histogram = np.histogram(np.ravel(curr_img_g), bins=np.arange(-1, 256))
86              if i == 0:
87                  r, c = curr_img_g.shape
88                  prev_histogram = histogram[0]
89                  continue
90              score = np.sum(np.abs(histogram[0] - prev_histogram))
91              scores.append(score)
92              prev_histogram = histogram[0]
93
94          x = np.arange(start_idx + 1, end_idx + 1)
95          scores = np.array(scores) / (r * c)
96          title = "Histogram differences"
97          new_filename = "output/" + input_dir.name + "_score_hd.png"
98
99      else:
100         raise ValueError("Illegal method value")
101
102     y_mean = [np.mean(scores)] * len(x)
103     threshold = [np.mean(scores) + k * np.std(scores)] * len(x)
104     f = plt.figure(figsize=(10, 5))
105     ax = f.gca()
106     ax.set_xticks(np.arange(start_idx, end_idx, 10))
107     plt.title(title)
108     plt.xlabel("Frame")
109     plt.ylabel("Score")
```

```
    plt.plot(x, scores, label="Scores")
    # Plot the average line
    plt.plot(x, y_mean, label="Mean", linestyle="--")
    plt.plot(x, threshold, label="Threshold k = " + str(k), linestyle="--")
    plt.legend(loc="upper right")
    plt.grid()
    f.savefig(new_filename)
    print("Output saved to " + new_filename)
```

Listing 2: logo.py

```
import cv2
import imutils
import numpy as np
import os

def get_score(img1, img2):
    """
    Get similarity score between img1 and img2 using SIFT features matching and
    Lowe's ratio testing.
    """
    sift = cv2.xfeatures2d.SIFT_create()
    kp1, des1 = sift.detectAndCompute(img1, None)
    kp2, des2 = sift.detectAndCompute(img2, None)
    if len(kp1) < 2 or len(kp2) < 2:
        return 0
    index_params = dict(algorithm=0, trees=5)
    flann = cv2.FlannBasedMatcher(index_params, None)
    matches = flann.knnMatch(des1, des2, k=2)
    good_matches = []
    for m, n in matches:
        if m.distance < 0.6*n.distance:
            good_matches.append(m)
    num_kps = 0
    if len(kp1) <= len(kp2):
        num_kps = len(kp1)
    else:
        num_kps = len(kp2)
    score = len(good_matches) / num_kps * 100
    return score

def logo_detection(input_dir, output_dir, logo_path, min_threshold):
    print("detect_logo")

    if not os.path.isdir(output_dir):
        os.mkdir(output_dir)

    template = cv2.imread(str(logo_path))
    template_g = cv2.cvtColor(template, cv2.COLOR_BGR2GRAY)

    w, h = template_g.shape[::-1]

    # Compute template of different sizes
    if template.shape[0] < 50:
        # scales = np.linspace(0.8, 1.0, 6)[::-1]
        scales = np.linspace(0.9, 1.0, 2)[::-1]
    else:
        scales = np.linspace(0.1, 1.0, 25)[::-1]
    templates = []
    ratios = []
```

```
50      for scale in scales:
51          resized = imutils.resize(template_g, width=int(template_g.shape[1] * scale))
52          templates.append(resized)
53          ratios.append(resized.shape[1] / float(template_g.shape[1]))
54
55      for img_name in os.listdir(input_dir):
56          if not img_name.endswith(".jpg"):
57              continue
58          img = cv2.imread(os.path.join(input_dir, img_name))
59          img_g = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
60          img_canny = cv2.Canny(img_g, 100, 200)
61
62          p = -1
63          q = -1
64          matches = []
65          # Loop through the templates
66          for i in range(len(templates) - 1, -1, -1):
67              # Stop when template is bigger than image
68              if img_g.shape[0] < templates[i].shape[0] or img_g.shape[1] < templates[i].
                    ↪ shape[1]:
69                  break
70
71              # First pass - normalized cross correlation
72              match = cv2.matchTemplate(img_g, templates[i], cv2.TM_CCORR_NORMED) # img_g.shape
                    ↪  - template_g.shape + 1
73              if p == -1 and q == -1:
74                  p, q = match.shape
75              m, n = match.shape
76              matches.append(np.pad(match, ((0, p - m), (0, q - n)), mode="constant",
                    ↪ constant_values=0))
77
78          boxes = []
79
80          matches = np.array(matches)
81          r, max_y, max_x = np.unravel_index(np.argmax(matches), matches.shape)
82          r = ratios[len(ratios) - 1 - r]
83          max_val = np.max(matches)
84          max_thresh = max(max_val * 0.95, min_threshold)
85          # If the match with the highest score is smaller than the min threshold,
86          # there is no match in this image and just saves the input image.
87          if max_val < min_threshold:
88              cv2.imwrite(os.path.join(output_dir, img_name), img)
89              continue
90          start_x, start_y = max_x, max_y
91          end_x, end_y = int((max_x + w * r)), int((max_y + h * r))
92          match_score = get_score(template, img[start_y:end_y, start_x:end_x])
93          if match_score < 5:
94              cv2.imwrite(os.path.join(output_dir, img_name), img)
95              continue
96          boxes.append((r, max_y, max_x, 1))
97
98          # Matches obtained from first pass
99          match_locations = np.where(matches >= max_thresh)
100         for i in range(len(match_locations[0])):
101             r1, y1, x1 = ratios[len(ratios) - 1 - match_locations[0][i]], match_locations
                    ↪ [1][i], match_locations[2][i]
102             found = False
103             for j in range(len(boxes)):
104                 r2, y2, x2, count = boxes[j]
```

