**Written Assignment 4**

1. When you examine the detected faces on the query images, what types of faces are hardest to detect? Why do you think these faces are hard to detect?

Darker-skinned faces are harder to detect. We trained and evaluate using grayscale, and darker-skinned faces don’t provide as much contrast as lighter-skinned faces do. Additionally, other faces that were more difficult to detect were faces that were not looking straight at the camera (chin up, or tongue out, etc) or had something occluding their face (hat, glasses, or another person). Our training set likely didn’t include a significant amount of faces beyond the normal shapes that would be needed to match all of these combinations of articles of clothing or other obstructions.

2. If you wanted to train a side face, or profile face detector how would you do it? Do you think detecting frontal faces or side faces would be easier?

I would provide lots of patches of side faces to train with. I would also expect training with side-faces to be more difficult. Frontal faces are symmetric about the middle vertical axis, while side faces are not. Additionally, different hair (and to a lesser extent ear) shapes can have a much stronger impact on matching side faces than they do frontal faces too.

3. In this assignment we only used Haar wavelets as features. What other features do you think would be useful? Would these new features be computationally efficient to compute?

Faces are generally circular, so being able to recognize shapes in the target picture would likely be beneficial in both confirming positives and rejecting negatives that are near the threshold. Shape recognition could likely be achieved with our previous work around interest point detection, and picking out edges (and corners, for shapes with corners).

Additionally, having features incorporate color would also be helpful, since faces are only certain colors (for instance, not blue, etc). Recognizing colors should be similarly straight-forward, and can be observed after our initial set of potential faces has been identified (to avoid scanning the entire image for interesting colors).

Finally, it might be useful to attempt to detect individual features of faces (for example, just eyes, nose, mouth), and if they are in the correct approximate relation to each other, then we can add confidence to our prior detections. Searching for individual features will likely add computation time similar to using face classifiers, so this approach may not be preferable for real-time detection applications.

4. Between three types of objects “Newsweek magazines, chairs and sheep” what is the easiest and hardest to recognize and why?

I would expect Newsweek magazines to be the easiest to match, because they always had the same header text across the top part of the front page of the magazine. The cover images themselves might differ, but a classifier could train on just the Newsweek logo in order to better recognize it.

I’d expect sheep to be intermediately difficult to train. They can be in any number of positions relative to the camera (facing away, facing towards, side, etc), but they are still somewhat predictable: white/light brown wool body, likely green or tan backdrop (grass/hay).

Chairs will likely be the hardest. They can come in all sorts of shapes and sizes, and some don’t even look like normal chairs, so training the classifer would be exceedingly difficult.