# Computer Vision:

## 1) Finding Lane lines:

First we need to develop a software pipeline that can be implemented on a series of images before we employ it on a live video.
lets employ a methodology:

i) Taking a test image and convert to grayscale from RGB using the function grayscale().

ii) Apply gaussian blur to remove noise gradients.

iii) Now apply Canny Edge detection to the blurred image & a binary image is produced

iv) Define a region of interest to seperate the lanes from surroundings and a masked image containing only lanes is extracted using cv2.bitwise_and() function.

v) The binary image of identified lane lines are finally merged with the original image using cv2.addweighted()

vi) It is observed that the lines are not continuous as required.

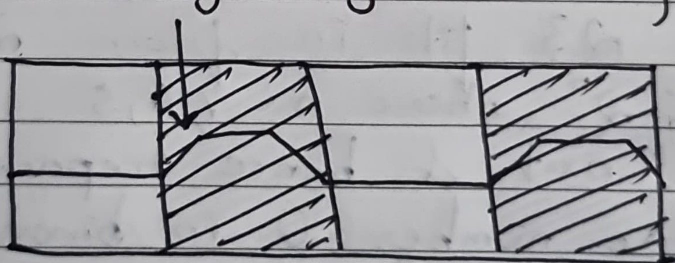
What is a Gaussian blur?

A Gaussian blur is used to remove noise from the image

Canny edge detection

Canny edge detection is a technique to identify & color the sharp edges in an image, the sharp edges can be identified by a sharp change in the color values of the pixels & neighbours.

High change in intensity of pixels



## Region of Interest:

A region of interest can be defined using a numpy array and define a 3 point polygon of the ROI. Now mask the defined region of interest in white color [255].

How do we mask the image?

lets first understand the basics of binary numbers.

Binary representation:

| | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 |
|---|---|---|---|---|---|---|---|---|
| 23 = | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| | $2^0$ | $2^1$ | $2^2$ | $2^3$ | $2^4$ | $2^5$ | $2^6$ | $2^7$ |

lets check if 23 fits in from $2^7$ to $2^5$

i.e. if $23 < 2^n$ where $n = 7, 6, 5$

It is not & hence represented by the number 0 in binary

whereas $23 < 2^n$ where $n = 4$

$\therefore 23 < 16$

$\therefore 2^3$ is 1 in binary

Now $23 - 16 = 7$

$2^3$ goes in 7? No

So that remains 0

i.e. $2^3 = 0$

Does $2^2$ goes in 7?

Yes :

$\therefore 2^2 = 1$ in binary value

Now $7 - 4 = 3$

Does 3 go in $2^1$?

Yes,

$\therefore 2^1 = 1$ in binary

Now $2 - 1 = 1$? Yes

$\therefore$ binary value is 1

Now we need to apply the mask to our canny image to only show us the region of interest.

The binary values outside the region of interest is of the colour black.

This can be done by applying bitwise& operation between the two images [canny & mask]

lets take an example;

$$\begin{array}{l} 0\,1\,1\,0\,0\,1 \\ 1\,1\,0\,0\,1\,0 \end{array} \& = 010000$$

The bitwise_& operation will give the value as 0 unless both the bits are '1' ie $1 \& 1 = 1$ or $0 \& 1 = 0$

Now if we look at the unmasked part of the image and consider it with the masked part of the image it is always going to yield the same binary numbers as in the region of interest.

let us consider:

Masked → 1 1 1 1 1 1 1 1

Region of interest from the cannyed image 1 1 1 1 0 0 0 0

Result → 1 1 1 1 0 0 0 0
i.e. same

So the pixels in the region of interesed when &_bitwised will remain the same no matter what & the uninterested region will be all black.

