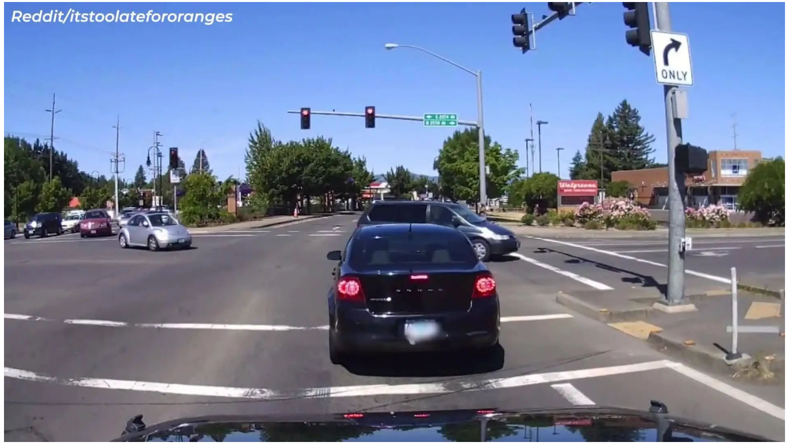
Dash-Cam Single Image Processing

Real Time case study

- Group G4: Amin Ghandi - Bahar Oveis

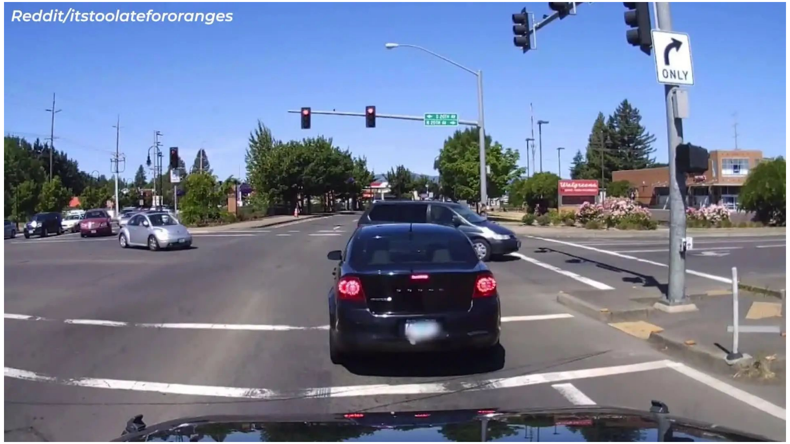
Problem Definition

- ❖ There are millions of dash-cams which mostly are used for critical scenes and accidents.



Problem Definition

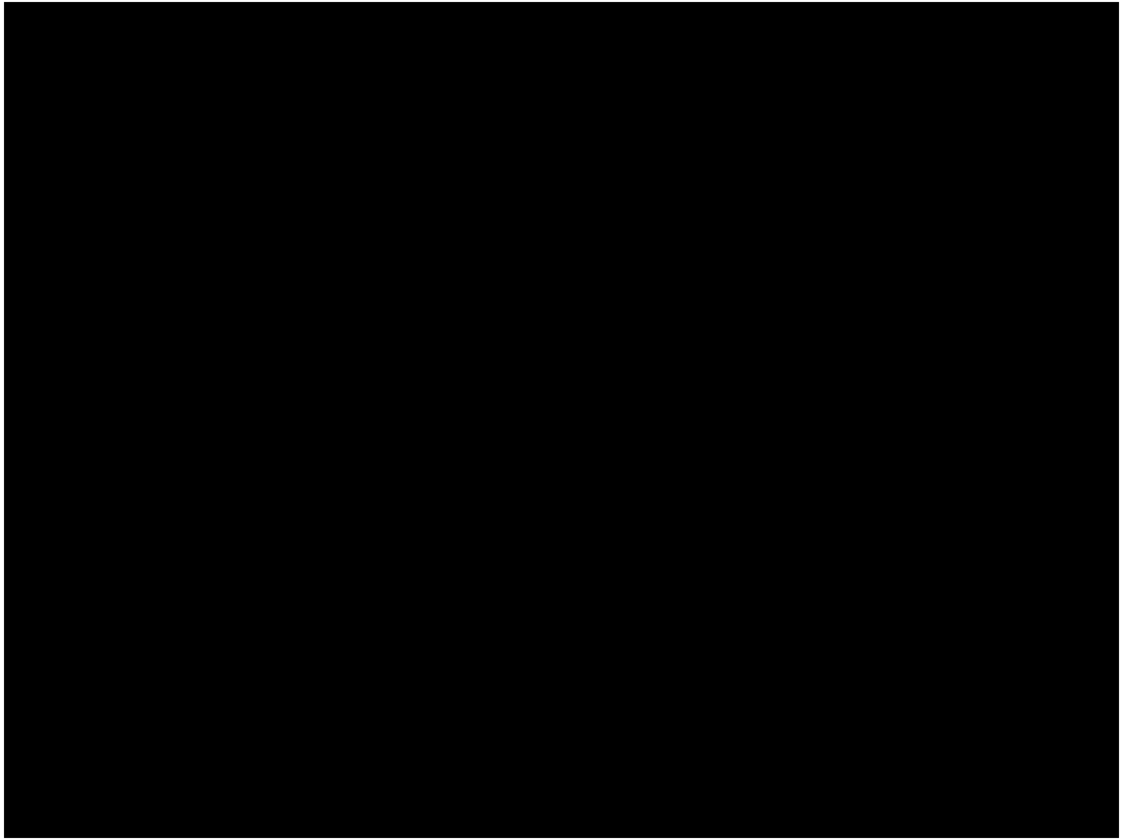
❖ However, these dash-cam records can be used for more applications. With the use of image processing, we are able to use these records for urban traffic analysis, urban city mapping, obstacle detection, traffic sign recognition, driving warning etc.



Problem Definition

- In this project, we use Image Processing with conventional approach to extract some common information from a fairly long dash-cam record. For reaching our goal, to be able extract information in all time, we choose dash-cam record in harsh condition.

Case Study



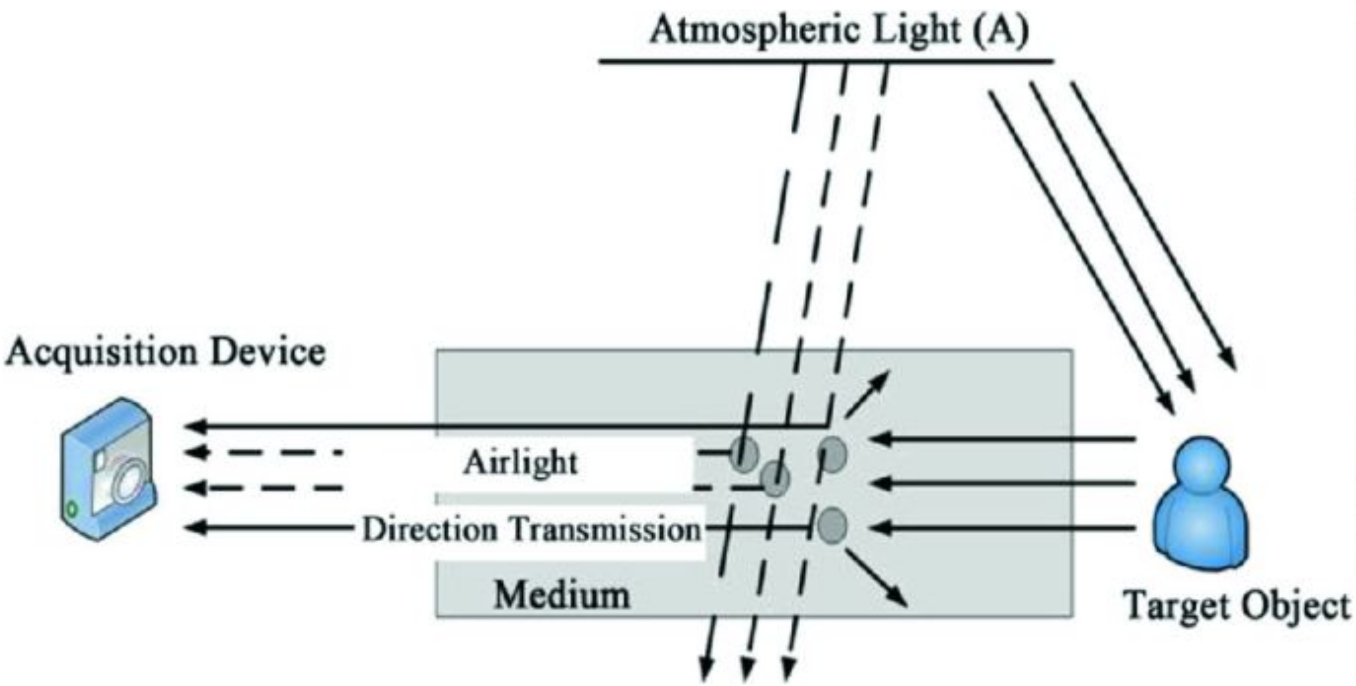
Challenge:

