CSE185
Introduction to Computer Vision
Lab 08: Hough Transform

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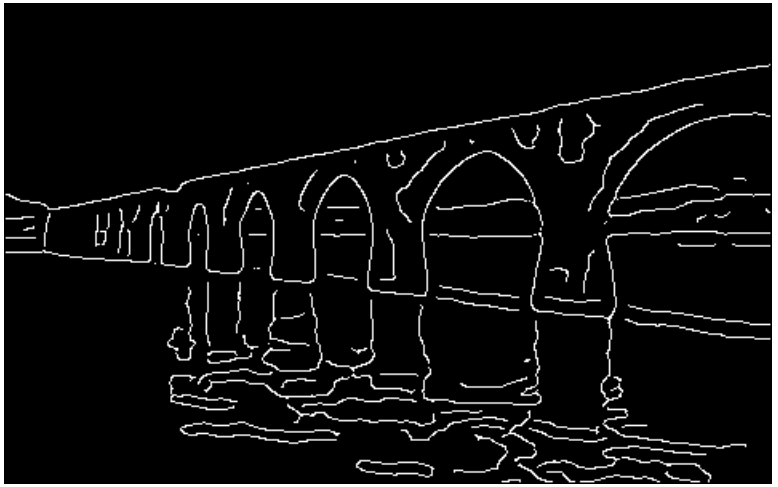
Line Fitting

- Given an input image, detect straight lines from the edge map



Line Equation in Cartesian Coordinate

- In image space:

$$y = m \cdot x + b$$

- In parameter/Hough space:

$$m = -\frac{1}{x} \cdot b + \frac{y}{x}$$

m: slope/gradient
b: intercept/offset

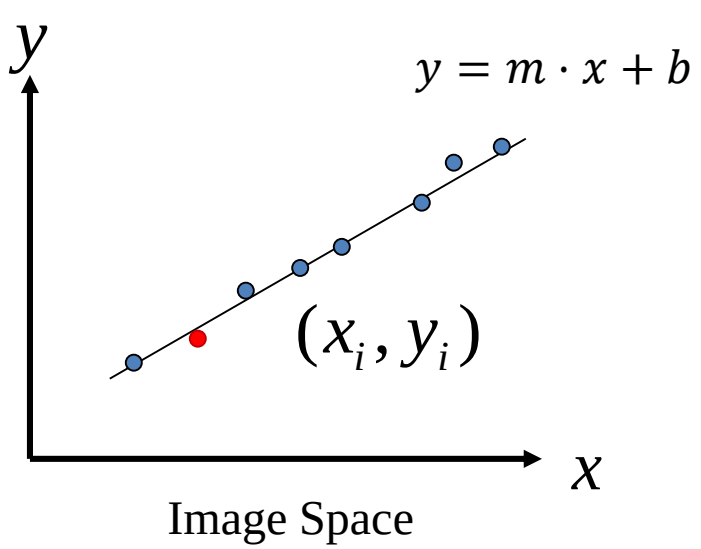
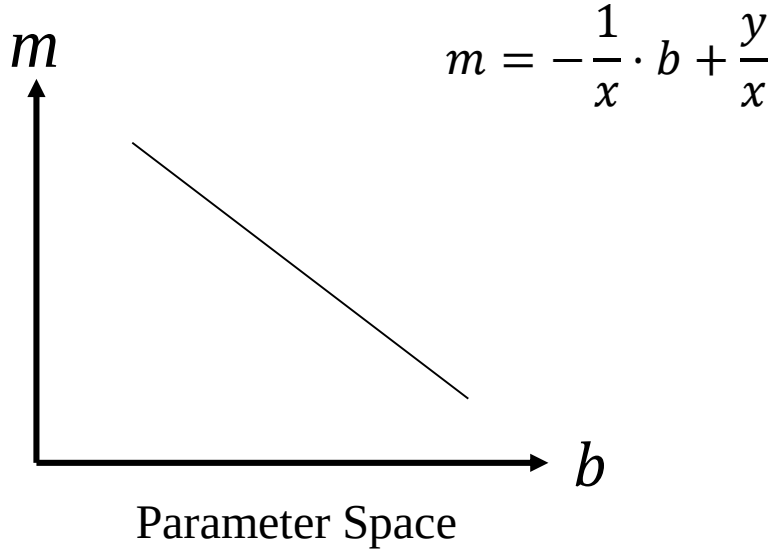


