A Lane Detection Algorithm Based on Reliable Lane Markings

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Step 1

*Convert Grayscale

*Global Binary Threshold

*Sobel Filter

*Neighborhood And Operator

Step 2

*Create Transformation Matrix

*Apply Trans. Matrix

*Interpolation

*Plot Histogram

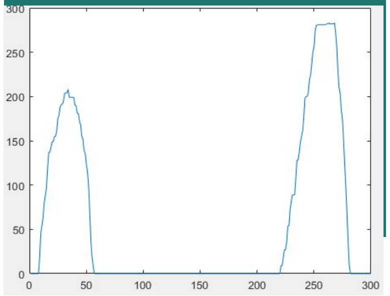
Step 3

*Calculate Standard Deviation

*Calculate Mean

*Calculate MSE

*Determine Right/Left Region



Step 4

*Calculate Polynomial with LSE

*Draw Polynomial Line

*Shift Lane

*Result Image

STEP 1

Convert Grayscale

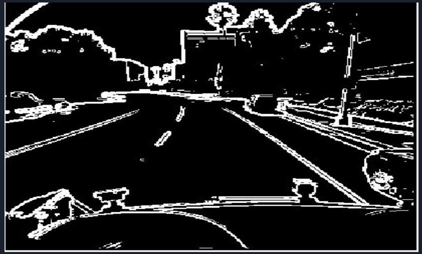
$$I_G(i,j) = 0.299\, I_{RGB}(i,j,R) + 0.587\, I_{RGB}(i,j,G) + 0.114\, I_{RGB}(i,j,B)$$

Global Binary Threshold

$$I_B(i,j) = \begin{cases} 1, & if\ I_G(i,j) \geq th \\ 0, & if\ I_G(i,j) < th \end{cases}$$

Sobel Filter

$$\text{Vertical Line: } \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \text{ Horizontal Line: } \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$



Neighborhood AND Operator

$$I(i,j) = \begin{cases} 0 & \text{if } \left(\sum_{l=i-k}^{i+k} \sum_{m=j-k}^{j+k} I_{B1}(l,m) \right) \cdot \left(\sum_{l=i-k}^{i+k} \sum_{m=j-k}^{j+k} I_{B2}(l,m) \right) = 0 \\ 1 & \text{otherwise} \end{cases}$$

STEP 2

Create Transformation Matrix → Apply Trans. Matrix → Interpolation → Plot Histogram