```
105                 # Check if two boxes of the same size overlap or
106                 # if a smaller one is contained in the bigger one
107                 if (r1 == r2 and np.abs(x1 - x2) < w * r1 and np.abs(y1 - y2) < h * r1) or
                        ↪ \
108                     ((r1 < r2) and (x1 <= (x2 + w * r2) <= (x1 + w * r1)) and (y1 <= (y2 + h
                            ↪  * r2) <= (y1 + h * r1))) or\
109                     (np.abs(x1 - x2) < 0.5 * w * r1 and np.abs((x1 + w * r1) - (x2 + w * r2
                            ↪ )) < 0.5 * w * r1 and\
110                     np.abs(y1 - y2) < 0.5 * h * r1 and np.abs((y1 + h * r1) - (y2 + h * r2)
                            ↪ ) < 0.5 * h * r1):
111                     boxes[j] = (r2, y2, x2, count + 1)
112                     found = True
113                     break
114             if not found:
115                 start_x, start_y = x1, y1
116                 end_x, end_y = int((x1 + w * r1)), int((y1 + h * r1))
117                 # Second pass — SIFT features matching
118                 match_score = get_score(template, img[start_y:end_y, start_x:end_x])
119                 if match_score > 5:
120                     boxes.append((r1, y1, x1, 1))
121 
122         for r, y, x, count in boxes:
123             start_x, start_y = x, y
124             end_x, end_y = int((x + w * r)), int((y + h * r))
125             cv2.rectangle(img, (start_x, start_y), (end_x, end_y), (0, 255, 0), thickness
                    ↪ =2)
126 
127         cv2.imwrite(os.path.join(output_dir, img_name), img)
128         # cv2.imshow("img", img)
129         # cv2.waitKey(0)
```

Listing 3: face.py

```
1  import copy
2  import cv2
3  import matplotlib.pyplot as plt
4  import numpy as np
5  import os
6  import pickle
7  import scipy.io, scipy.misc
8  from skimage import io
9  from skimage import transform as tf
10 from skimage.color import rgb2hsv
11 from sklearn import svm
12 from utils import shuffle
13 
14 def visualize_distributions(imgs_dir):
15     """
16     Visualize the distributions of values in HSV and BGR of pictures in imgs_dir.
17     """
18     H, S, V = None, None, None
19     B, G, R = None, None, None
20     for filename in os.listdir(imgs_dir):
21             if not filename.endswith(".png"):
22                 continue
23             img = cv2.imread(imgs_dir + filename)
24             hsv_img = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)
25             if H is None:
26                 H = hsv_img[..., 0].flatten()
27                 S = hsv_img[..., 1].flatten()
```