Image Space



Parameter Space

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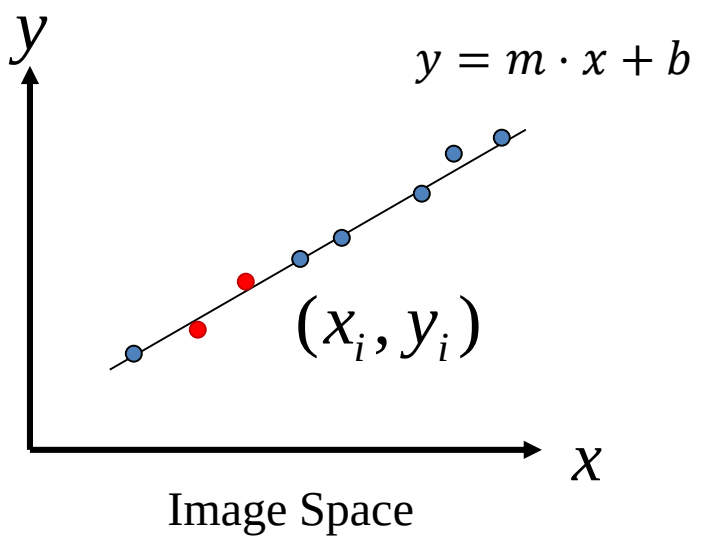
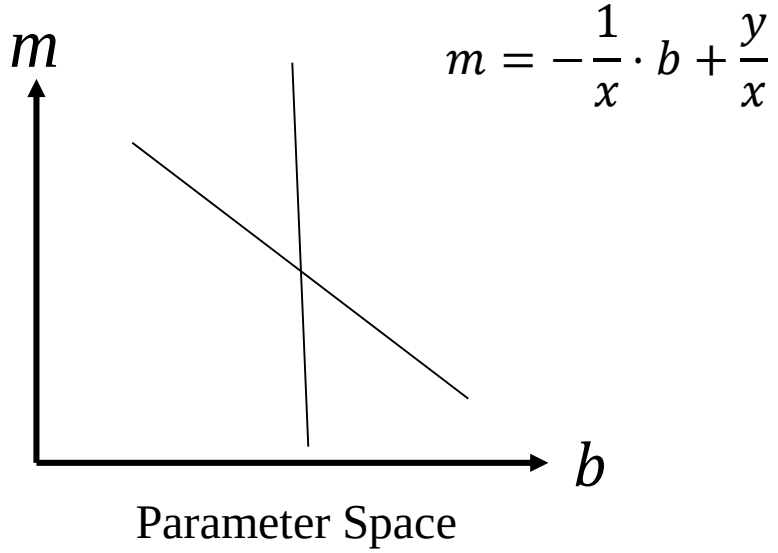


Image Space



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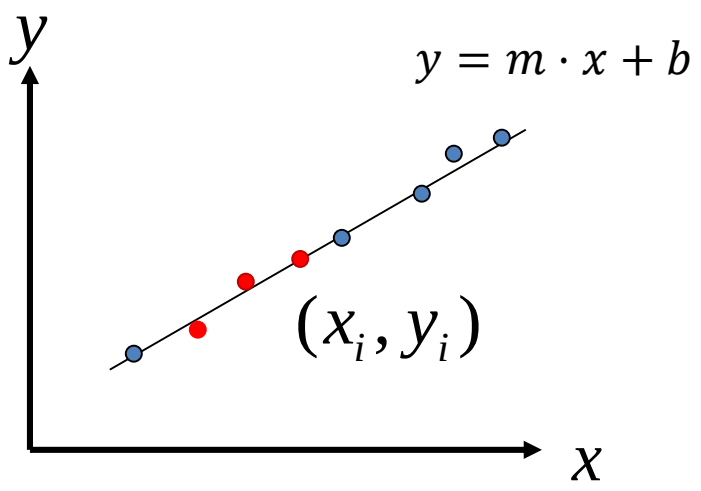
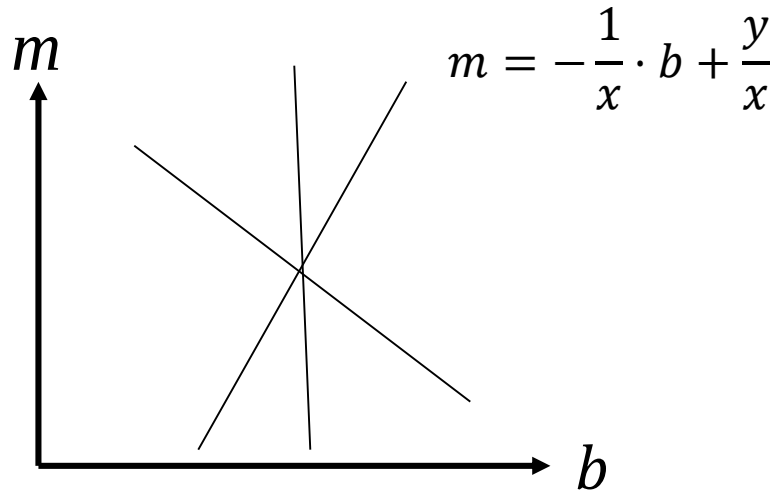