$$[C] = [B]\ [A]$$

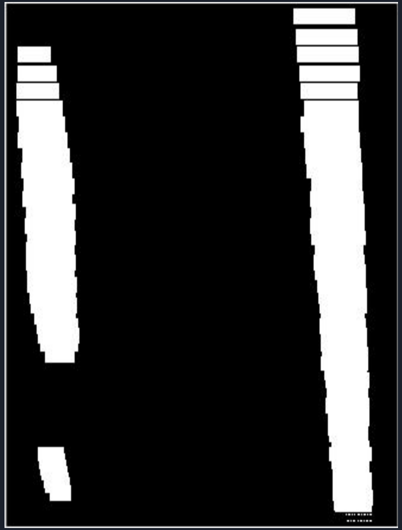
$$[A] = [B^{-1}]\ [C]$$

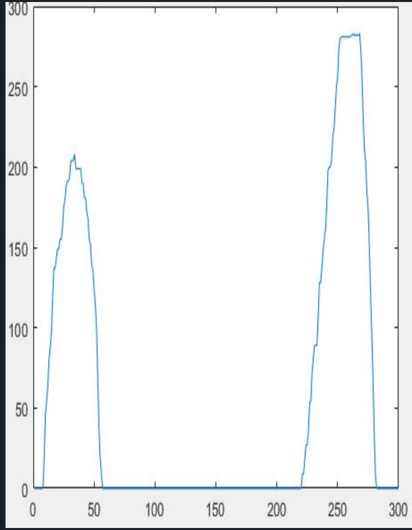
$$\begin{bmatrix} X_1 \\ Y_1 \\ X_2 \\ Y_2 \\ X_3 \\ Y_3 \\ X_4 \\ Y_4 \end{bmatrix} = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1X_1 & -y_1X_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -x_1Y_1 & -y_1Y_1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2X_2 & -y_2X_2 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -x_2Y_2 & -y_2Y_2 \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3X_3 & -y_3X_3 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -x_3Y_3 & -y_3Y_3 \\ x_4 & y_4 & 1 & 0 & 0 & 0 & -x_4X_4 & -y_4X_4 \\ 0 & 0 & 0 & x_4 & y_4 & 1 & -x_4Y_4 & -y_4Y_4 \end{bmatrix} \begin{bmatrix} a_{11} \\ a_{12} \\ a_{13} \\ a_{21} \\ a_{22} \\ a_{23} \\ a_{31} \\ a_{32} \end{bmatrix}$$

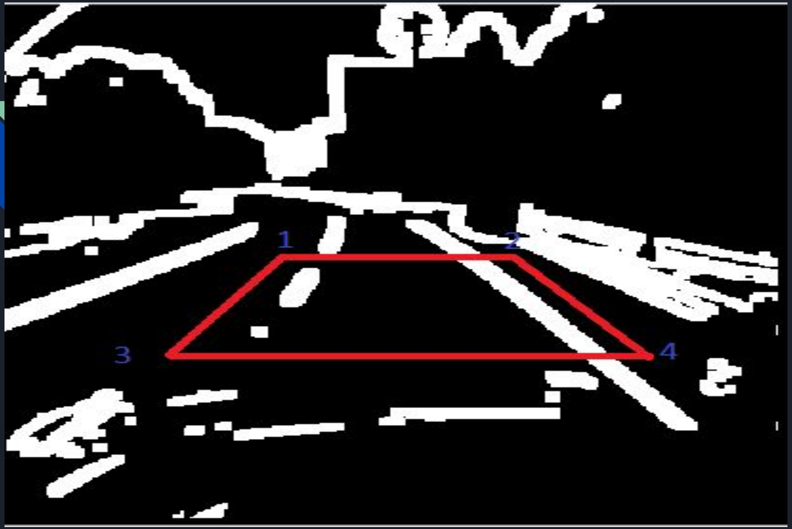
$$\begin{bmatrix} X_1 z \\ Y_1 z \\ z \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix}$$

$$\mathbf{X} = \frac{a_{00}\mathbf{x} + a_{01}\mathbf{y} + a_{02}}{\mathbf{z}}$$

$$\mathbf{Y} = \frac{a_{10}\mathbf{x} + a_{11}\mathbf{y} + a_{12}}{\mathbf{z}}$$







	Kaynak Noktalar	Hedef Noktalar
1.nokta	x1 = 160 , y1 = 120	X1 = 0 , Y1 = 0
2.nokta	x2 = 160 , y2 = 210	X2 = 0 , Y2 =300
3.nokta	x3 = 210 , y3 = 75	X3 = 300 , Y3 = 0
4.nokta	x4 = 210 , y4 = 255	X4 = 300 , Y4 = 300

$$\begin{bmatrix} X_1 z \\ Y_1 z \\ z \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} \rightarrow$$

$$\begin{bmatrix} X_1 \\ Y_1 \\ X_2 \\ Y_2 \\ X_3 \\ Y_3 \\ X_4 \\ Y_4 \end{bmatrix} = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1X_1 & -y_1X_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -x_1Y_1 & -y_1Y_1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2X_2 & -y_2X_2 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -x_2Y_2 & -y_2Y_2 \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3X_3 & -y_3X_3 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -x_3Y_3 & -y_3Y_3 \\ x_4 & y_4 & 1 & 0 & 0 & 0 & -x_4X_4 & -y_4X_4 \\ 0 & 0 & 0 & x_4 & y_4 & 1 & -x_4Y_4 & -y_4Y_4 \end{bmatrix} \begin{bmatrix} a_{11} \\ a_{12} \\ a_{13} \\ a_{21} \\ a_{22} \\ a_{23} \\ a_{31} \\ a_{32} \end{bmatrix} \rightarrow [C] = [B]\,[A] \rightarrow [A] = [B^{-1}]\,[C] \rightarrow$$