```
28                V = hsv_img[..., 2].flatten()
29                B = img[..., 0].flatten()
30                G = img[..., 1].flatten()
31                R = img[..., 2].flatten()
32            else:
33                H = np.concatenate([H, hsv_img[..., 0].flatten()])
34                S = np.concatenate([S, hsv_img[..., 1].flatten()])
35                V = np.concatenate([V, hsv_img[..., 2].flatten()])
36                B = np.concatenate([B, img[..., 0].flatten()])
37                G = np.concatenate([G, img[..., 1].flatten()])
38                R = np.concatenate([R, img[..., 2].flatten()])
39
40    # Plot
41    f = plt.figure()
42    ax1 = f.add_subplot(1, 3, 1)
43    ax1.hist(H, bins=180,
44        range=(0.0, 180.0), histtype="stepfilled", color="b", label="Hue")
45    plt.title("Hue")
46    plt.xlabel("Value")
47    plt.ylabel("Frequency")
48    ax2 = f.add_subplot(1, 3, 2)
49    ax2.hist(S, bins=256,
50        range=(0.0, 255.0),histtype="stepfilled", color="g", label="Saturation")
51    plt.title("Saturation")
52    plt.xlabel("Value")
53    plt.ylabel("Frequency")
54    ax3 = f.add_subplot(1, 3, 3)
55    ax3.hist(V, bins=256,
56        range=(0.0, 255.0), histtype="stepfilled", color="r", label="Value")
57    plt.title("Value")
58    plt.xlabel("Value")
59    plt.ylabel("Frequency")
60    f.tight_layout()
61    f.savefig(imgs_dir + "_hsv_distributions.png")
62    plt.show()
63
64    f = plt.figure()
65    ax1 = f.add_subplot(1, 3, 1)
66    ax1.hist(B, bins=256,
67        range=(0.0, 255.0), histtype="stepfilled", color="b", label="Blue")
68    plt.title("Blue")
69    plt.xlabel("Value")
70    plt.ylabel("Frequency")
71    ax2 = f.add_subplot(1, 3, 2)
72    ax2.hist(G, bins=256,
73        range=(0.0, 255.0),histtype="stepfilled", color="g", label="Saturation")
74    plt.title("Green")
75    plt.xlabel("Value")
76    plt.ylabel("Frequency")
77    ax3 = f.add_subplot(1, 3, 3)
78    ax3.hist(R, bins=256,
79        range=(0.0, 255.0), histtype="stepfilled", color="r", label="Red")
80    plt.title("Red")
81    plt.xlabel("Value")
82    plt.ylabel("Frequency")
83    f.tight_layout()
84    f.savefig(imgs_dir + "_rgb_distributions.png")
85    plt.show()
86
```

```
87  def crop_images(old_dir, new_dir):
88      """
89      Crop .jpg images in old_dir given coordinates of left eye, right eye,
90      nose and mouth in .mat files. Save cropped images in new_dir.
91      """
92      print("crop_images")
93      os.mkdir(new_dir)
94
95      H, S, V = None, None, None
96      for filename in os.listdir(old_dir):
97          if not filename.endswith(".jpg"):
98              continue
99
100         index = filename.find(".jpg")
101         name = filename[:index]
102
103         # Approximate coordinates of face
104         coords = scipy.io.loadmat(old_dir + name + ".mat")
105         start_x = int(coords["x"][0][0] - 0.5*(coords["x"][1][0] - coords["x"][0][0]))
106         end_x = int(coords["x"][1][0] + 0.5*(coords["x"][1][0] - coords["x"][0][0]))
107         start_y = int(coords["y"][0][0] - (coords["y"][3][0] - coords["y"][0][0]))
108         end_y = int(coords["y"][3][0] + (coords["y"][3][0] - coords["y"][2][0]))
109         img = io.imread(old_dir + filename)
110         face = img[start_y:end_y, start_x:end_x]
111         # Save cropped image
112         scipy.misc.imsave(new_dir + name + ".png", face)
113
114 def resize_images(input_dir, output_dir, size=72):
115     """
116     Resize images in input_dir to size x size.
117     """
118     print("resize_images")
119     if not os.path.isdir(output_dir):
120         os.mkdir(output_dir)
121
122     for filename in os.listdir(input_dir):
123         if not filename.endswith(".png"):
124             continue
125         img = cv2.imread(os.path.join(input_dir, filename))
126         x, y, d = img.shape
127         # Pad image to square
128         if x > y:
129             padded_img = np.pad(img, ((0, 0), (0, x - y), (0, 0)),
130                 mode="constant", constant_values=0)
131         else:
132             padded_img = np.pad(img, ((0, y - x), (0, 0), (0, 0)),
133                 mode="constant", constant_values=0)
134         resized_img = cv2.resize(padded_img, (size, size))
135         scipy.misc.imsave(output_dir + filename, cv2.cvtColor(resized_img, cv2.
              ↪ COLOR_BGR2RGB))
136
137 def get_features(input_dir):
138     """
139     Get keypoints and descriptors of the images in input_dir with SIFT.
140     """
141     kps, des = None, None
142     sift = cv2.xfeatures2d.SIFT_create()
143
144     for filename in os.listdir(input_dir):
```