Image Space



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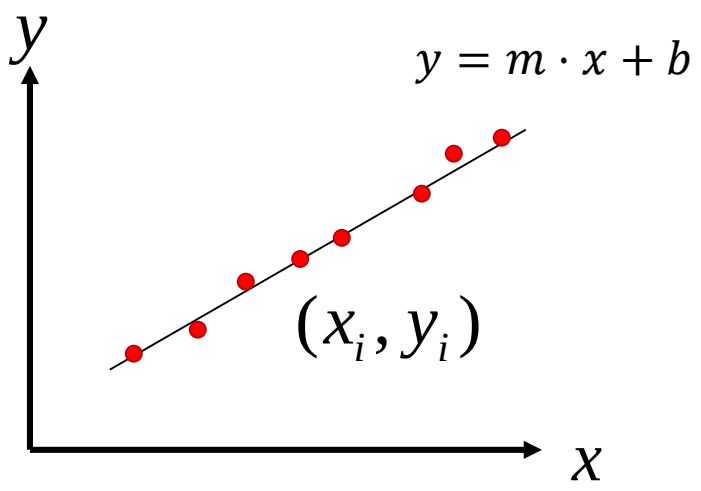
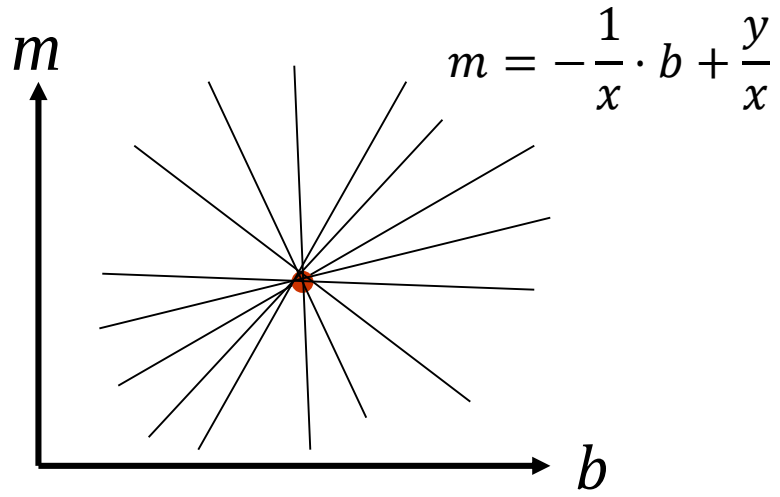


Image Space



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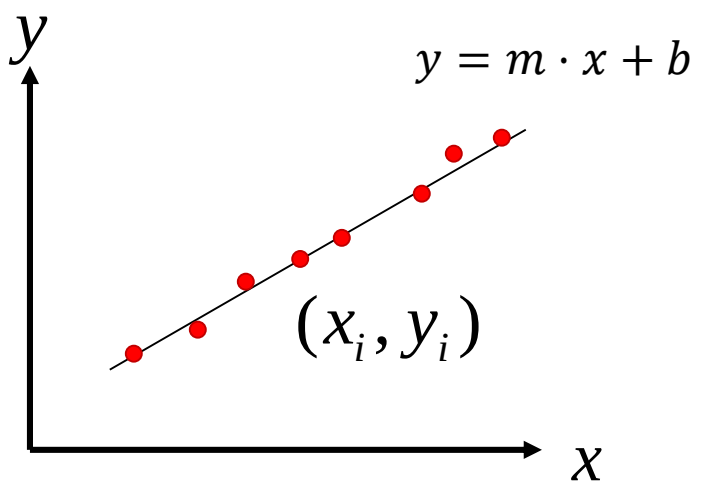
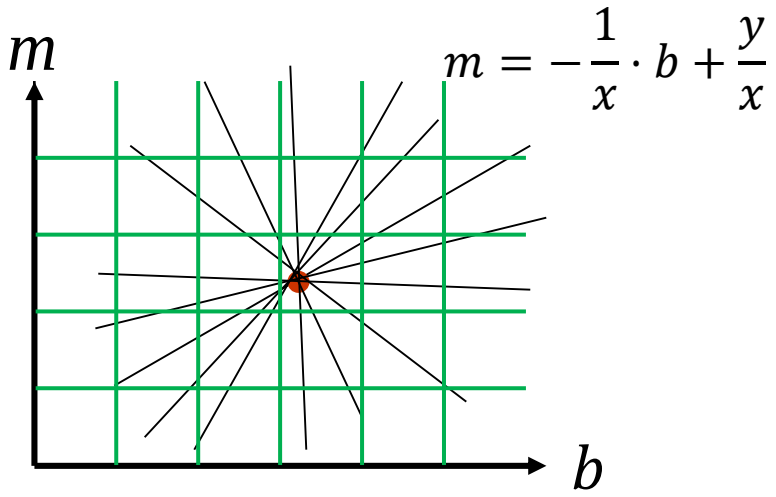