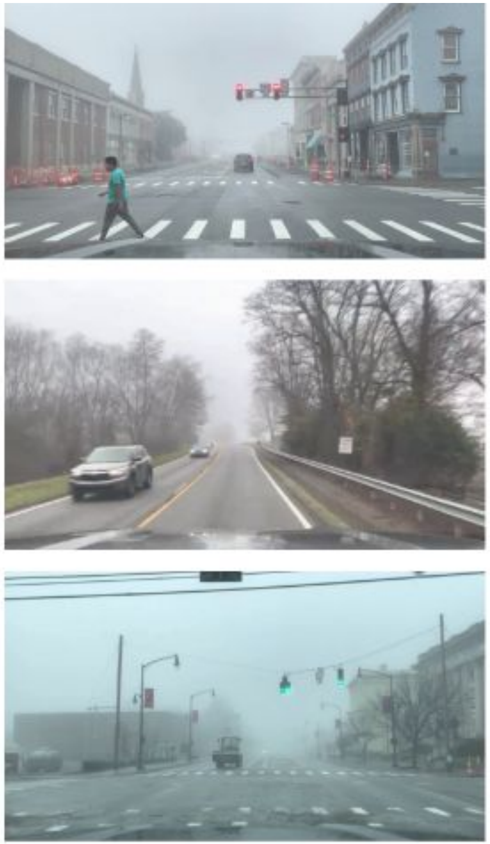
- The case study is recorded in a foggy day.
- The case study is included different scene in different lightness since the driver is going from suburban to urban city.
- According to dash-cam record characteristics and weather condition, quality is not very high.
- We have to avoid time consuming methods and we are just allowed to use single image processing approach.
- We are looking for general methods to use. Therefore, we are not allowed to use different approaches for different scenes.

Table contents:

De-hazing

De-hazing Theory





De-hazing Theory

$$\boxed{\mathbf{I}(x) = t(x)\mathbf{J}(x) + (1 - t(x))\mathbf{A},}$$

$$\rightarrow$$

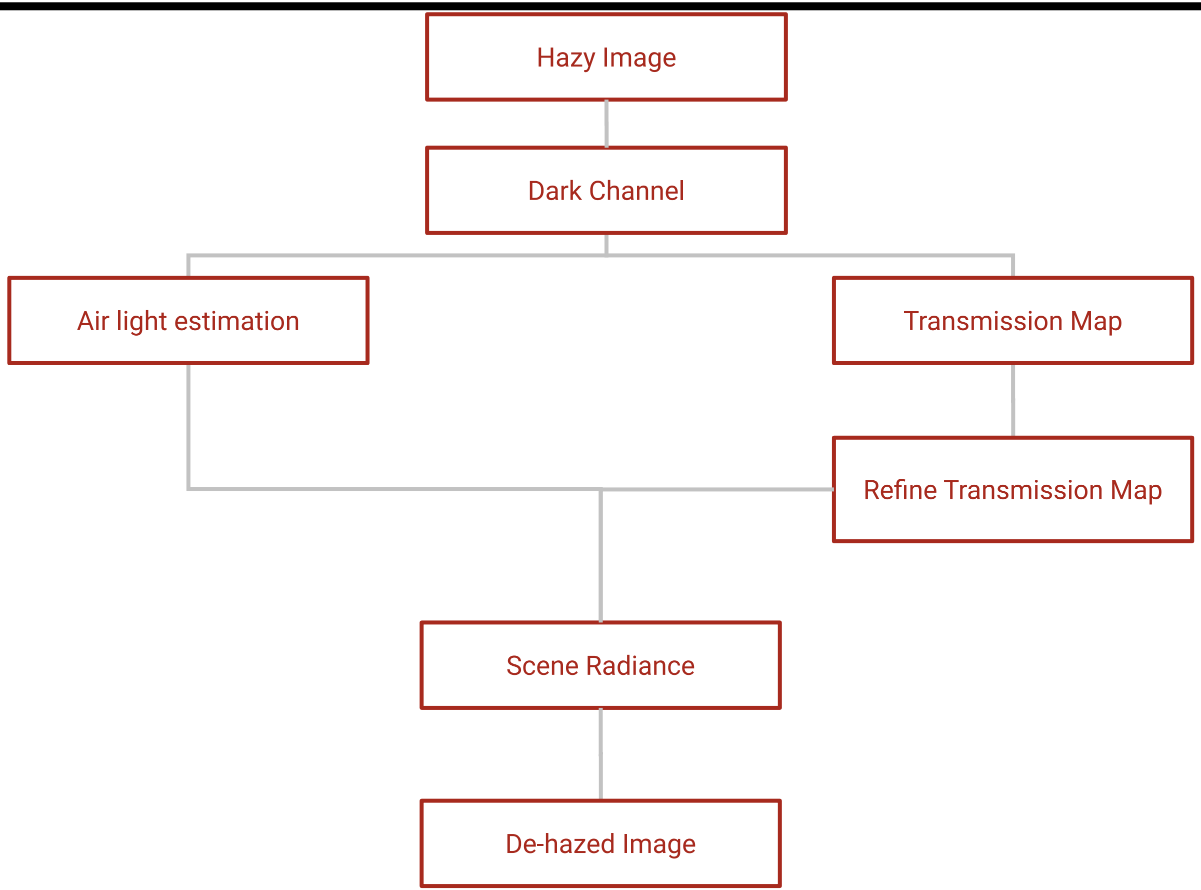
$$\boxed{\mathbf{J}(x) = \frac{\mathbf{I}(x) - \mathbf{A}}{[\max(t(x), \epsilon)]^{\delta}} + \mathbf{A},}$$

Challenge:

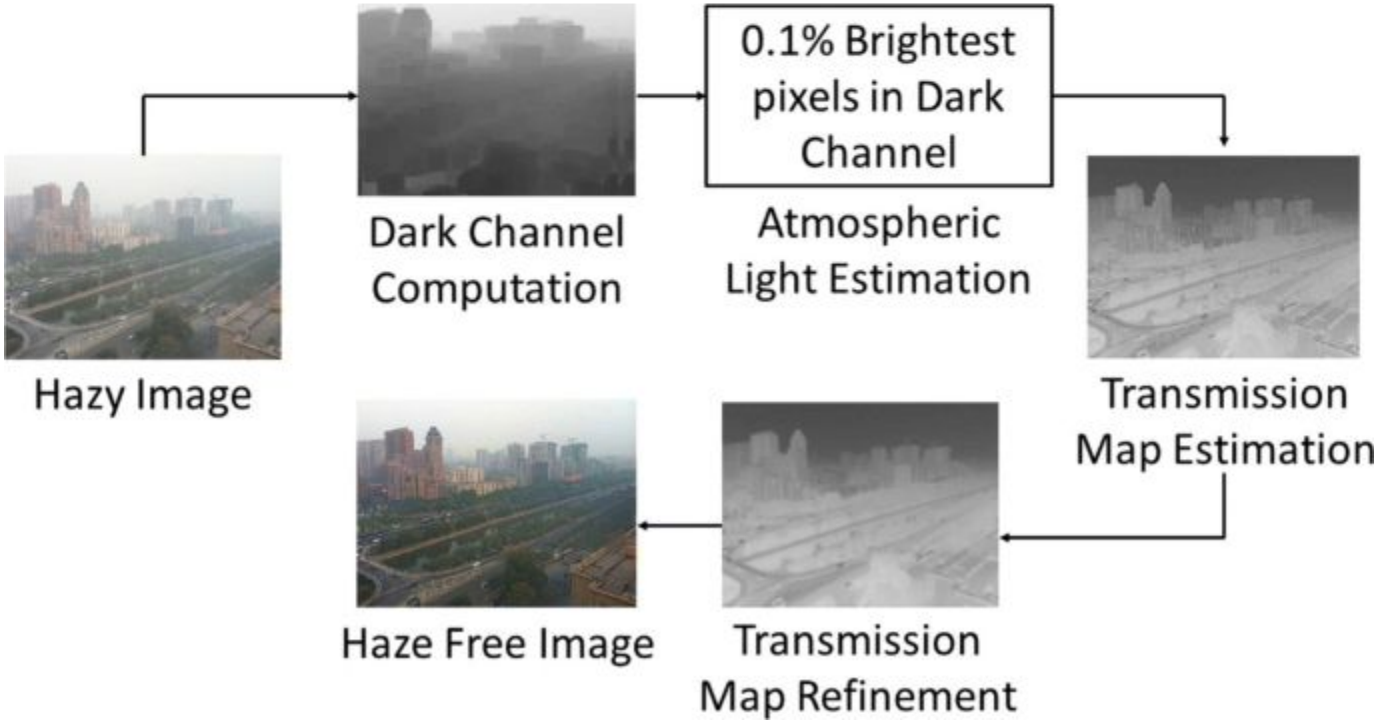
- **Dehazing from a single image is highly underconstrained, since the number of unknowns is much greater than the number of available equations.**

❖ **Source:Meng, G., Wang, Y., Duan, J., Xiang, S., & Pan, C. (2013). Efficient image dehazing with boundary constraint and contextual regularization. Proceedings of the IEEE international conference on computer vision, 617-624.**