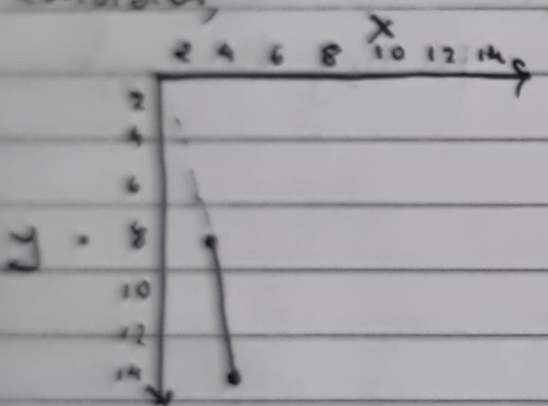
# Hough Transform:

Let we consider hough transform to identify straight lines in an image

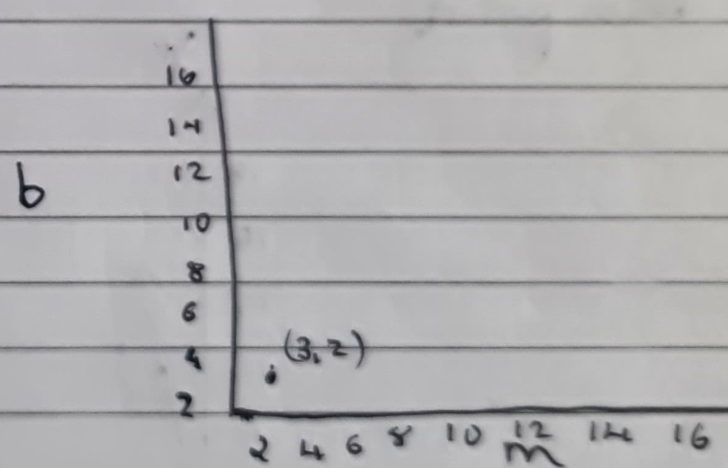
Let us consider a 2 Dimensional co-ordinate space of X, Y where the line is given by the equation

$y = mx + b$ → Equation of line

consider;




hough space




In equation $y = mx + b$

$b \rightarrow$ y intercept

$m \rightarrow$ slope

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

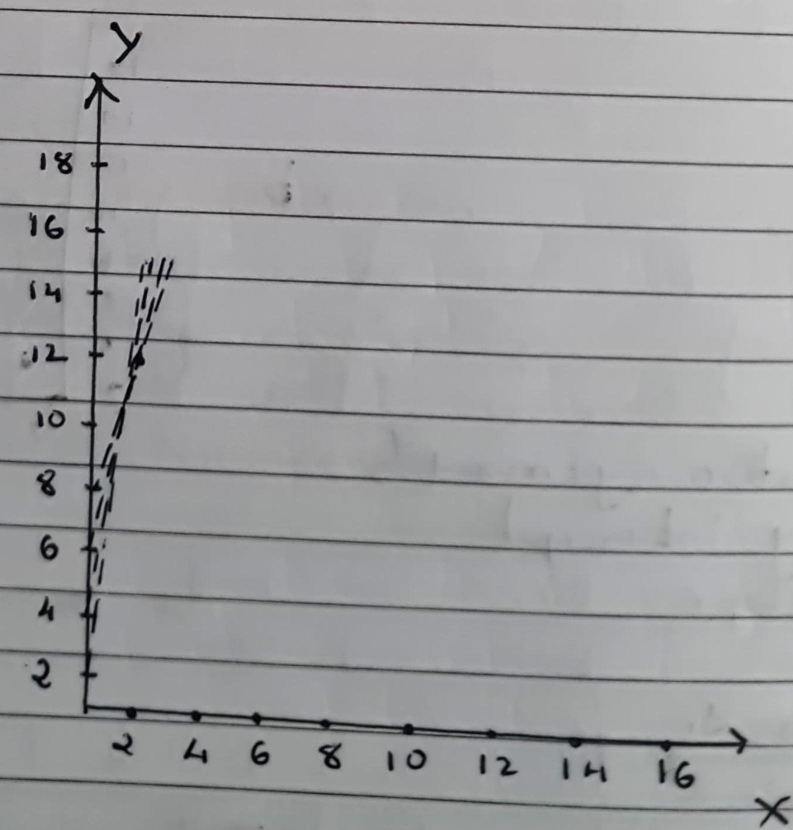
so $m = 3$ here & $b = 2$

$$y = 3x + 2$$

If we consider a single dot in X and Y axis space, we can draw infinite amount of line throught the point. A single dot can produce infinite lines in the X & Y space and all the points considering these lines will give a single straight line in the Hough space.

let us take an example;

let us consider a point (2,12) in the X and Y plane and draw 6 lines passing through this point.