Image Space



Parameter Space

Hough Transform

- Algorithm:

```
quantize parameter space (m, b)
create a 2D accumulate matrix V

for each (x, y) in edge map:
    for each b:
        compute m = -1 / x * b + y / x
        add vote to V
    end
end

find the maximal votes in V
find the corresponding value of m and b
```

Hough Transform

- In hough_transform.m

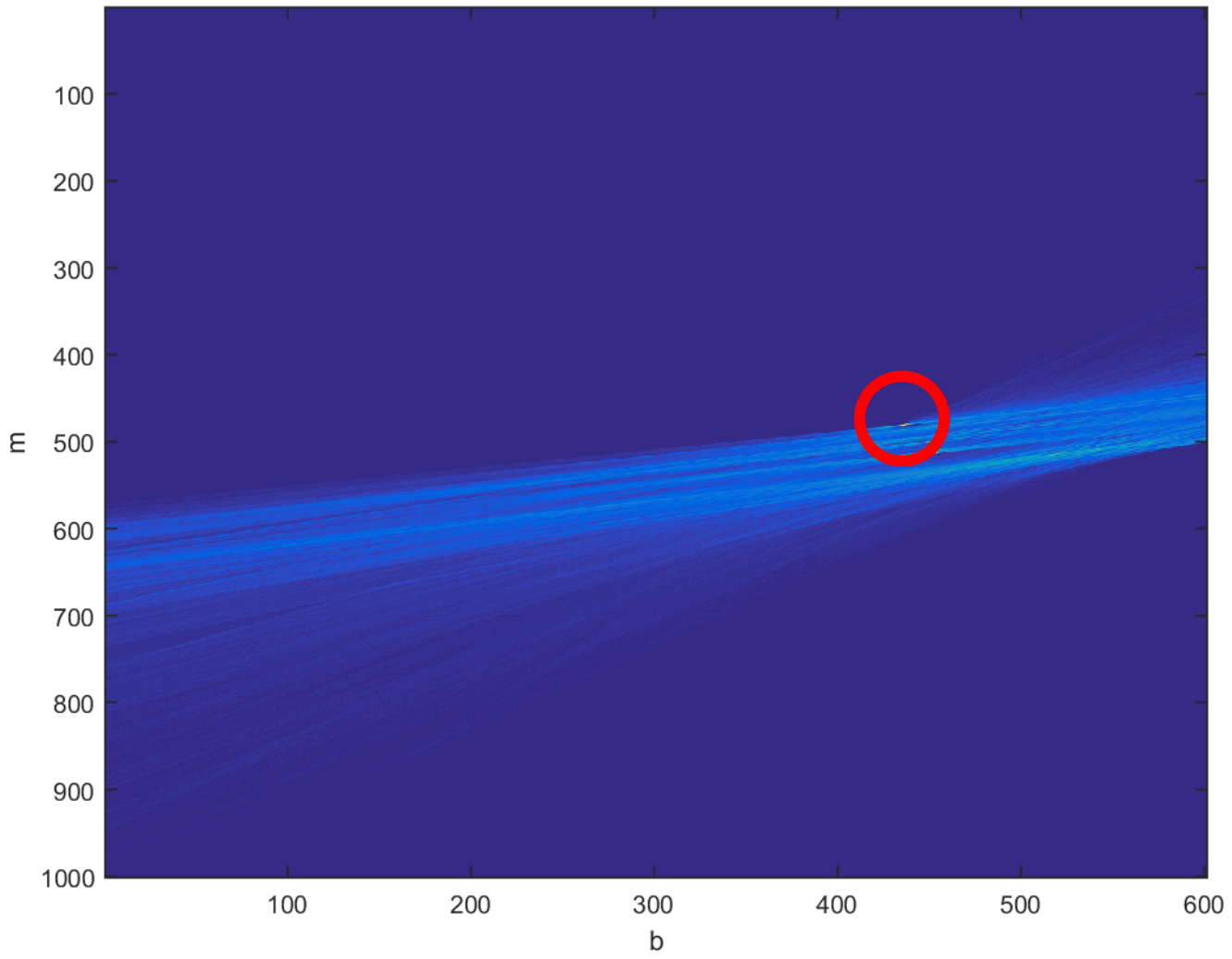
```
function [m, b] = hough_transform(edge_map)

    %% find x, y position from edge map
    [edge_y, edge_x] = find(edge_map);

    %% range of b
    H = size(edge_map, 1);
    b_range = -H : 1 : H;

    %% range of m
    m_step = 0.01;
    m_max = 5;
    m_min = -m_max;
    m_range = m_min : m_step : m_max;

    %% create vote matrix
    V = zeros(length(m_range), length(b_range));
```

