# COMP6223 Coursework 2: Subverting Face Detection

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## 1. Introduction

This report presents the results and findings for the tasks stated in COMP6223 coursework 2. In this report, different types of camouflages are explored and added to my own face in hopes of subverting the Viola-Jones face detector [9]. The only condition imposed in the coursework is that the camouflage should be non-invasive and have minimal occlusion.

## 2. Viola-Jones Object Detector

Viola-Jones, or Haar Cascade face detector was proposed by Viola and Jones [9] in 2001. The framework uses three main concepts, namely: "Integral Image", AdaBoost feature selector and cascade classifier.

First, a subwindow (originally $24 \times 24$) is chosen. Within the subwindow, the author proposed the use of four Haar-like features to match every pixel. In a $24 \times 24$ subwindow, there exist a set of over 160,000 features. The subwindow is shifted over the the image, similar to a convolution operation.

Integral Image was proposed to be able to calculate the sum of values of a block of pixels in linear time, more specifically 4 steps. This is important for the calculation of the Haar-like features as there are too many features.

Next, AdaBoost, a boosting algorithm which transforms a set of weak classifiers into a strong classifier, is then used to select a smaller set of features with the largest weights.

Finally, the features selected is then ordered in a cascade of classifiers, more specifically a degenerate decision tree. For every subwindow, if the values of the features passes through every classifier of the cascade, a face is detected.

## 3. Camouflages

Subversion of the Viola-Jones face detector can be done by camouflaging face components. There are two main types of camouflage: concealment and deception [3]. Both types of camouflage can be performed by occlusion, face paints, accessories (hat, glasses), jewellery and more.

Humans faces consist of five major face components: face shape, right and left eyes, right and left eyebrows, nose and lip. All the face components stated above can be camouflaged with different tools. The sections below explore the effective camouflages for different face components. Other miscellaneous approaches for effective camouflages will also be explored in Section 3.4. It should be noted that camouflages for the lips was not found, thus will not be discussed in this section.

Almost all camouflages in this report are added to images of my face using GNU Image Manipulation Program (GIMP) [8]. This is due to the lack of accessories and tools to complete real, physical camouflages.

### 3.1. Face Shape

Figure 1 shows an example of camouflage which attempts to modify the shape of the face. The camouflage used includes a face mask to deceive the chin area, a wig do alter the overall face structure, and a turban to change the forehead shape. The goal of the camouflage introduced is to modify the face shape into a non-round shape by introducing edges and curved surfaces. This approach of camouflage is proved to be effective in [3]

Through empirical findings, it was difficult to find camouflages that was able to deceive the face detector with face shapes. The Viola-Jones algorithm might not have many features that emphasises on the face shapes.

### 3.2. Eyes and Eyebrows

Figure 2 shows an example of camouflage which attempts to occlude eyebrows and facial features around the eyes. The camouflage used is a domino mask used by DC Comic's fictional character, Robin.

From personal observations and other empirical findings [4], it is identified that the area that intersects both eyes, and the area between the eyebrows and eyes are important features for the face detector. This is possibly due to the obvious significant difference of pixel values between those areas. By adding a black domino mask as a camouflage, there will be less difference in pixel values between those

(a) Neutral (b) Smiling

Figure 1: Face shape camouflage using face covering, wig (Sourced from [2]) and turban (Sourced from [6]) with face detection results of OpenCV online face detection tool.

(a) Neutral (b) Smiling with tongue out

Figure 2: Eyes camouflage using Robin mask (Sourced from [1]) with face detection results of OpenCV online face detection tool.

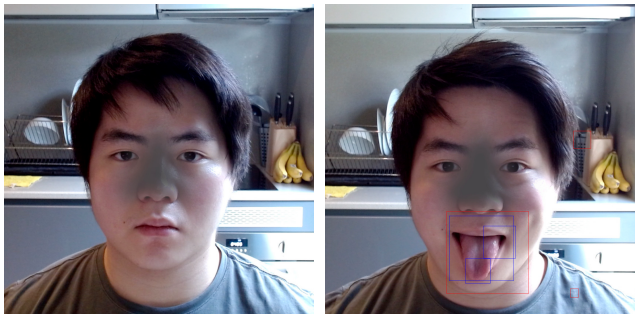
areas. Hence, it causes the Haar-like features (especially the black-white-black features) to have values indifferent to the classifier thresholds.

In addition, equipping myself with a Robin domino mask gives me the ability to be Batman's side-kick and fight crimes in the dark, hence being undetectable from face detectors.

### 3.3. Nose

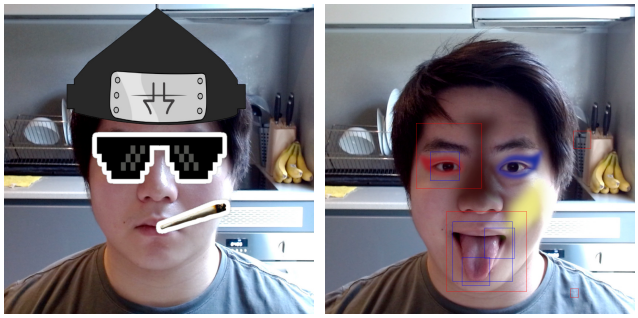
Figure 3 shows an example of camouflage on the nose bridge area. Using the paint brush function in GIMP, a grey colour was used to paint the nose bridge area. Gaussian blur is then applied to the paint repeatedly until it is observationally realistic. This approach is synonymous to when real face paint is applied to face.

With minimal effort, by just painting the nose bridge area, subversion of the face detector is achieved. Similar to Section 3.2, the Viola-Jones algorithm also prioritise on features around the nose bridge area. This is due to the significant difference of pixel values in that particular area. By applying "artificial" face paint, the Haar-like features will produce an output very indifferent of the threshold for the classification.



(a) Neutral (b) Smiling with tongue out

Figure 3: Nose camouflage using face paint with face detection results of OpenCV online face detection tool.



(a) Camouflage with ninja bandana and "thug life" meme glasses and cigarette (b) Camouflage with asymmetric colour and position of face paint

Figure 4: Miscellaneous camouflages (Sourced from [7, 5]) with face detection results of OpenCV online face detection tool.

### 3.4. Miscellaneous

There is a non-exhaustive list of approaches to subverting the face detector. There are two other approach that was found to be effective to the Viola-Jones algorithm.

First is to combine approaches from the previous sections to camouflage several face components at once. Figure 4a shows and example of camouflaging several face components.

Another approach that is found to be effective is asymmetry. Harvey [4] identified that asymmetry between left and right side of the face will allow for more effective camouflage. Figure 4b shows an example of asymmetric face paint applied using GIMP's paint brush and gaussian blur.

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