Road Map : De-hazing



Road Map : De-hazing



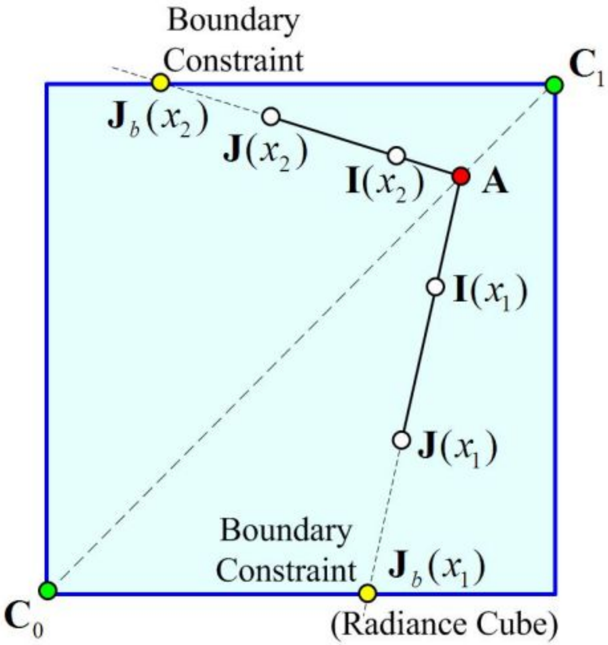
Boundary Constraint from Radiance Cube

$$\mathbf{J}(x) = \frac{\mathbf{I}(x) - \mathbf{A}}{[\max(t(x), \epsilon)]^{\delta}} + \mathbf{A},$$

$$\frac{1}{t(x)} = \frac{||\mathbf{J}(x) - \mathbf{A}||}{||\mathbf{I}(x) - \mathbf{A}||}.$$

<u>Conditions:</u>

$$\mathbf{C}_0 \leq \mathbf{J}(x) \leq \mathbf{C}_1, \forall x \in \Omega,$$



Scene Transmission Estimation

$$\frac{1}{t(x)} = \frac{||\mathbf{J}(x) - \mathbf{A}||}{||\mathbf{I}(x) - \mathbf{A}||}.$$

- **With the assumed condition and a supposed A , we can reach to Jb (b ~ Boundary)**

Conditions:

$$\mathbf{C}_0 \leq \mathbf{J}(x) \leq \mathbf{C}_1, \forall x \in \Omega,$$

$$0 \leq t_b(x) \leq t(x) \leq 1,$$

$$t_b(x) = \min\left\{ \max_{c \in \{r,g,b\}} \left(\frac{A^c - I^c(x)}{A^c - C_0^c}, \frac{A^c - I^c(x)}{A^c - C_1^c} \right), 1 \right\} \rightarrow \tilde{t}(x) = \max_{y \in \omega_x} t_b(y)$$

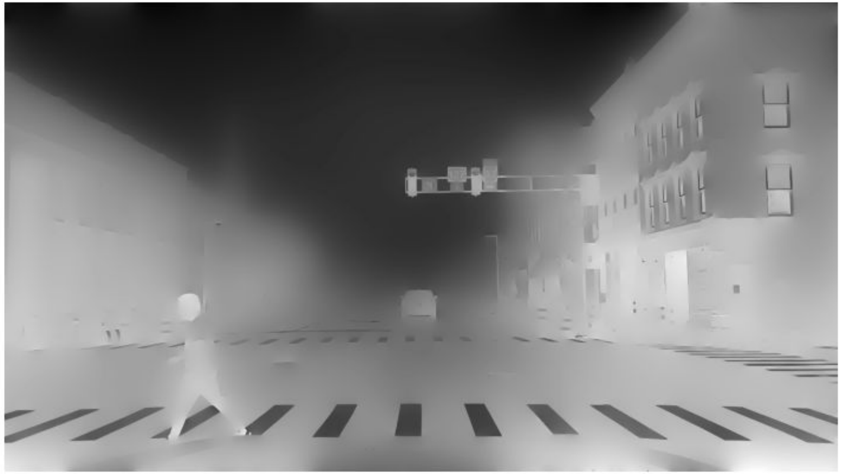
$$t(x) = e^{-\beta d(x)},$$

Scene Transmission Estimation

$$\hat{t}(x) = \min_{y \in \omega_x} \max_{z \in \omega_y} t_b(z).$$

$$\frac{\lambda}{2} \|t - \hat{t}\|_2^2 + \sum_{j \in \omega} \|W_j \circ u_j\|_1 + \frac{\beta}{2} \left(\sum_{j \in \omega} \|u_j - D_j \otimes t\|_2^2 \right)$$