Hough Transform

- In hough_transform.m

```
%% create vote matrix
V = zeros(length(m_range), length(b_range));

%% TODO: add votes



%% plot votes
figure, imagesc(V); xlabel('b'); ylabel('m');


%% find the maximal vote
max_vote = max(V(:));
[max_m_index, max_b_index] = find(V == max_vote);
m = m_range(max_m_index);
b = b_range(max_b_index);
```

Visualization of vote matrix



Detected Line

Your implementation (mb)

Hints

- for each (x, y) in edge map:

```
for i = 1:length(edge_y)
    y = edge_y(i);
    x = edge_x(i);
```

- for each b:

```
for b_index = 1:length(b_range)
    b = b_range(b_index);
```

Hints

- Before you add votes to V, check the range of m:

  m_min <= m <= m_max

- You should convert m, b to their indexes in matrix V

```
m_index = round( (m - m_min) / m_step ) + 1;

V(m_index, b_index) = V(m_index, b_index) + 1;
```

add 1 because index start from 1

Line Equation in Polar Coordinate

- $y = m \cdot x + b$ cannot represent vertical lines ($m \to \infty$):

- Use polar representation:

$$r = x\cos\theta + y\sin\theta$$

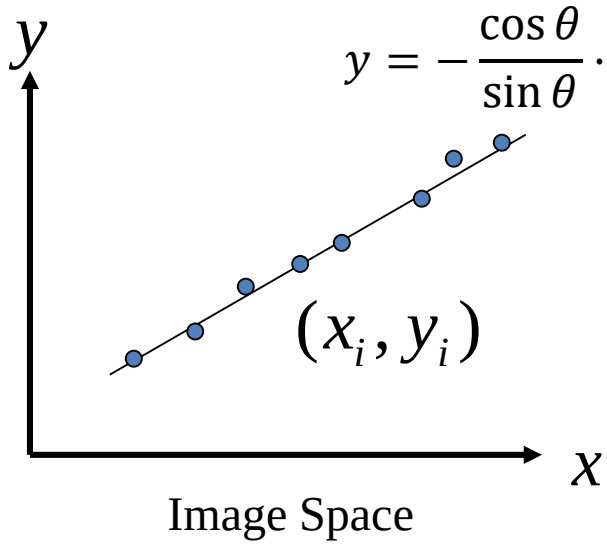
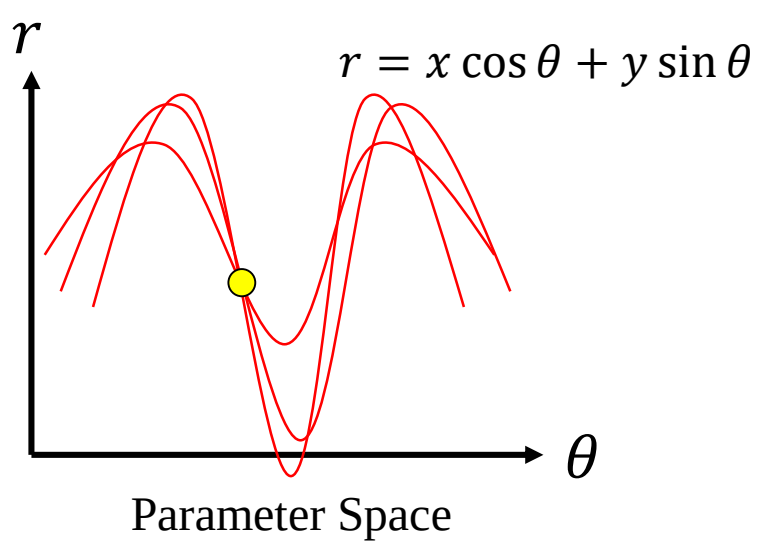