let us check the slope for the line with y & x intercepts;

$y = 8, 16$ & $x = 4, 0$

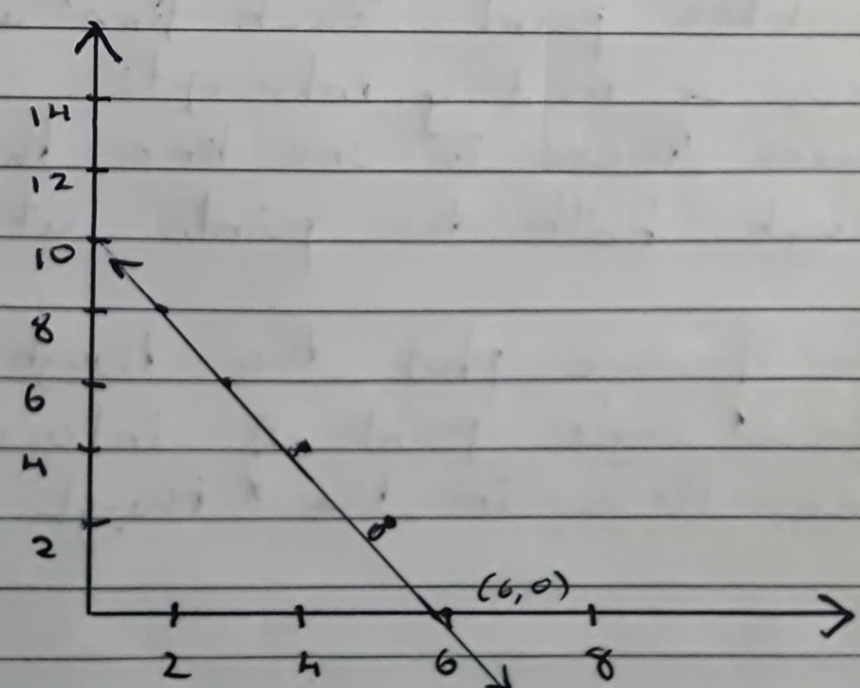
$\therefore m = \frac{16-8}{4-0} = \frac{8}{4} = 2$

$\therefore$ Equation of the line becomes

$y = 2x + 8$

Similarly for; $\left.\begin{array}{l} y = 3x + 6 \\ y = 4x + 4 \\ y = 5x + 2 \\ y = 6x + 0 \end{array}\right\} \longrightarrow y = mx + b$

Now let us plot the points as b, m in the Hough space



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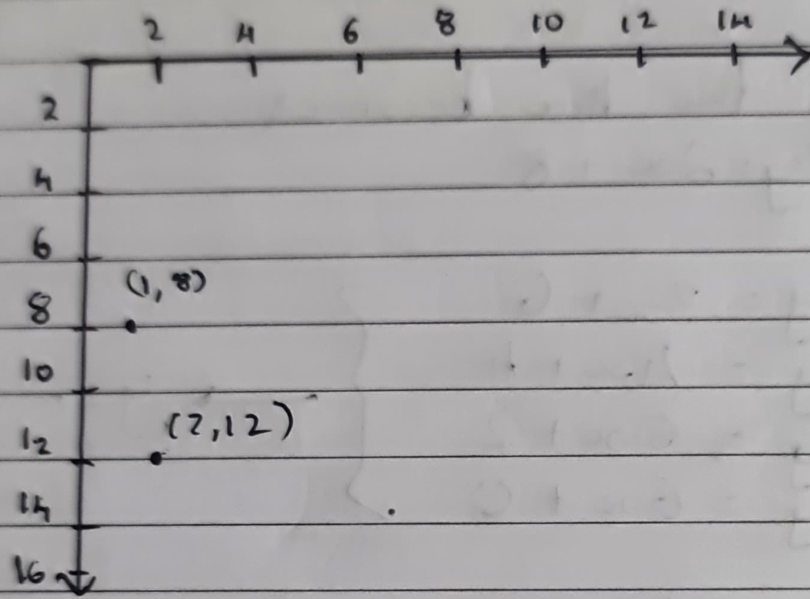
we see that the points b & m respresent a single straight line in the Hough space

