## Facial Recognition

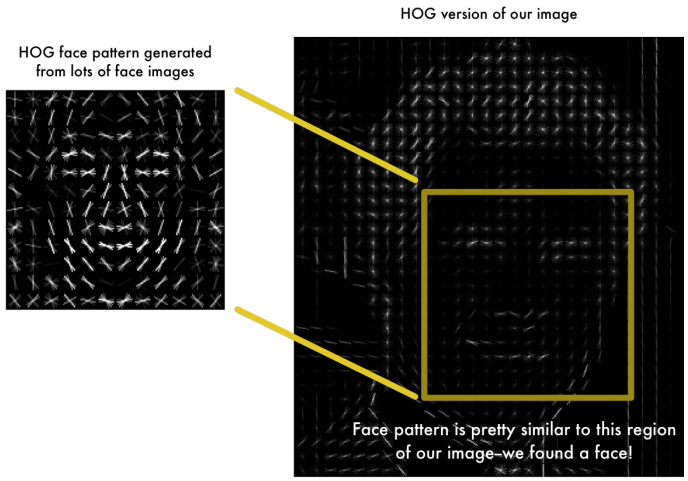
1. Look at a picture and find all the faces
2. Focus on each face and understand that even if a face is turned in a weird direction or bad lighting, it is still the same person
3. Pick out unique features to tell people apart
4. Compare unique features to people known to determine name

### Histogram of Oriented Gradients (HOG)

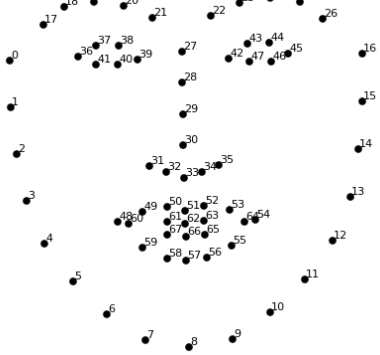
1. Make image black an white since we don't need color to find faces
2. Then look at every pixel, we will look at pixels directly surrounding it and determine how dark the current pixel is to those around it
    a. Then draw arrows in direction of darker image
    b. If repeated, every pixel becomes an arrow and these are called gradients
    c. They are used so that lighting will have negligible effect
    d. However, this is too much detail
3. Break image into small squares (16x16 for example)
    a. Count up how many gradients point in each major direction, then replace the square with arrow directions that were strongest

4. To find faces in this HOG image, all we have to do is find the part of our image that looks the most similar to a known HOG pattern that was extracted from a bunch of other training faces:

a.




5. Posing and Projecting Faces
    a. faces turned different directions look totally different to a computer:
    b. warp each picture so that the eyes and lips are always in the sample place in the image



c.

d. Now that we know where the eyes and mouth are, we'll simply rotate, scale and shear the image so that the eyes and mouth are centered as best as possible. We won't do any fancy 3d warps because that would introduce distortions into the image. We are only going to use basic image transformations like rotation and scale that preserve parallel lines (called affine transformations):

6. Encoding faces

a. Simplest method is compare previous tagged photos to new photos, however that will take forever

b. We need a few mathematical measurements from each face (so they can be placed into an array)

c. Things such as eye color, and facial structure (which make sense to humans) don't work that well for computers

d. Researchers find that the best method it to let the computer firgute out the best measurements

e. The solution is to train a Deep Convolutional Network (just like the bird classifier)

i. Train to Generate 128 measurements for each face

ii. Look at 3 face images at a time

1. Load training face image of a known person

2. Loan another picture of the same known person

3. Load a picture of a totally different person

iii. Then the algorithm looks at the measurements it is currently generating for each of those three images. It then tweaks the neural network slightly so that it makes sure the measurements it generates for #1 and #2 are slightly closer while making sure the measurements for #2 and #3 are slightly further apart

slightly further apart

iiii. Repeat missions of times for millions of images of thousands of people

v. 128 measurements are called an **embedding**

f. The process requires a lot of data and computer power

i. Once trained, it can generate measurements for any face (even new ones)

ii. Run face through pretrained network to get the 128 measurements

7. Finding the person's name from the encoding

a. All we have to do is find the person in our database of known people who has the closest measurements to our test image

b. Can be done with any basic ML classification

c. Use a basic Linear SVM classifier

Quick Rundown to Run:

1. Encode a picture using the HOG algorithm to create a simplified version of the image. Using this simplified image, find the part of the image that most looks like a generic HOG encoding of a face.
2. Figure out the pose of the face by finding the main landmarks in the face. Once we find those landmarks, use them to warp the image so that the eyes and mouth are centered.
3. Pass the centered face image through a neural network that knows how to measure features of the face. Save those 128 measurements.
4. Looking at all the faces we've measured in the past, see which person has the closest measurements to our face's measurements. That's our match!