Image Space



Parameter Space

Hough Transform

- Algorithm:

```
quantize parameter space (r, theta)
create a 2D accumulate matrix V

for each (x, y) in edge map:
    for each theta:
        compute r = x * cos(theta) + y * sin(theta)
        add vote to V
    end
end

find the maximal votes in V
find the corresponding value of r and theta
```

Hough Transform

- In hough_transform_polar.m

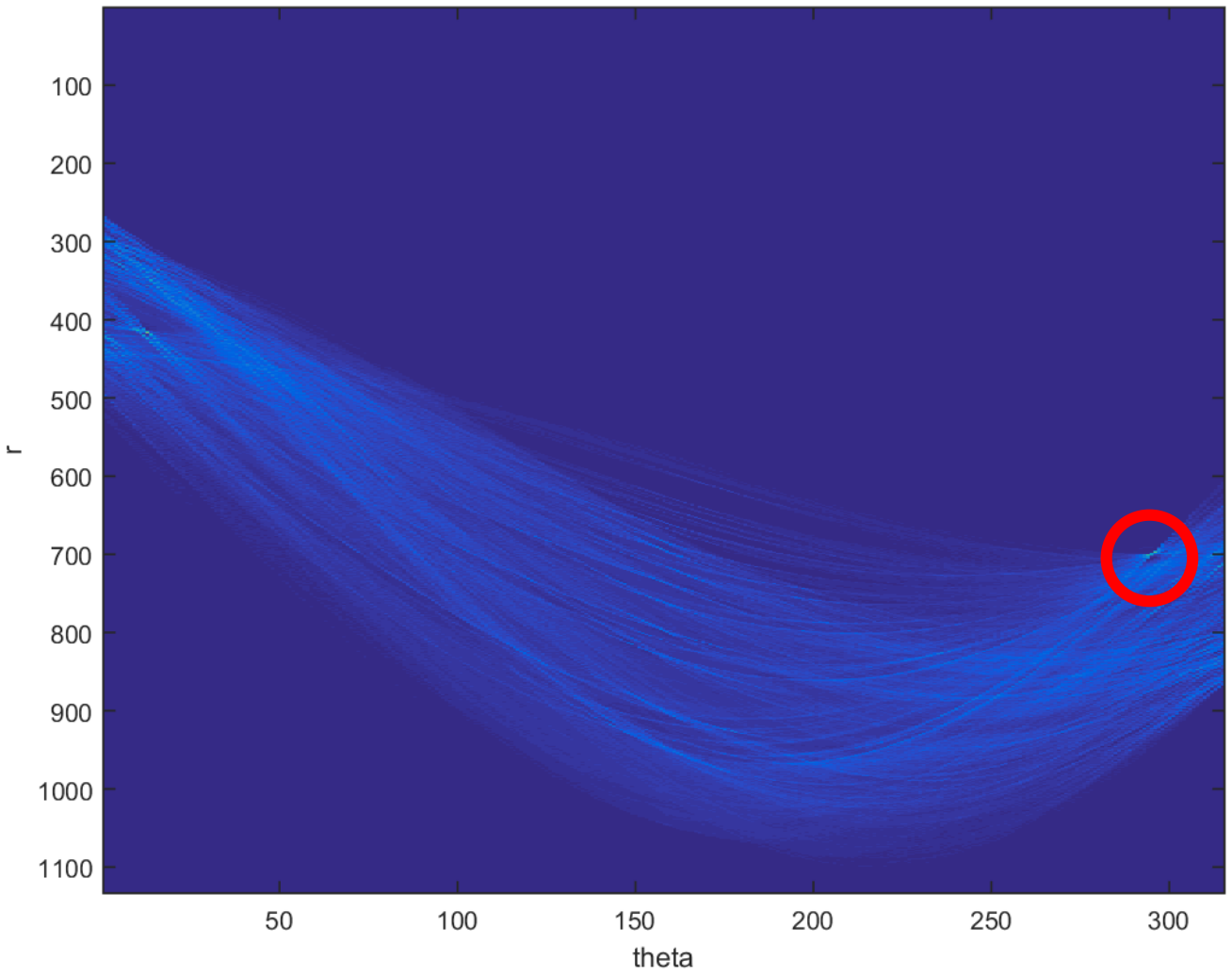
```
function [r, theta] = hough_transform_polar(edge_map)

    %% find x, y position from edge map
    [edge_y, edge_x] = find(edge_map);

    %% range of r
    H = size(edge_map, 1);
    W = size(edge_map, 2);
    r_max = round(sqrt(H^2 + W^2));
    r_min = -r_max;
    r_step = 1;
    r_range = r_min : r_step : r_max;

    %% range of theta
    theta_step = 0.01;
    theta_range = -pi/2 : theta_step : pi/2;
```