Optimization



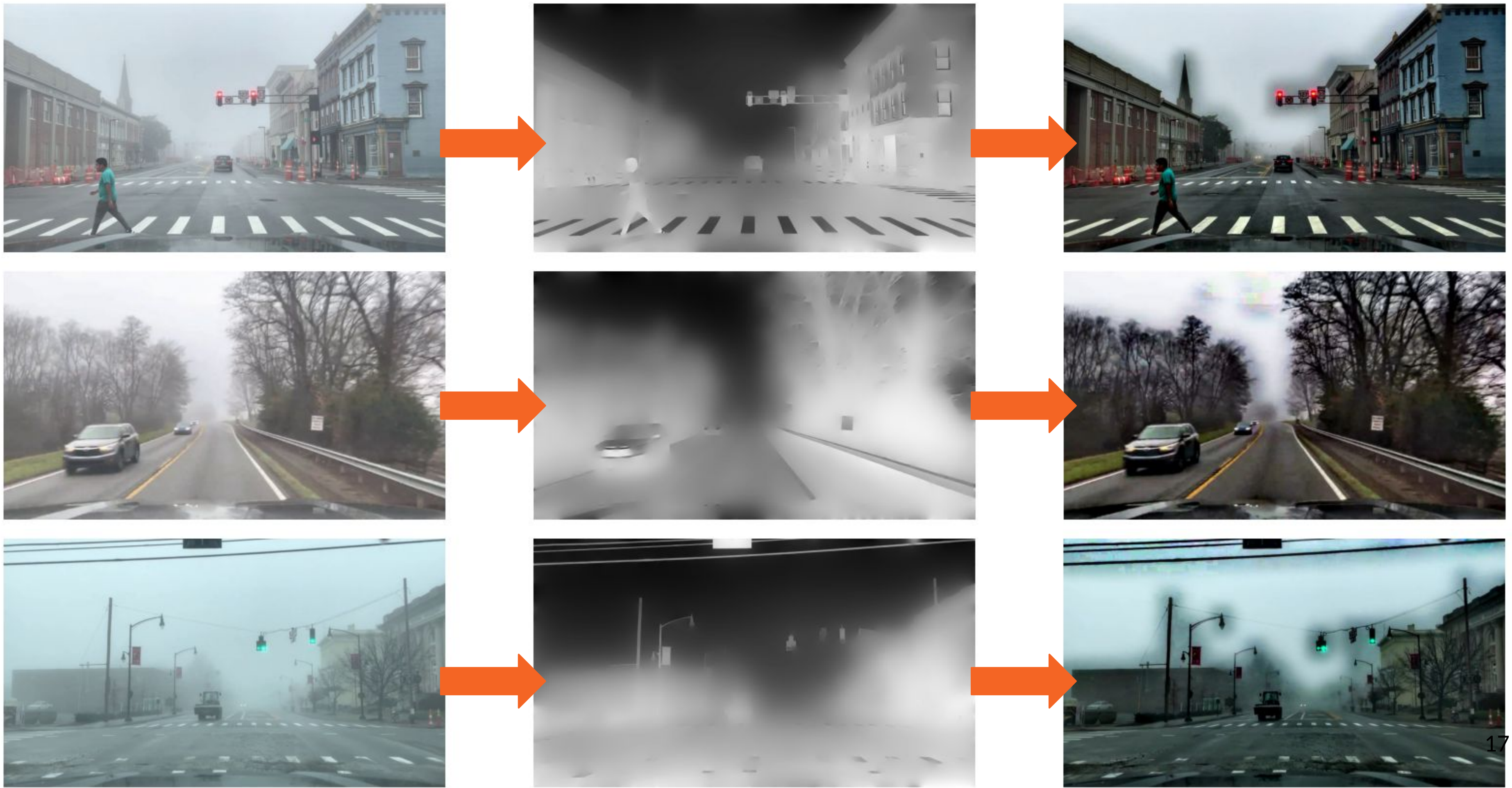
Remove sky

1

2

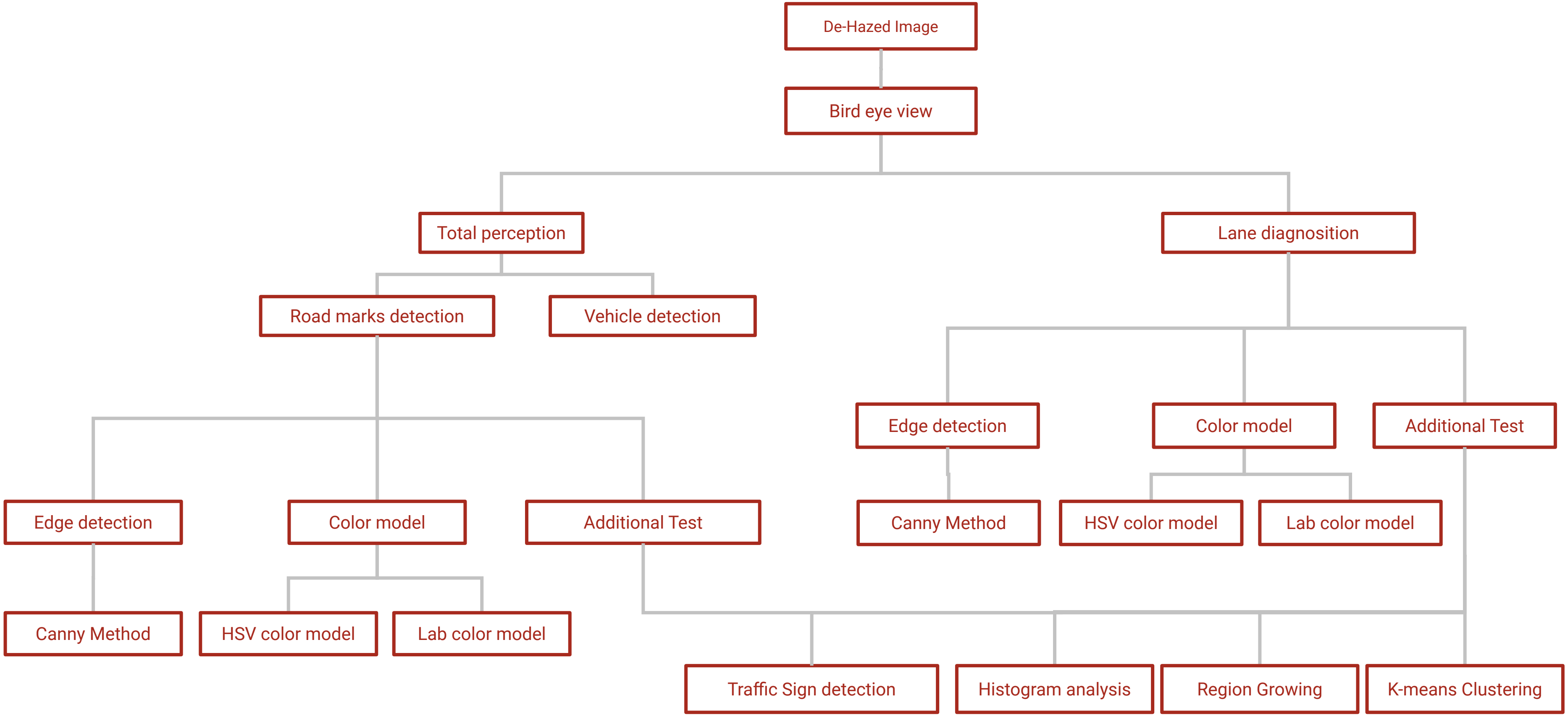
3

Final De-hazed Image

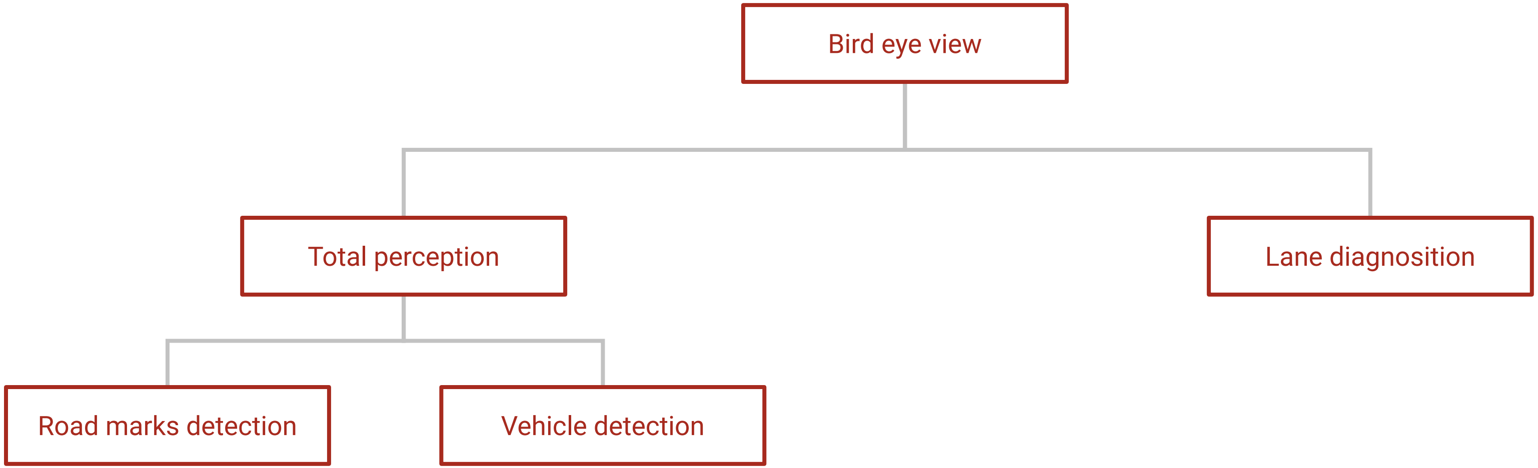


Mark & Lane Detection

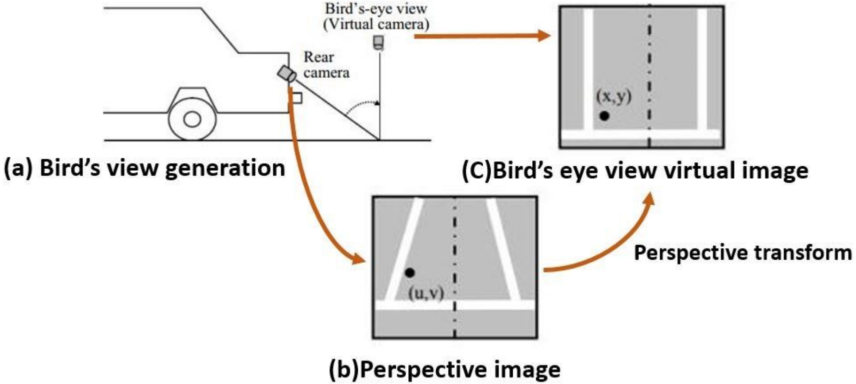
Road Map : Mark & Lane Detection