```
145         if not filename.endswith(".png"):
146             continue
147         img = io.imread(input_dir + filename)
148         kp, d = sift.detectAndCompute(img, None)
149 
150         if des is None:
151             kps = kp
152             des = d
153         else:
154             kps = np.concatenate([kps, kp], axis=0)
155             des = np.concatenate([des, d], axis=0)
156     return kps, des
157 
158 def get_data(f_dir, m_dir):
159     """
160     Get the images of the F and M classes from their respective directories and shuffle.
161     """
162     import keras
163     x = []
164     y = [0] * len(os.listdir(f_dir)) + [1] * len(os.listdir(m_dir))
165     imgs = os.listdir(f_dir) + os.listdir(m_dir)
166     for filename in os.listdir(f_dir):
167         if not filename.endswith(".png"):
168             continue
169         x.append(cv2.imread(os.path.join(f_dir, filename)))
170     for filename in os.listdir(m_dir):
171         if not filename.endswith(".png"):
172             continue
173         x.append(cv2.imread(os.path.join(m_dir, filename)))
174 
175     x, y = shuffle(x, y)
176     y = keras.utils.to_categorical(y, num_classes=2)
177     return x, y
178 
179 def train_model(model_path, classification):
180     """
181     Train either a SVM or neural network model using SIFT features or
182     a CNN using face images.
183     """
184     OLD_F_DIR = "original_data/female/"
185     OLD_M_DIR = "original_data/male/"
186     F_TRAIN_DIR = "data/female_train/"
187     M_TRAIN_DIR = "data/male_train/"
188     F_TEST_DIR = "data/female_test/"
189     M_TEST_DIR = "data/male_test/"
190     F_TRAIN_CNN_DIR = "data/female_cnn_train/"
191     M_TRAIN_CNN_DIR = "data/male_cnn_train/"
192     F_TEST_CNN_DIR = "data/female_cnn_test/"
193     M_TEST_CNN_DIR = "data/male_cnn_test/"
194 
195     if not os.path.isdir("data/"):
196         os.mkdir("data/")
197         crop_images(OLD_F_DIR, F_TRAIN_DIR)
198         crop_images(OLD_M_DIR, M_TRAIN_DIR)
199 
200     if classification == "SVM":
201         f_train_kps, f_train_des = get_features(F_TRAIN_DIR)
202         m_train_kps, m_train_des = get_features(M_TRAIN_DIR)
203         x_train = np.concatenate([f_train_des, m_train_des], axis=0)
```

```
204         y_train = [-1] * len(f_train_des) + [1] * len(m_train_des)
205         model = svm.SVC(kernel="rbf", gamma="scale", C=10.0)
206 
207         model.fit(x_train, y_train)
208         # Save model
209         pickle.dump(model, open(model_path, "wb"))
210         print("Model saved as " + str(model_path))
211 
212     elif classification == "NN_SIFT":
213         import keras
214         from keras.layers import Conv2D, Dense, Dropout, Flatten, MaxPooling2D
215         from keras.models import Sequential
216         from keras.optimizers import Adam, SGD
217         from keras.utils import plot_model
218 
219         f_train_kps, f_train_des = get_features(F_TRAIN_DIR)
220         m_train_kps, m_train_des = get_features(M_TRAIN_DIR)
221         x_train = np.concatenate([f_train_des, m_train_des], axis=0)
222         y_train = [0] * len(f_train_des) + [1] * len(m_train_des)
223         x_train, y_train = shuffle(x_train, y_train)
224 
225         f_test_kps, f_test_des = get_features(F_TEST_DIR)
226         m_test_kps, m_test_des = get_features(M_TEST_DIR)
227         x_test = np.concatenate([f_test_des, m_test_des], axis=0)
228         y_test = [0] * len(f_test_des) + [1] * len(m_test_des)
229         x_test, y_test = shuffle(x_test, y_test)
230 
231         model = Sequential()
232         model.add(Dense(64, activation='relu', kernel_initializer='random_normal', input_dim
                ↪ =128))
233         model.add(Dense(64, activation='relu', kernel_initializer='random_normal'))
234         model.add(Dense(64, activation='relu', kernel_initializer='random_normal'))
235         model.add(Dense(64, activation='relu', kernel_initializer='random_normal'))
236         model.add(Dense(1, activation='sigmoid', kernel_initializer='random_normal'))
237         model.compile(optimizer ='adam',loss='binary_crossentropy', metrics =['accuracy'])
238 
239         model.fit(x_train, y_train, batch_size=10, epochs=20)
240         score = model.evaluate(x_test, y_test)
241         print("score:", score)
242 
243         model.save(model_path)
244         print("Model saved as " + str(model_path))
245         plot_model(model, to_file="output/nn_model.png", show_shapes=True)
246 
247     elif classification == "CNN":
248         import keras
249         from keras.layers import Conv2D, Dense, Dropout, Flatten, MaxPooling2D
250         from keras.models import Sequential
251         from keras.optimizers import Adam, SGD
252         from keras.utils import plot_model
253 
254         np.random.seed(123)
255         size = 72
256 
257         # Pad and resize images to size by size
258         # resize_images(F_TRAIN_DIR, F_TRAIN_CNN_DIR, size)
259         # resize_images(M_TRAIN_DIR, M_TRAIN_CNN_DIR, size)
260         # resize_images(F_TEST_DIR, F_TEST_CNN_DIR, size)
261         # resize_images(M_TEST_DIR, M_TEST_CNN_DIR, size)
```