Hough Transform

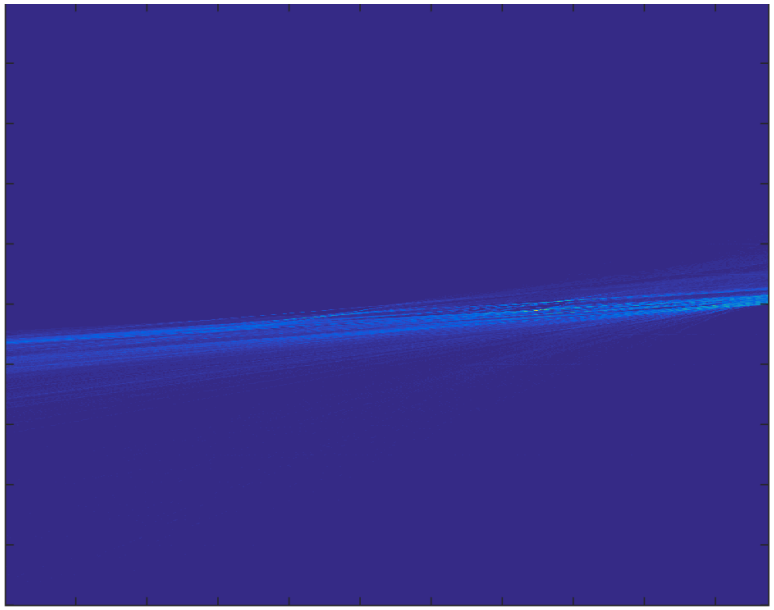
- In hough_transform_polar.m

```
%% create vote matrix
V = zeros(length(r_range), length(theta_range));

%% TODO: add votes



%% visualize votes
figure, imagesc(votes);
xlabel('theta'); ylabel('r');

%% find the maximal vote
max_vote = max(votes(:));
[max_r_index, max_theta_index]
                        = find( votes == max_vote );
r = r_range(max_r_index);
theta = theta_range(max_theta_index);
```