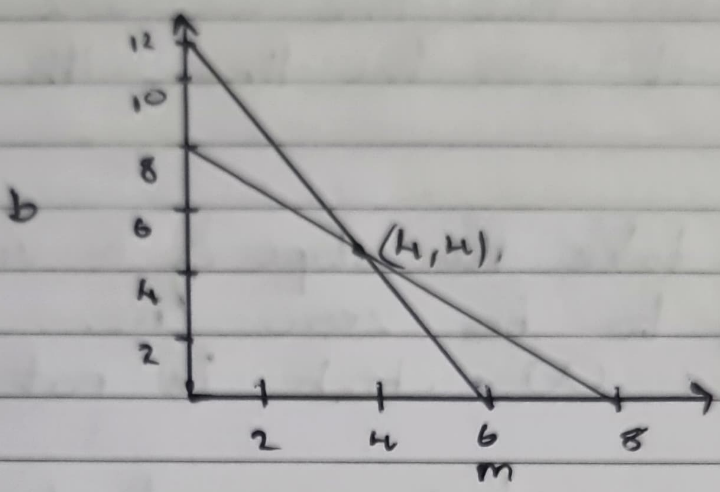
Now let us consider another point at (1, 8) at X & Y intercepts




Again there are infinite no. of lines passing through the point each line with different values of m & y intercepts. However there is one line that will pass through both the points at once.

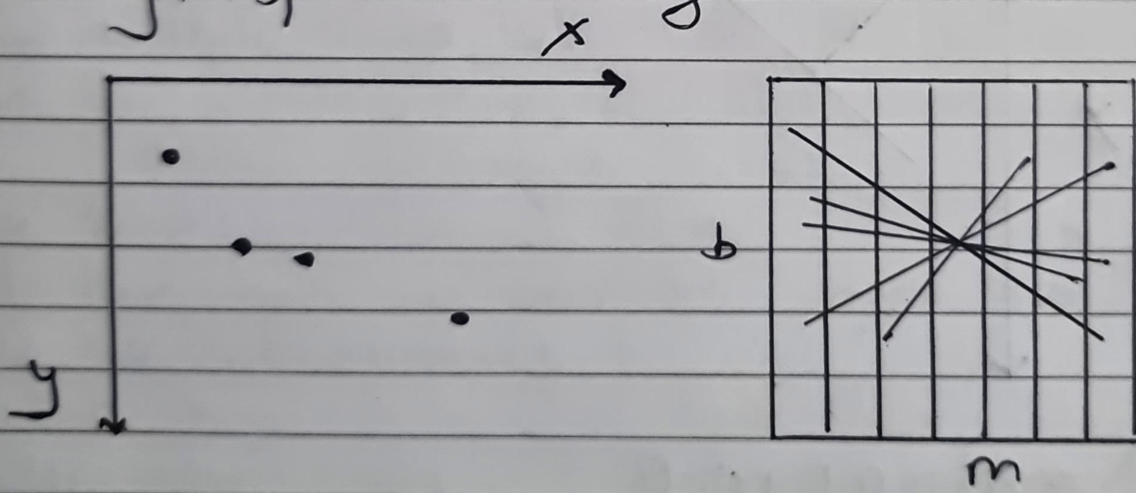
Now if we plot the Hough space we will get a single point of intersection for these lines in the Hough space.

: Hough Space :




