The Hough Transform for Circles

Let's first review how to draw a circle in an image. The x and y coordinates of a circle can be found using the following parametric equations.

$$\mathbf{x = r \cos(t) + x_c}$$
$$\mathbf{y = r \sin(t) + y_c}$$

where $\mathbf{x_c}$ and $\mathbf{y_c}$ are the center coordinates of the circle, $\mathbf{r}$ is the radius and $\mathbf{t}$ is a parameter that varies from 0 to 2 pi (in small increments).

The Hough Transform for Circles

To modify the Hough Transform for lines so that it can find circles we would need to change the accumulator array. We now have a third variable that we need to search over. Namely, we need to find the most probable circle at a position x_1, y_1 with radius r_1.

Since we are working from the edge image, the voting will be performed for each edge point. That is, if an edge point has been encountered, then we will need to increment all possible cells in the accumulator array that could be the center of a circle for this point (this point lies on the perimeter).

Initialize variables **min_radius, max_radius** to set the minimum and maximum radii.

Initialize a variable called **threshold** to determine qualified peaks in the accumulator array.

Read image, find edge image **E,** get dimensions **y_dim**, **x_dim.**

Initialize accumulator array **ACC** with dimensions **y_dim**, **x_dim**, **max_radius**
for all pixels in **E**
    if pixel at (**x, y**) in **E** is an edge
        for **radius** = **min_radius** to **max_radius**
            for **theta** around the circle in degrees
                calculate possible center points
                xcp = **x** - **r** cosd(**theta**)
                ycp = **y** - **r** sind(**theta**)
                if point (**xcp, ycp**) is within bounds of the image
                    increment **ACC** cell at (**ycp, xcp, radius**)

Iterate through **ACC** to find qualifying peaks (> **threshold**) zeroing out the neighborhood of the peak after each iteration. Draw a circle for each peak on the original color image using the parametric equations above to verify location and radius.

Hint: you can find the coordinate (x_max, y_max) and radius (r_max) for the peak in **ACC** using the following code:

```
[v idx] = max(ACC(:));
[y_max, x_max, r_max] = ind2sub([size(E,1),size(E,2),max_radius], idx);
```