```
262
263         x_train, y_train = get_data(F_TRAIN_CNN_DIR, M_TRAIN_CNN_DIR)
264         x_test, y_test = get_data(F_TEST_CNN_DIR, M_TEST_CNN_DIR)
265
266         model = Sequential()
267         model.add(Conv2D(32, (3, 3), activation="relu", input_shape=(size, size, 3)))
268         model.add(Conv2D(32, (3, 3), activation="relu"))
269         model.add(MaxPooling2D(pool_size=(2, 2)))
270         model.add(Dropout(0.25))
271
272         model.add(Conv2D(64, (3, 3), activation="relu"))
273         model.add(Conv2D(64, (3, 3), activation="relu"))
274         model.add(MaxPooling2D(pool_size=(2, 2)))
275         model.add(Dropout(0.25))
276
277         model.add(Conv2D(128, (3, 3), activation="relu"))
278         model.add(Conv2D(128, (3, 3), activation="relu"))
279         model.add(MaxPooling2D(pool_size=(2, 2)))
280         model.add(Dropout(0.25))
281
282         model.add(Flatten())
283         model.add(Dense(256, activation="relu"))
284         model.add(Dropout(0.5))
285         model.add(Dense(2, activation="softmax"))
286
287         adam = Adam(lr=0.0005)
288         model.compile(loss="binary_crossentropy", optimizer=adam, metrics=["accuracy"])
289
290         model.fit(x_train, y_train, epochs=10)
291         score = model.evaluate(x_test, y_test)
292         print("score:", score)
293
294         model.save(model_path)
295         print("Model saved as " + str(model_path))
296         plot_model(model, to_file="output/cnn_model.png", show_shapes=True)
297
298     else:
299         raise ValueError("Illegal classification value")
300
301 def predict_model(model_path):
302     """
303     Get accuacy of test set for either the SVM or neural network model.
304     """
305     print("predict_model")
306     F_TEST_DIR = "data/female_test/"
307     M_TEST_DIR = "data/male_test/"
308
309     ext = os.path.splitext(model_path)[1]
310     if ext == ".sav":
311         model = pickle.load(open(model_path, "rb"))
312     elif ext == ".h5":
313         from keras.models import load_model
314         model = load_model(model_path)
315     else:
316         raise ValueError("Not valid model extension")
317
318     sift = cv2.xfeatures2d.SIFT_create()
319
320     correct = 0
```

```
321     for filename in os.listdir(F_TEST_DIR):
322         if not filename.endswith(".png"):
323             continue
324         img = cv2.imread(os.path.join(F_TEST_DIR, filename))
325         kps, des = sift.detectAndCompute(img, None)
326         result = model.predict(des)
327         if ext == ".sav":
328             f_count = np.count_nonzero(result == -1)
329             m_count = np.count_nonzero(result == 1)
330         elif ext == ".h5":
331             f_count = np.sum(result < 0.5)
332             m_count = np.sum(result > 0.5)
333         if f_count > m_count:
334             correct += 1
335 
336     for filename in os.listdir(M_TEST_DIR):
337         if not filename.endswith(".png"):
338             continue
339         img = cv2.imread(os.path.join(M_TEST_DIR, filename))
340         kps, des = sift.detectAndCompute(img, None)
341         result = model.predict(des)
342         if ext == ".sav":
343             f_count = np.count_nonzero(result == -1)
344             m_count = np.count_nonzero(result == 1)
345         elif ext == ".h5":
346             f_count = np.sum(result < 0.5)
347             m_count = np.sum(result > 0.5)
348         if m_count > f_count:
349             correct += 1
350     score = correct / (len(os.listdir(F_TEST_DIR)) + len(os.listdir(M_TEST_DIR))) * 100
351     print(str(score) + "% of images are categorized correctly")
352 
353 def face_detection_hsv(input_dir, output_dir):
354     """
355     Face detection with HSV color detection (does not work well).
356     """
357     print("face_detection_hsv")
358 
359     if not os.path.isdir(output_dir):
360         os.mkdir(output_dir)
361     for filename in os.listdir(input_dir):
362         if not filename.endswith(".jpg"):
363             continue
364         img = cv2.imread(os.path.join(input_dir, filename))
365 
366         # HSV color detection
367         hsv_img = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)
368 
369         lower1 = np.array([0, 48, 80])
370         upper1 = np.array([20, 255, 255])
371         mask1 = cv2.inRange(hsv_img, lower1, upper1) # img_hsv.shape
372         lower2 = np.array([170, 0, 0])
373         upper2 = np.array([180, 255, 255])
374         mask2 = cv2.inRange(hsv_img, lower2, upper2) # img_hsv.shape
375         mask = cv2.bitwise_or(mask1, mask2)
376 
377         kernel = cv2.getStructuringElement(cv2.MORPH_ELLIPSE, (10, 10))
378         new_img = cv2.bitwise_and(img, img, mask=mask)
379         cv2.imwrite(os.path.join(output_dir, filename), new_img)
```