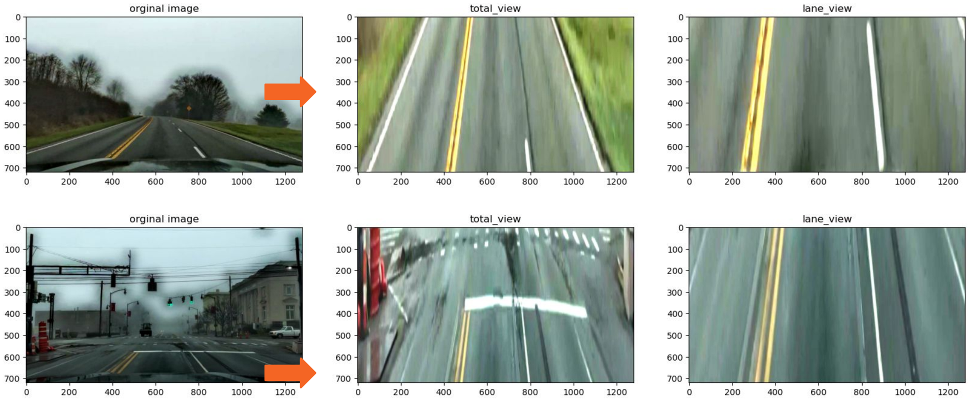


Bird Eye View

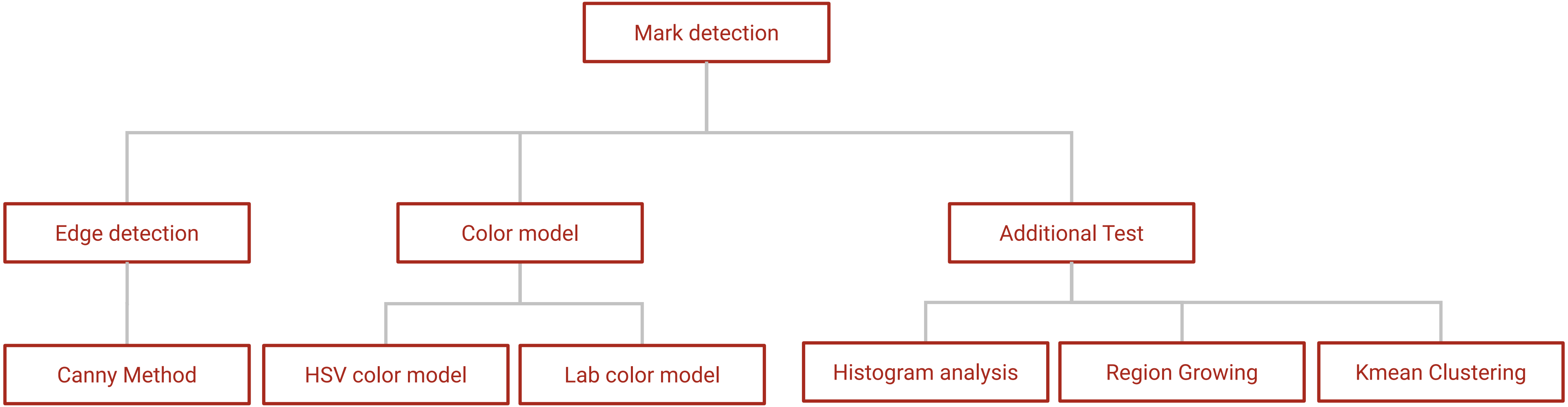


Bird Eye View

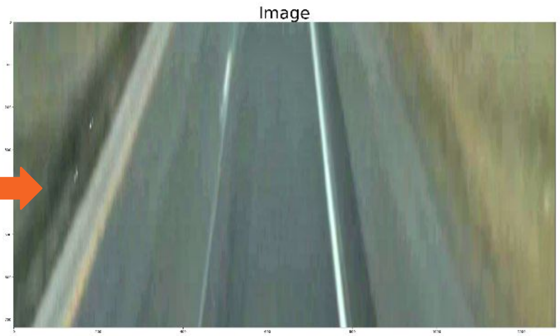


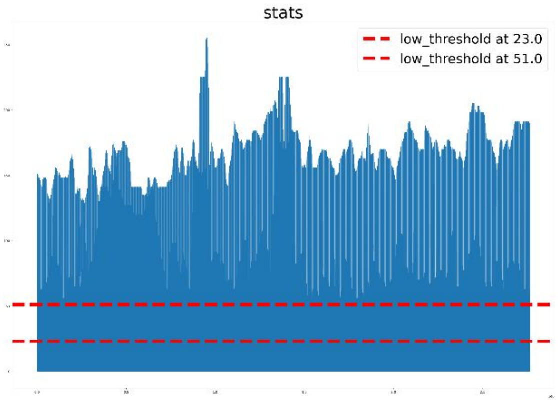


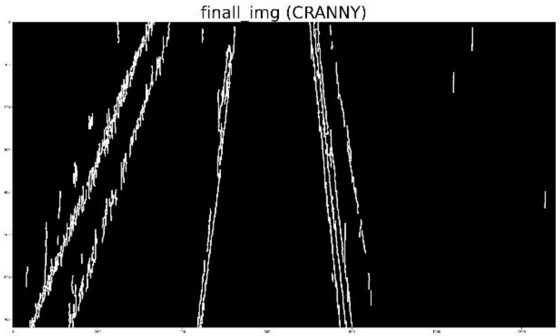
Marks detection