$y = 4x + 4$ is consistent on both points of the line

Take 4 points in image space & draw their Hough space in a grid

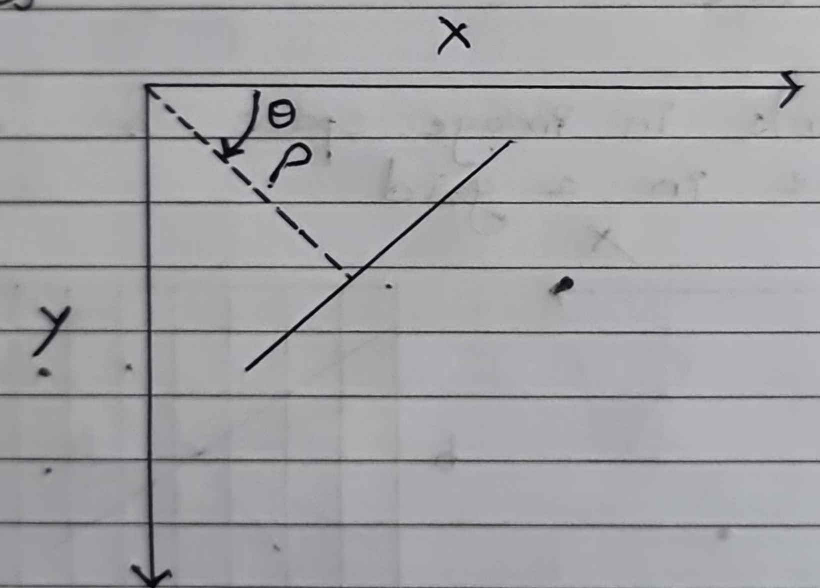



All of these point of intersection are inside a bin for each point of intersection we will cast a vote. The bin with the maximum number of votes is going to be the line to be considerd

Now considering the b & m values of the of the b,m, thats the line we are going to draw ∵ it was the line with the best fit

Now, if we take the slope of a vertical line it is going to be zero i.e. the slope becomes $\infty$ which is not acceptable

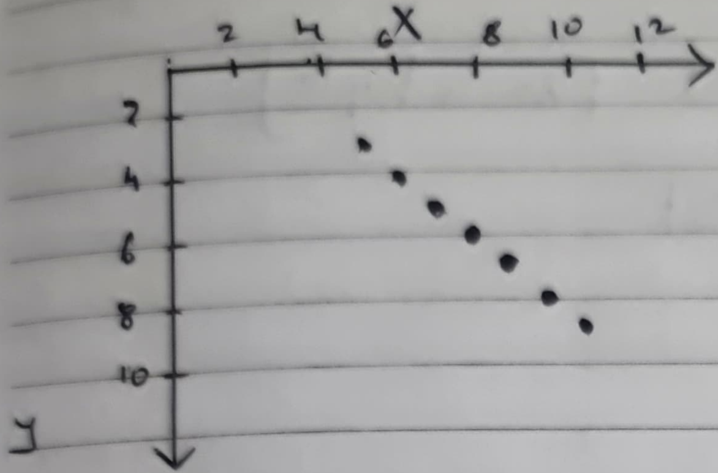
So we consider cartesian co-ordinates to represent the lines but now let us consider polar co-ordinates

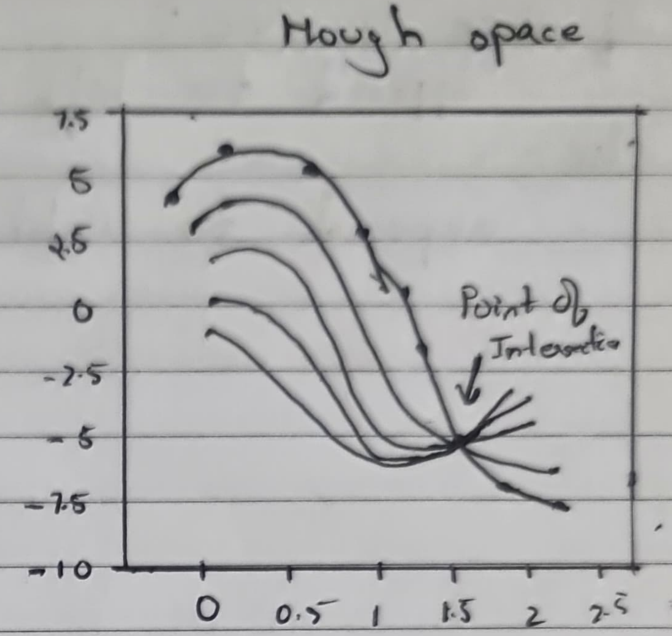



$$\rho = x\cos\theta + y\sin\theta$$

$\rho \rightarrow$ Rho

Now if we take a point and map out all possible lines passing through the points we get a sinousoidal curve.




Now we can represent the Hough space in a grid and the grids with the maximum number of intersection is considered to be the line

For multiple lines we need to average out as a single line, to do that;

We know:
A line has a positive slope as y increases as x in-creases

So accordingly lines going from left to right has a negative slope, & lines on the left has coming from right has a positive slope.