```
380
381 def face_detection_cascade(input_dir, output_dir, model_path, classification, min_size):
382     """
383     Face detection with classifier, face tracking, and gender classification
384     using the method specified in classification variable using model_path.
385     """
386     print("face_detection_cascade")
387     XML_FILENAME = "models/haarcascade_frontalface_default.xml"
388     F_TEXT = "Female"
389     M_TEXT = "Male"
390     O_TEXT = "Not sure"
391     F_COLOR = (0, 0, 255)
392     M_COLOR = (255, 0, 0)
393     O_COLOR = (0, 255, 0)
394
395     if classification == "SVM":
396         model = pickle.load(open(model_path, "rb"))
397     elif classification == "NN_SIFT":
398         from keras.models import load_model
399         model = load_model(model_path)
400     elif classification == "CNN":
401         from keras.models import load_model
402         model = load_model(model_path)
403         size = 72
404     else:
405         raise ValueError("Illegal classification value")
406
407     if not os.path.isdir(output_dir):
408         os.mkdir(output_dir)
409
410     exts = [".jpg", ".png"]
411     img_names = [img for img in os.listdir(input_dir) if img.endswith(tuple(exts))]
412     # Sort images by name in ascending order
413     img_names.sort(key=lambda img: int("".join(filter(str.isdigit, img))))
414     sift = cv2.xfeatures2d.SIFT_create()
415     index_params = dict(algorithm=0, trees=5)
416     flann = cv2.FlannBasedMatcher(index_params, None)
417     face_count = 0
418     prev_faces = {}
419
420     for filename in img_names:
421         img = cv2.imread(os.path.join(input_dir, filename))
422         img_g = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
423
424         ##############################
425         ### Cascade face detection ###
426         ##############################
427         face_cascade = cv2.CascadeClassifier(XML_FILENAME)
428         faces = face_cascade.detectMultiScale(img_g, scaleFactor=1.3,
429             minNeighbors=5, minSize=(min_size, min_size))
430         curr_faces = {}
431
432         for x, y, w, h in faces:
433             ######################
434             ### Face tracking ###
435             ######################
436             face = img[y:y+h, x:x+w]
437             kp1, des1 = sift.detectAndCompute(face, None)
438             found_face = False
```

```
            for (x2, y2, w2, h2), index in prev_faces.items():
                face2 = img[y2:y2+h, x2:x2+w]
                kp2, des2 = sift.detectAndCompute(face2, None)
                if len(kp1) < 2 or len(kp2) < 2:
                    continue
                matches = flann.knnMatch(des1, des2, k=2)
                good_matches = []
                for m, n in matches:
                    if m.distance < 0.6*n.distance:
                        good_matches.append(m)
                num_kps = 0
                if len(kp1) <= len(kp2):
                    num_kps = len(kp1)
                else:
                    num_kps = len(kp2)
                score = len(good_matches) / num_kps * 100
                if score > 45:
                    found_face = True
                    face_number = index
                    curr_faces[(x, y, w, h)] = index
            if not found_face:
                face_number = face_count
                curr_faces[(x, y, w, h)] = face_count
                face_count += 1

            ##############################
            ### Gender classification ###
            ##############################
            if classification == "SVM":
                # Get SIFT descriptors
                kps, des = sift.detectAndCompute(face, None)
                # Predict female or male
                result = model.predict(des)
                f_count = np.count_nonzero(result == -1)
                m_count = np.count_nonzero(result == 1)
                # Plot color box
                if f_count > m_count:
                    text = str(face_number) + " " + F_TEXT + ": " +\
                        format(f_count/(f_count + m_count)*100, ".2f") + "%"
                    color = F_COLOR
                elif m_count > f_count:
                    text = str(face_number) + " " + M_TEXT + ": " +\
                        format(m_count/(f_count + m_count)*100, ".2f") + "%"
                    color = M_COLOR
                else:
                    text = str(face_number) + " " + O_TEXT
                    color = O_COLOR

            elif classification == "NN_SIFT":
                assert w == h
                kps, des = sift.detectAndCompute(face, None)
                prediction = model.predict(des)
                f_count = np.sum(prediction < 0.5)
                m_count = np.sum(prediction > 0.5)
                if f_count > m_count:
                    text = str(face_number) + " " + F_TEXT + ": " +\
                        format(f_count/(f_count + m_count)*100, ".2f") + "%"
                    color = F_COLOR
                elif m_count > f_count:
```