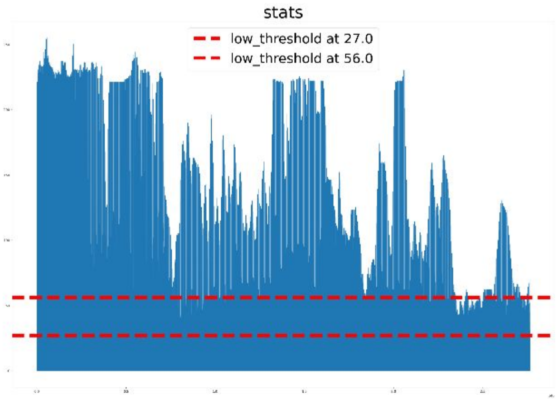


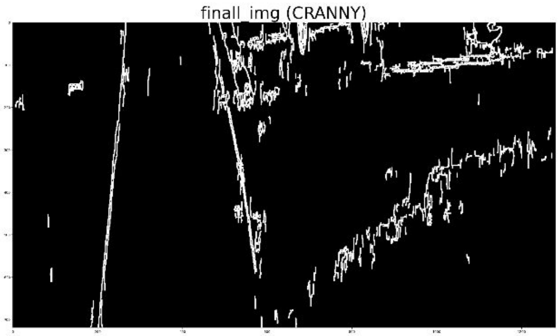
Marks detection : Canny edge detection



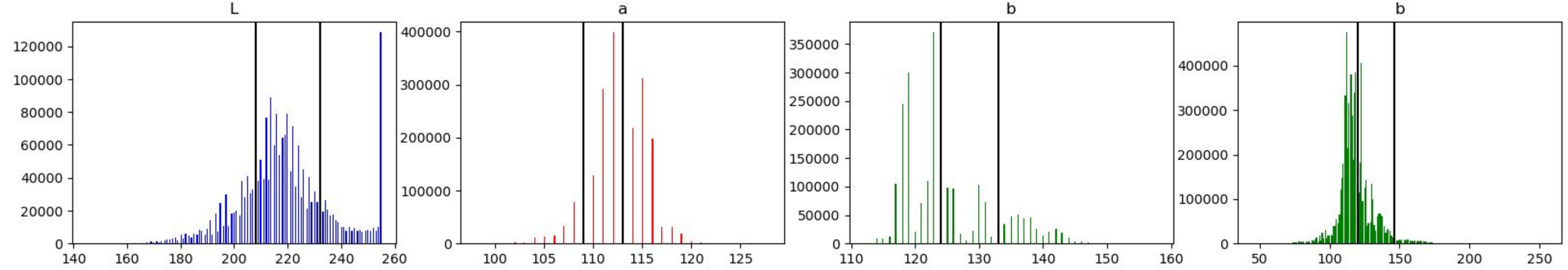


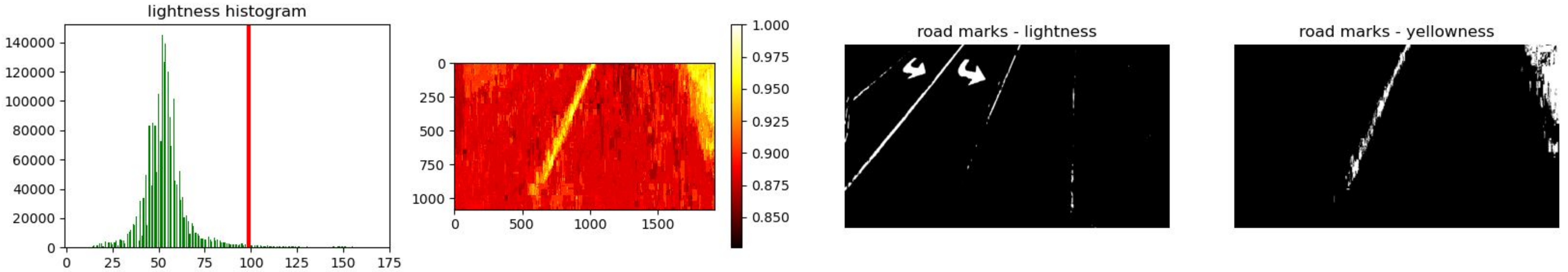




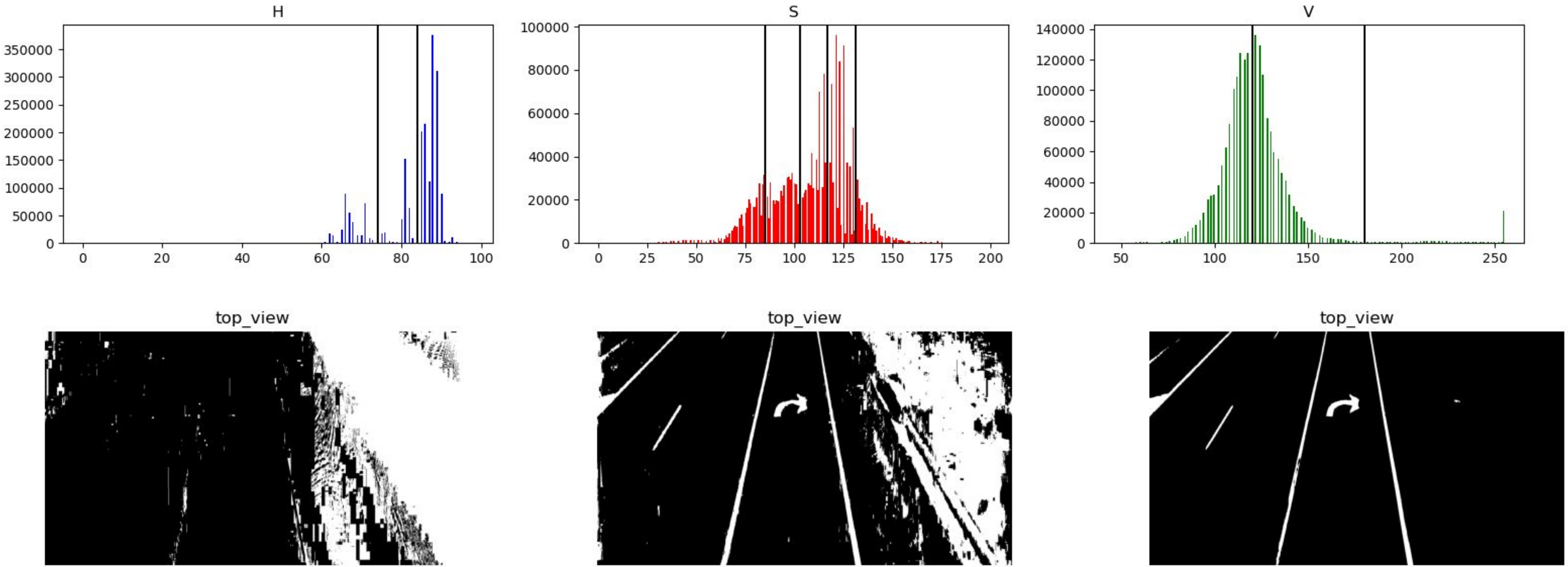


Marks detection : Lab color model