$$\mathbf{X} = \frac{a_{00}x + a_{01}y + a_{02}}{z}$$

$$\mathbf{Y} = \frac{a_{10}x + a_{11}y + a_{12}}{z}$$

STEP 3

Calculate Mean

$$\mu_l = \frac{2}{N}\sum_{j=1}^{N/2}\sum_{i=1}^{M} j \cdot I(i,j);$$

$$\mu_r = \frac{2}{N}\sum_{j=N/2+1}^{N}\sum_{i=1}^{M} j\, I(i,j);$$

Calculate MLE

$$\sigma_l^2 = \frac{2}{N}\sum_{j=1}^{N/2}\sum_{i=1}^{M} \mathrm{I}(\mathrm{i},\mathrm{j}) \cdot (\mathrm{j} - \mu_l)^2$$

$$\sigma_r^2 = \frac{2}{N}\sum_{j=N/2+1}^{N}\sum_{i=1}^{M} \mathrm{I}(\mathrm{i},\mathrm{j})(\mathrm{j} - \mu_r)^2$$

Determine Right/Left Region

Choose left region, if $(t\,P_l - \sigma_l) \geq (t\,P_r - \sigma_r)$

Choose right region, if $(t\,P_l - \sigma_l) < (t\,P_r - \sigma_r)$

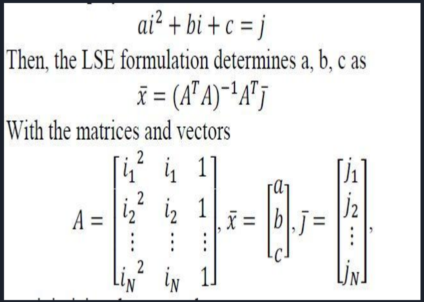
STEP 4

Calculate Polynomial with LSE

Draw Polynomial Line

Shift Lane

Finish



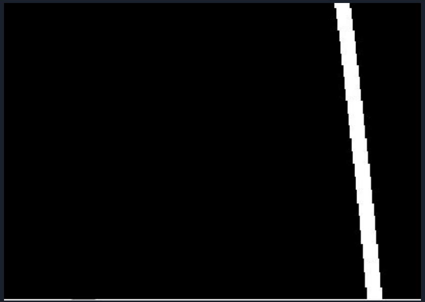
$$ai^2 + bi + c = j$$

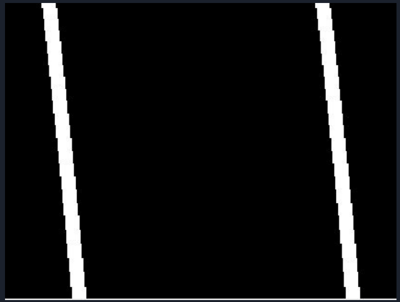
Then, the LSE formulation determines a, b, c as

$$\bar{x} = (A^T A)^{-1} A^T \bar{j}$$

With the matrices and vectors

$$A = \begin{bmatrix} i_1^2 & i_1 & 1 \\ i_2^2 & i_2 & 1 \\ \vdots & \vdots & \vdots \\ i_N^2 & i_N & 1 \end{bmatrix}, \bar{x} = \begin{bmatrix} a \\ b \\ c \end{bmatrix}, \bar{j} = \begin{bmatrix} j_1 \\ j_2 \\ \vdots \\ j_N \end{bmatrix},$$





Teşekkürler