```
                text = str(face_number) + " " + M_TEXT + ": " +\
                    format(m_count/(f_count + m_count)*100, ".2f") + "%"
                color = M_COLOR
            else:
                text = str(face_number) + " " + O_TEXT
                color = O_COLOR

        elif classification == "CNN":
            assert w == h
            face = cv2.resize(face, (size, size))
            prediction = model.predict(np.array([face]), verbose=0)
            prediction = prediction[0]
            if prediction[0] > 0.5:
                text = str(face_number) + " " + F_TEXT + ": " +\
                    format(prediction[0]*100, ".2f") + "%"
                color = F_COLOR
            elif prediction[0] < 0.5:
                text = str(face_number) + " " + M_TEXT + ": " +\
                    format(prediction[0]*100, ".2f") + "%"
                color = M_COLOR
            else:
                text = str(face_number) + " " + O_TEXT
                color = O_COLOR
        cv2.rectangle(img, (x, y), (x+w, y+h), color, thickness=2)
        cv2.putText(img, text, (x, y-10), color=color,
            fontFace=cv2.FONT_HERSHEY_PLAIN, fontScale=1)

    prev_faces = curr_faces
    cv2.imwrite(os.path.join(output_dir, filename), img)
    # cv2.imshow("img", img)
    # cv2.waitKey(0)
```

Listing 4: utils.py

```
import cv2
import os
import numpy as np

def make_video(imgs_dir, vid_name, fps):
    """
    Make vid_name.mp4 using images in imgs_dir.
    """
    OUTPUT_DIR = "output/"
    if not os.path.isdir(OUTPUT_DIR):
        os.mkdir(OUTPUT_DIR)
    exts = [".jpg", ".png"]
    imgs = [img for img in os.listdir(imgs_dir) if img.endswith(tuple(exts))]
    # Sort images by name in ascending order
    imgs.sort(key=lambda img: int("".join(filter(str.isdigit, img))))
    frame = cv2.imread(os.path.join(imgs_dir, imgs[0]))
    h, w, _ = frame.shape

    # Make sure vid_name does not include a file extension
    index = vid_name.find(".")
    if index != -1:
        vid_name = vid_name[:index]
    file_path = OUTPUT_DIR + vid_name + ".mp4"
    vid = cv2.VideoWriter(file_path, cv2.VideoWriter_fourcc(*"MP4V"), fps, (w, h))
    for img in imgs:
        vid.write(cv2.imread(os.path.join(imgs_dir, img)))
```

```
    vid.release()
    print("Video is now in ", file_path)

def shuffle(x, y):
    """
    Shuffle data x and their labels y.
    """
    assert len(x) == len(y)
    idx = np.random.permutation(len(x))
    x, y = np.array(x)[idx], np.array(y)[idx]
    return x, y
```

Listing 5: run.py

```
import click
from pathlib import Path

@click.group()
def main():
    pass

@main.command()
# @click.option("--model_path", "-m", type=Path, default="models/cnn_model.h5")
@click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
@click.option("--classification", "-c", default="SVM", help="SVM or NN_SIFT or CNN")
def train(**kwargs):
    from face import train_model
    train_model(**kwargs)

@main.command()
# @click.option("--model_path", "-m", type=Path, default="models/nn_model.h5")
@click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
def predict(**kwargs):
    from face import predict_model
    predict_model(**kwargs)

@main.command()
@click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
# @click.option("--model_path", "-m", type=Path, default="models/nn_model.h5")
@click.option("--classification", "-c", default="SVM", help="SVM or NN_SIFT or CNN")
# Clip 1
@click.option("--input_dir", "-i", type=Path, default="original_data/clip_1/")
@click.option("--output_dir", "-o", type=Path, default="output/clip_1_face/")
@click.option("--min_size", "-s", default=70, type=int, help="Min size for face
    ↪ detection")
# Clip 2
# @click.option("--input_dir", "-i", type=Path, default="original_data/clip_2/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_2/")
# @click.option("--min_size", "-s", default=70, type=int, help="Min size for face detection")
def face_detection(**kwargs):
    from face import face_detection_hsv, face_detection_cascade
    # face_detection_hsv(**kwargs)
    face_detection_cascade(**kwargs)

@main.command()
# Clip 1
# @click.option("--input_dir", "-i", type=Path, default="original_data/clip_1/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_1_logo/")
# @click.option("--logo_path", "-d", type=Path, default="data/clip_1_logo2.png")
# @click.option("--min_threshold", "-t", type=float, default=0.87)
```