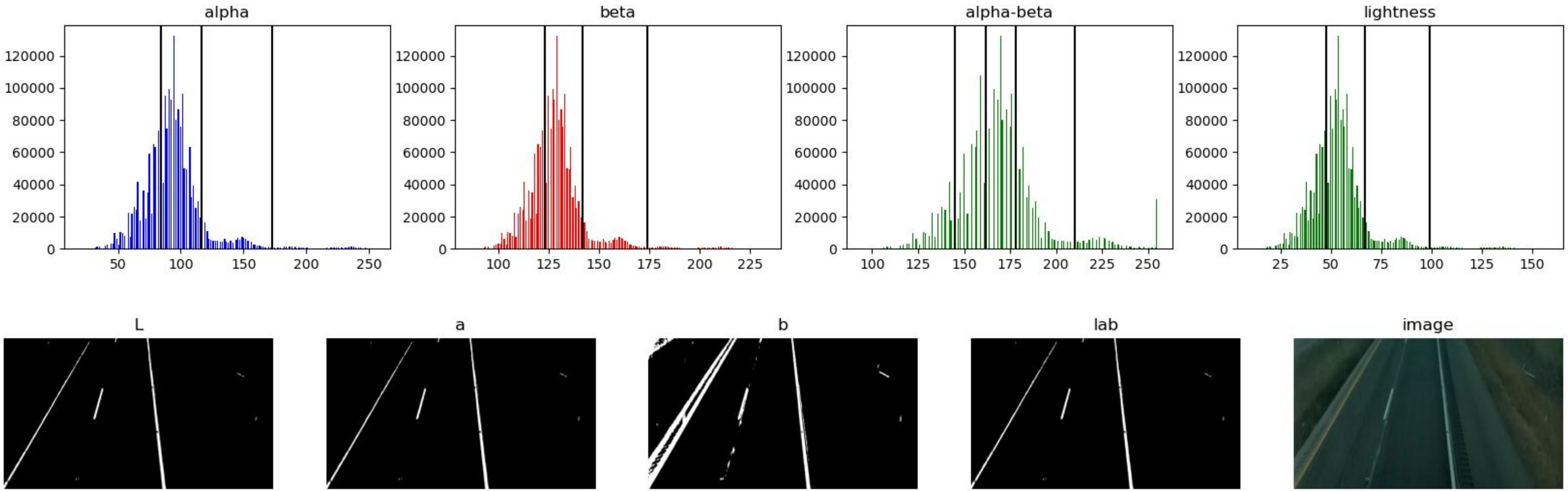




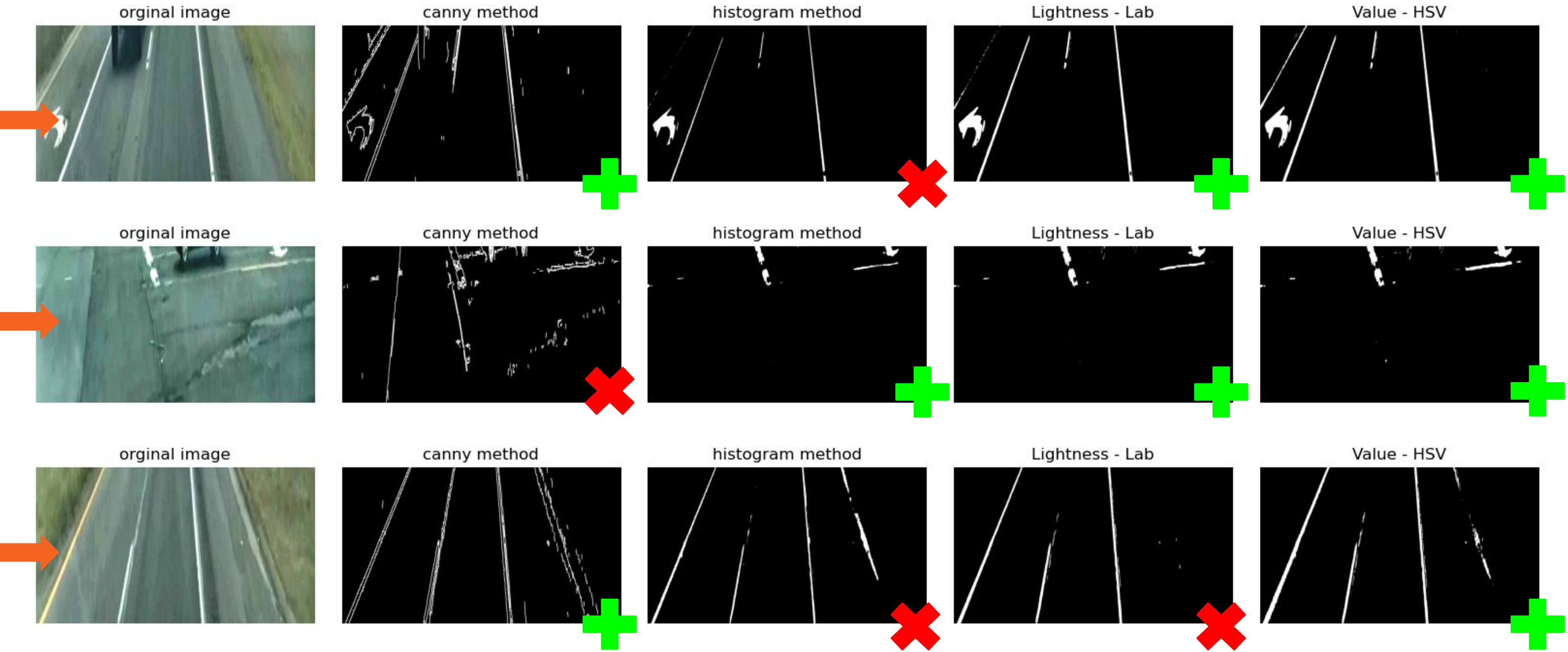
Marks detection : HSV color model



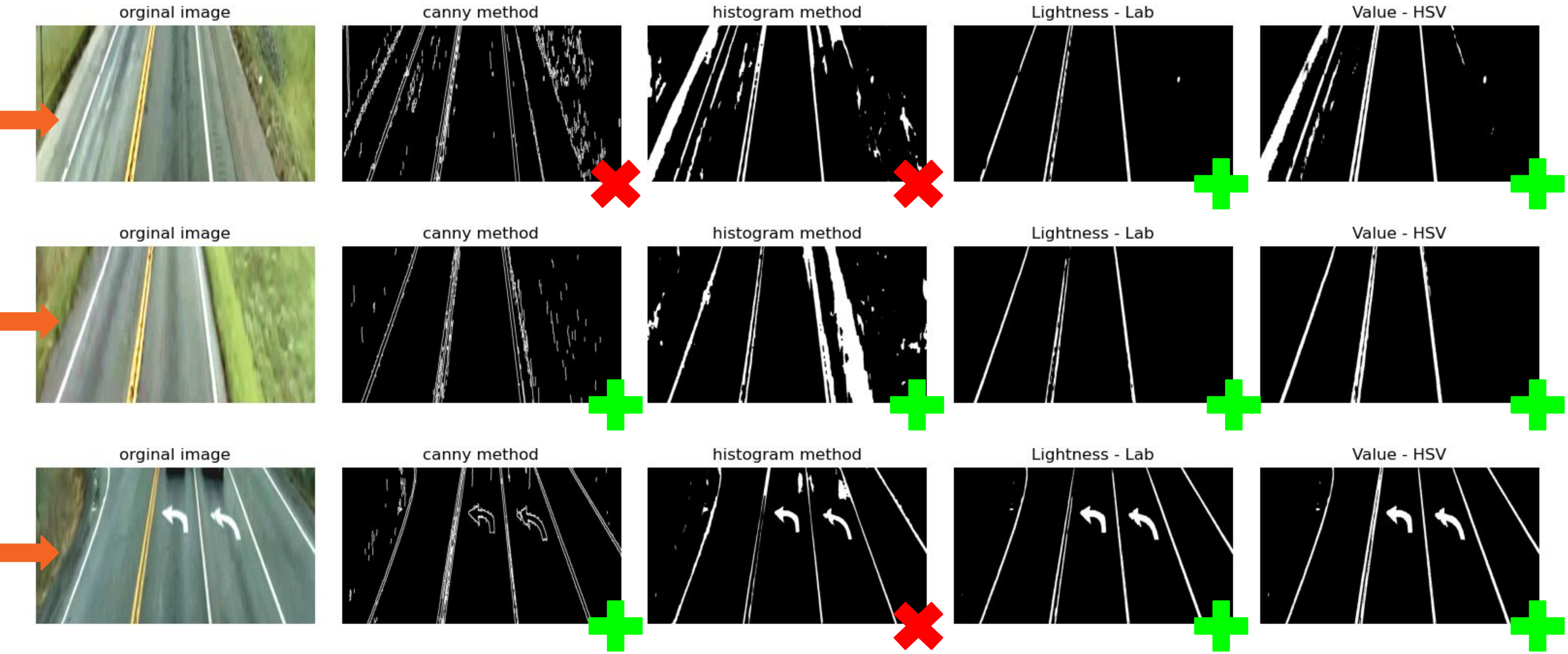
Marks detection : Contrast & Brightness



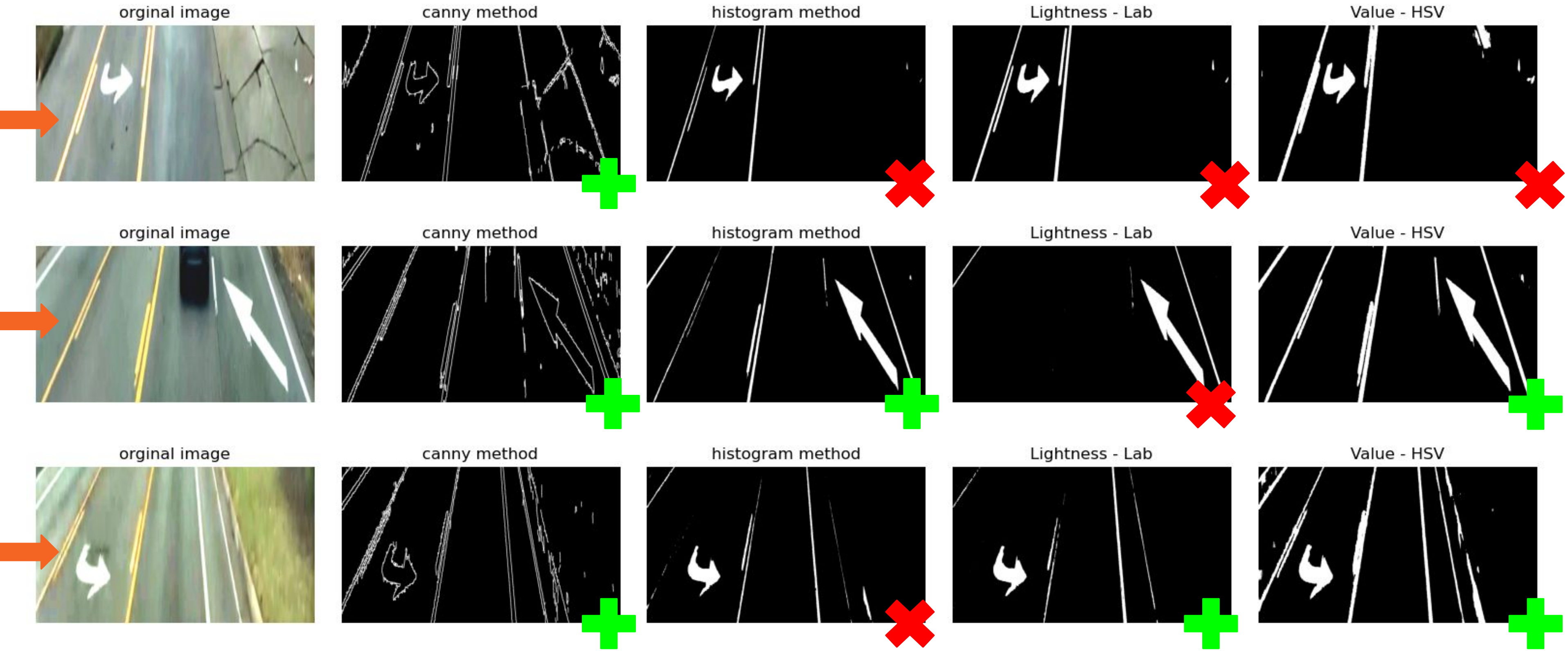
Marks detection : Comparison