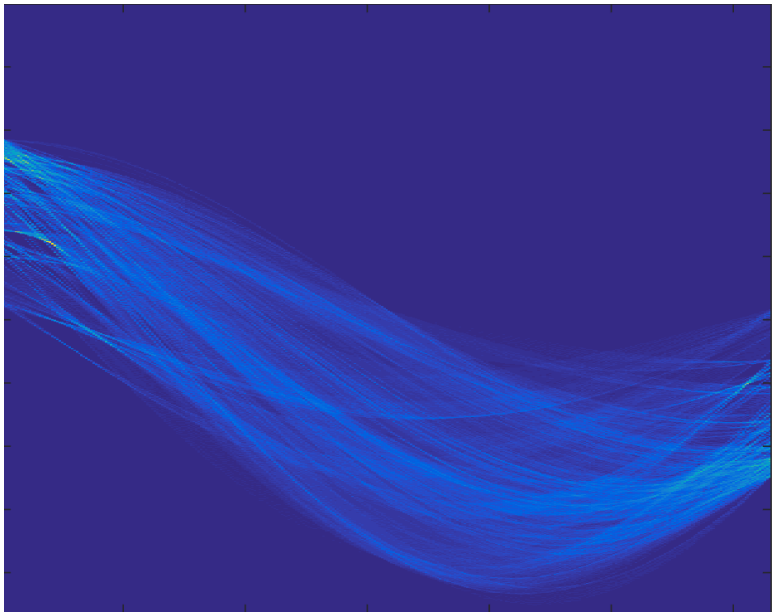
Visualization of vote matrix



Outputs

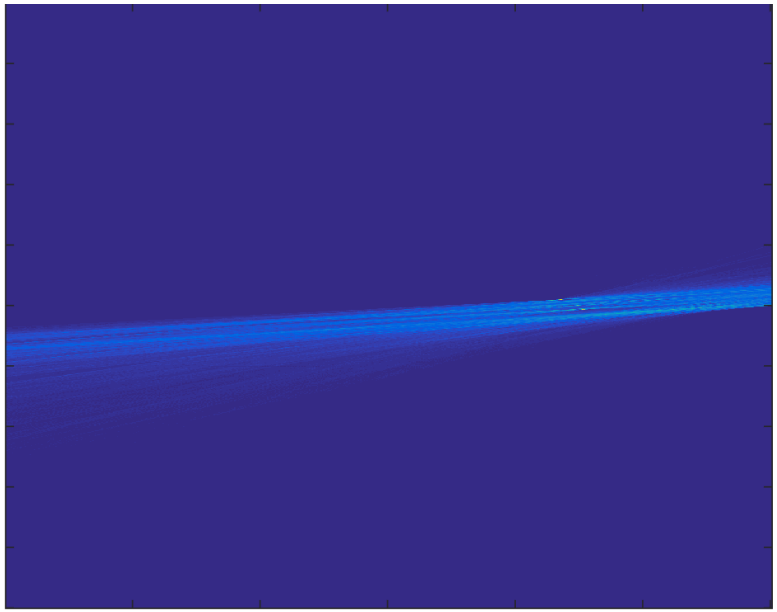


Cartesian space (m, b)

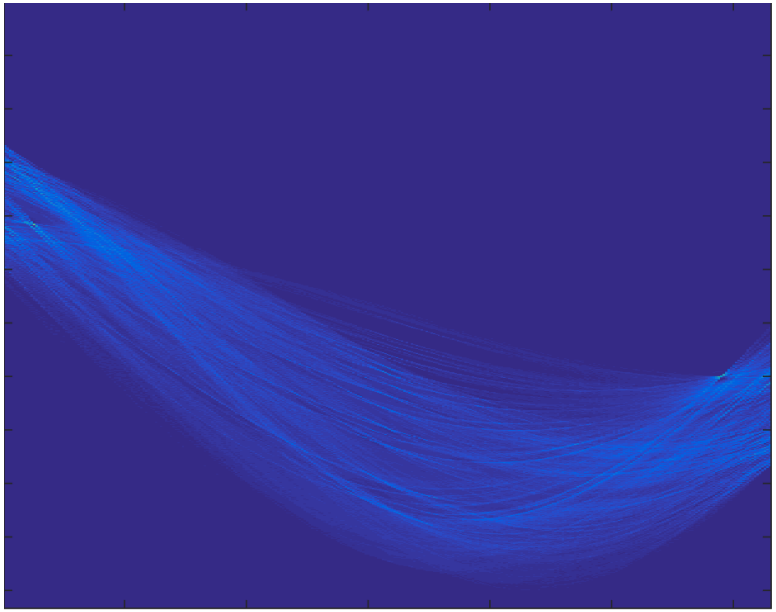


Polar space (r, θ)

Outputs



Cartesian space (m, b)

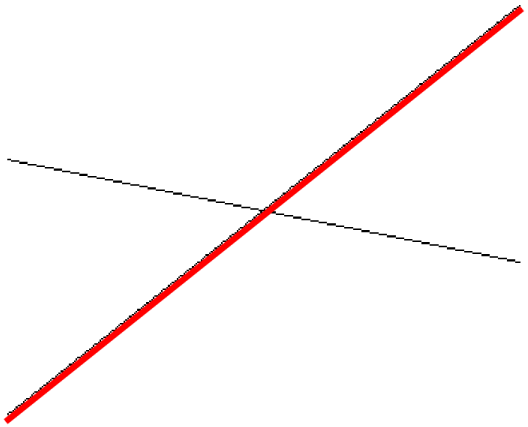


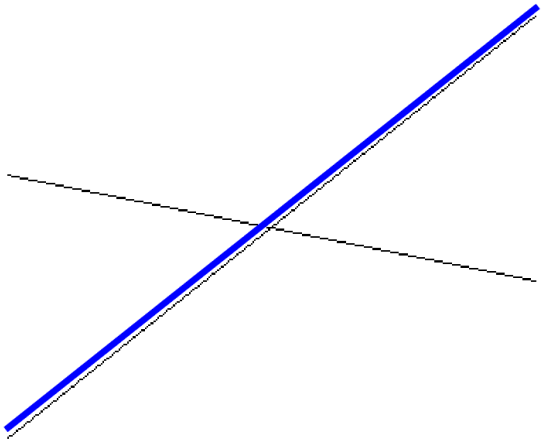
Polar space (r, θ)

Outputs

Cartesian space (m, b)

Polar space (r, θ)





TODO

- Implement hough_transform.m and hough_transform_polar.m
- Upload lab08.m, hough_transform.m (8pt), hough_transform_polar.m (8pt) and XXX_mb_line.png (2pt), XXX_polar_line.png (2pt) (XXX = lines, bridge, hill)