```
# Clip 2
# @click.option("--input_dir", "-i", type=Path, default="original_data/clip_2/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_2/")
# @click.option("--logo_path", "-d", type=Path, default="data/clip_2_logo.png")
# @click.option("--min_threshold", "-t", type=float, default=0.82)
# Clip 3
@click.option("--input_dir", "-i", type=Path, default="original_data/clip_3/")
@click.option("--output_dir", "-o", type=Path, default="output/clip_3/")
@click.option("--logo_path", "-d", type=Path, default="data/clip_3_logo.png")
@click.option("--min_threshold", "-t", type=float, default=0.82)
def logo_detection(**kwargs):
    from logo import logo_detection
    logo_detection(**kwargs)

@main.command()
@click.option("--input_dir", "-i", type=Path, default="original_data/clip_3/")
@click.option("--method", "-m", default="SAD2", help="SAD2 or HD")
@click.option("--k", "-k", default=1, help="k used in threshold")
def shot_detection(**kwargs):
    from shot import shot_detection
    shot_detection(**kwargs)

@main.command()
@click.option("--imgs_dir", "-i", default="original_data/clip_1/", type=Path)
@click.option("--vid_name", "-v", default="clip_1")
@click.option("--fps", "-fps", default=6, type=int, help="Frame per second")
def make_video(**kwargs):
    from utils import make_video
    make_video(**kwargs)

@main.command()
# Clip 1
@click.option("--input_dir", "-i", type=Path, default="original_data/clip_1/")
@click.option("--output_dir", "-o", type=Path, default="output/clip_1_shots/")
@click.option("--shots", "-s", type=list, default=[22, 156])
# Clip 2
# @click.option("--input_dir", "-i", type=Path, default="original_data/clip_2/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_2_shots/")
# @click.option("--shots", "-s", type=list, default=[65, 120, 138, 144, 152, 164, 177, 188])
# Clip 3
# @click.option("--input_dir", "-i", type=Path, default="original_data/clip_3/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_3_shots/")
# @click.option("--shots", "-s", type=list, default=[16, 51, 57, 59, 61, 63, 65, 67, 69, 71, 72, 74, 78, 80, 84, 91,
    ↪ 95, 102, 165, 187, 260, 267])
def add_shot_number(**kwargs):
    from shot import add_shot_number
    add_shot_number(**kwargs)

@main.command()
# Clip 1
@click.option("--input_dir", "-i", type=Path, default="output/clip_1_shots/")
@click.option("--output_dir", "-o", type=Path, default="output/clip_1_two/")
@click.option("--logo_path", "-d", type=Path, default="data/clip_1_logo.png")
@click.option("--min_threshold", "-t", type=float, default=0.87)
@click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
@click.option("--classification", "-c", default="SVM", help="SVM or NN_SIFT or CNN")
@click.option("--vid_name", "-v", default="clip_1_two")
@click.option("--fps", "-fps", default=6, type=int, help="Frame per second")
```

```
@click.option("--min_size", "-s", default=70, type=int, help="Min size for face
    ↪ detection")
# Clip 2
# @click.option("--input_dir", "-i", type=Path, default="output/clip_2_shots/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_2/")
# @click.option("--logo_path", "-d", type=Path, default="data/clip_2_logo.png")
# @click.option("--min_threshold", "-t", type=float, default=0.82)
# @click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
# @click.option("--classification", "-c", default="SVM", help="SVM or NN_SIFT or CNN")
# @click.option("--vid_name", "-v", default="clip_2")
# @click.option("--fps", "-fps", default=6, type=int, help="Frame per second")
# @click.option("--min_size", "-s", default=70, type=int, help="Min size for face detection")
# Clip 3
# @click.option("--input_dir", "-i", type=Path, default="output/clip_3_shots/")
# @click.option("--output_dir", "-o", type=Path, default="output/clip_3/")
# @click.option("--logo_path", "-d", type=Path, default="data/clip_3_logo.png")
# @click.option("--min_threshold", "-t", type=float, default=0.82)
# @click.option("--model_path", "-m", type=Path, default="models/svm_model.sav")
# @click.option("--classification", "-c", default="SVM", help="SVM or NN_SIFT or CNN")
# @click.option("--vid_name", "-v", default="clip_3")
# @click.option("--fps", "-fps", default=10, type=int, help="Frame per second")
# @click.option("--min_size", "-s", default=40, type=int, help="Min size for face detection")
def run_all(input_dir, output_dir, logo_path, min_threshold, model_path, \
    classification, vid_name, fps, min_size):
    from face import face_detection_cascade
    from logo import logo_detection
    from utils import make_video
    logo_detection(input_dir=input_dir, output_dir=output_dir,\
        logo_path=logo_path, min_threshold=min_threshold)
    face_detection_cascade(input_dir=output_dir, output_dir=output_dir,\
    # face_detection_cascade(input_dir=input_dir, output_dir=output_dir,\
        model_path=model_path, classification=classification, min_size=min_size)
    make_video(imgs_dir=output_dir, vid_name=vid_name, fps=fps)

if __name__ == "__main__":
    main()
```