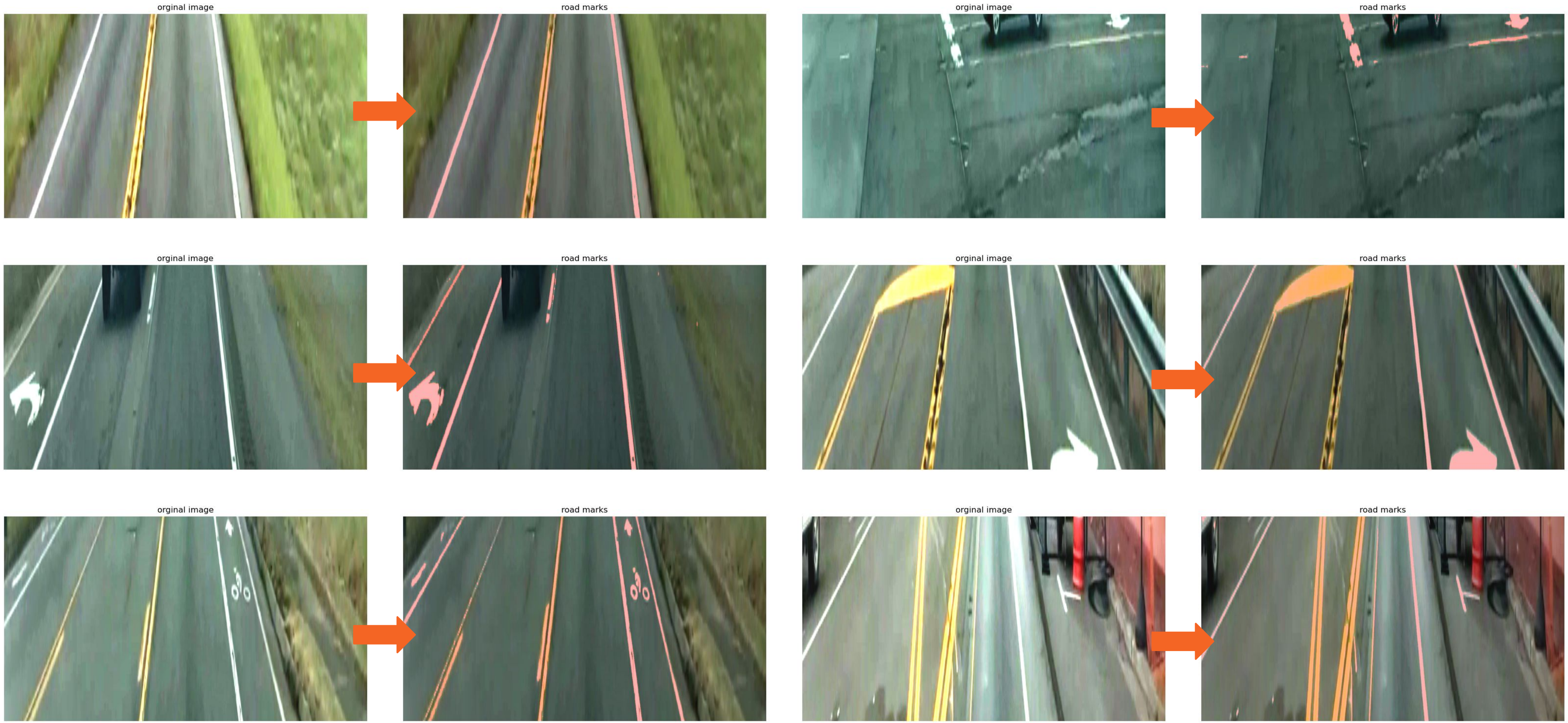
Marks detection : Comparison



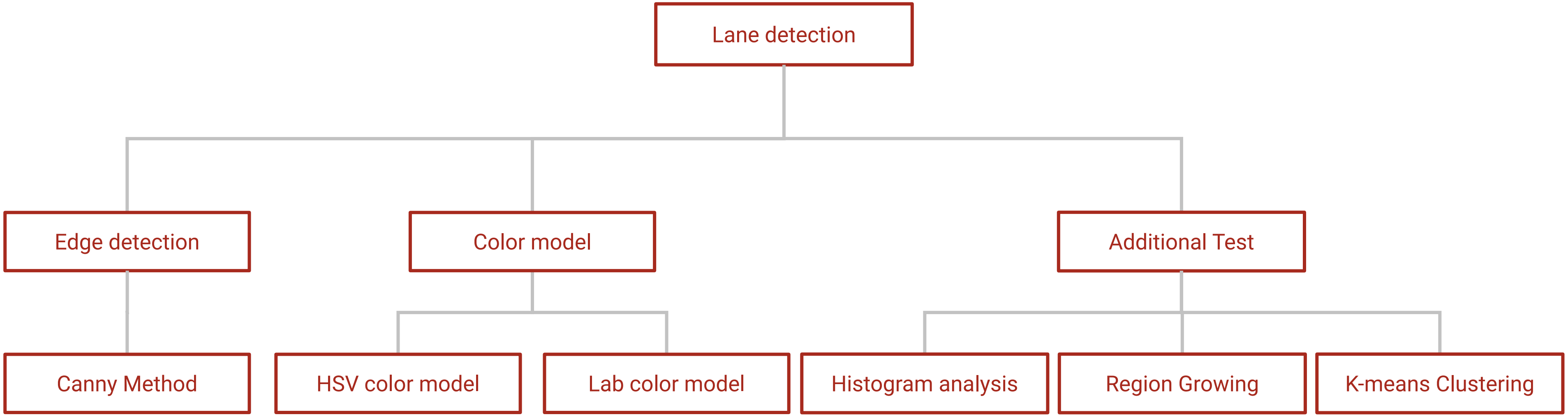
Marks detection : Comparison



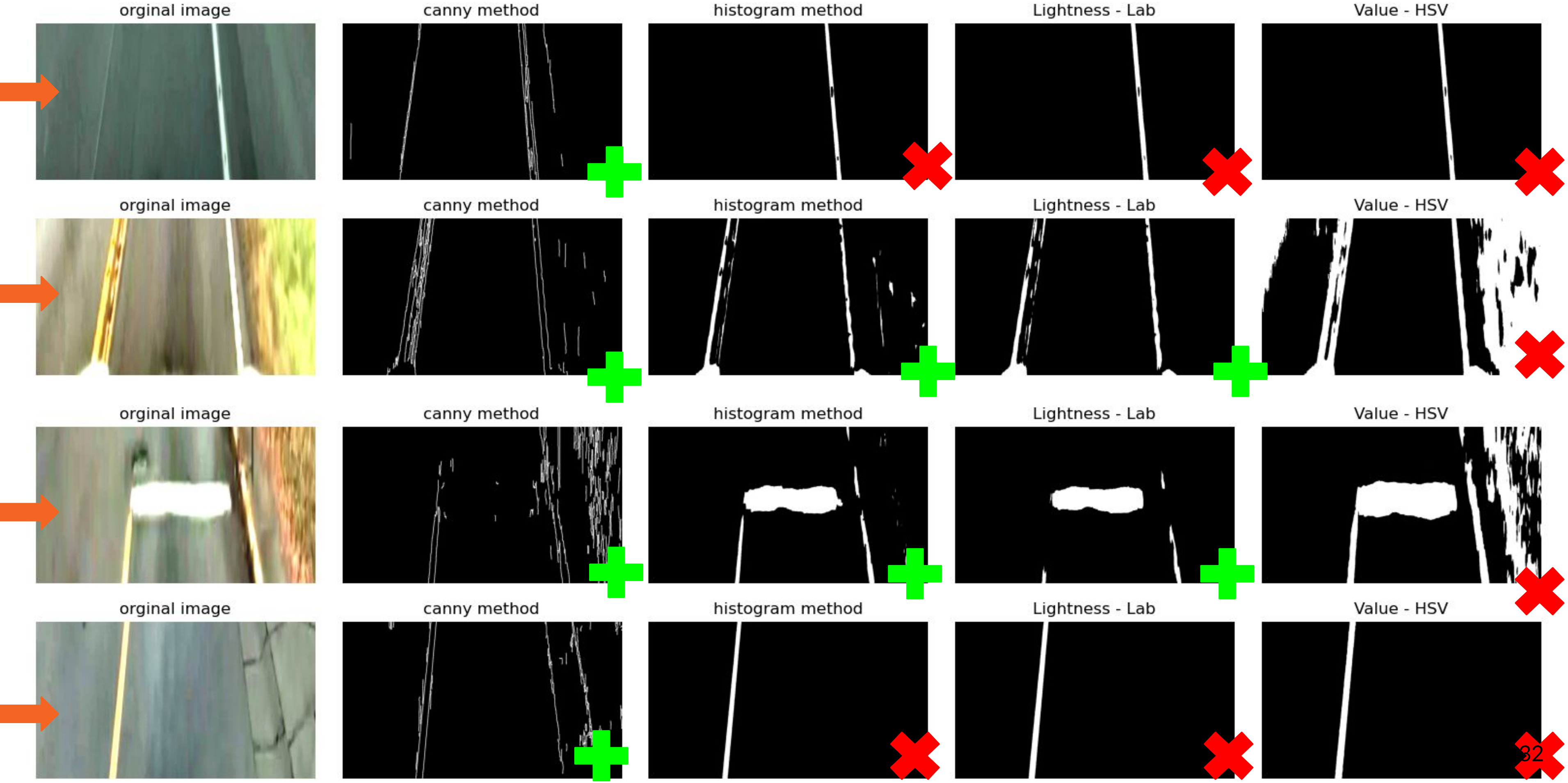
Marks detection : Final Outputs



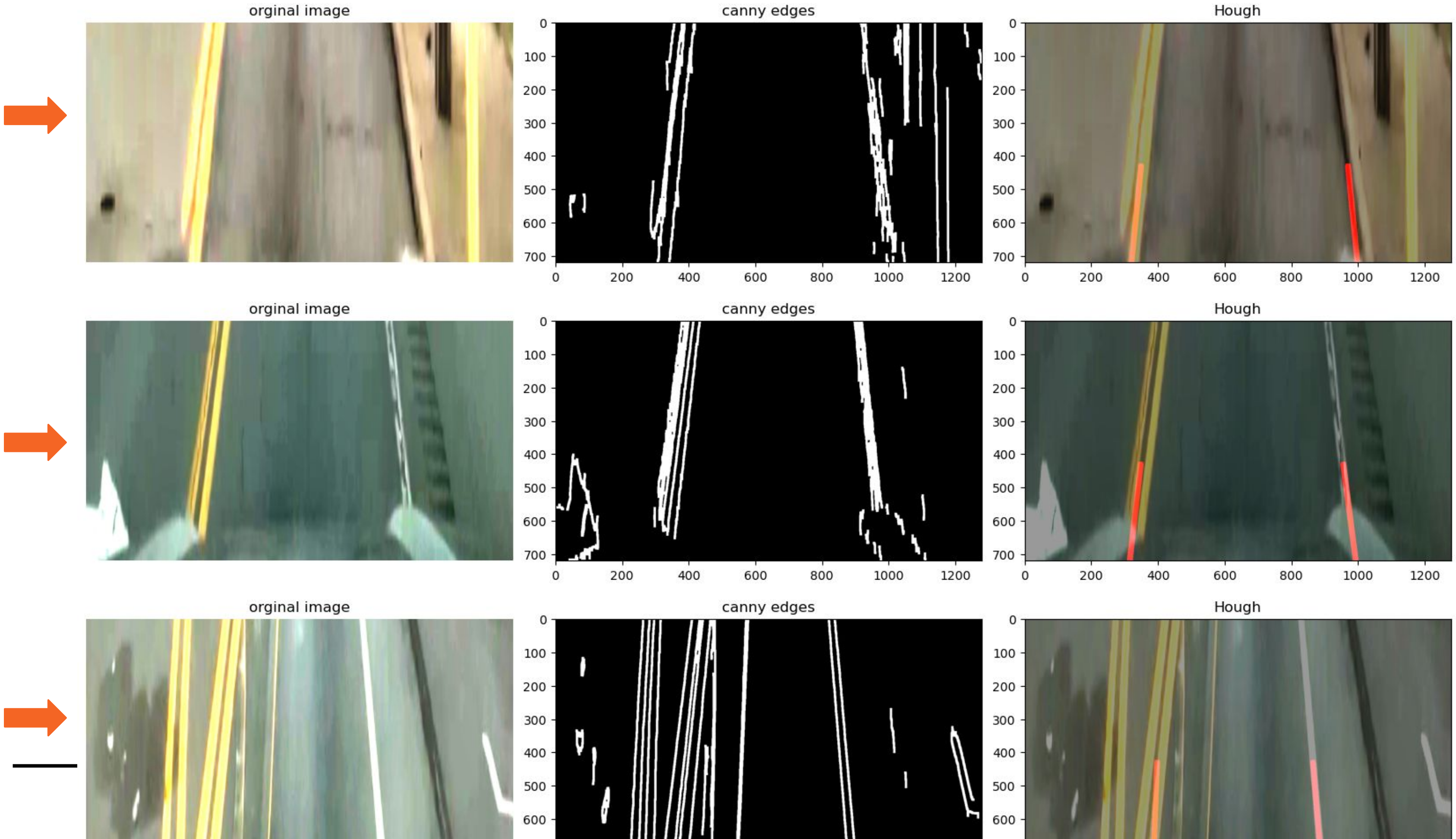
Lane detection



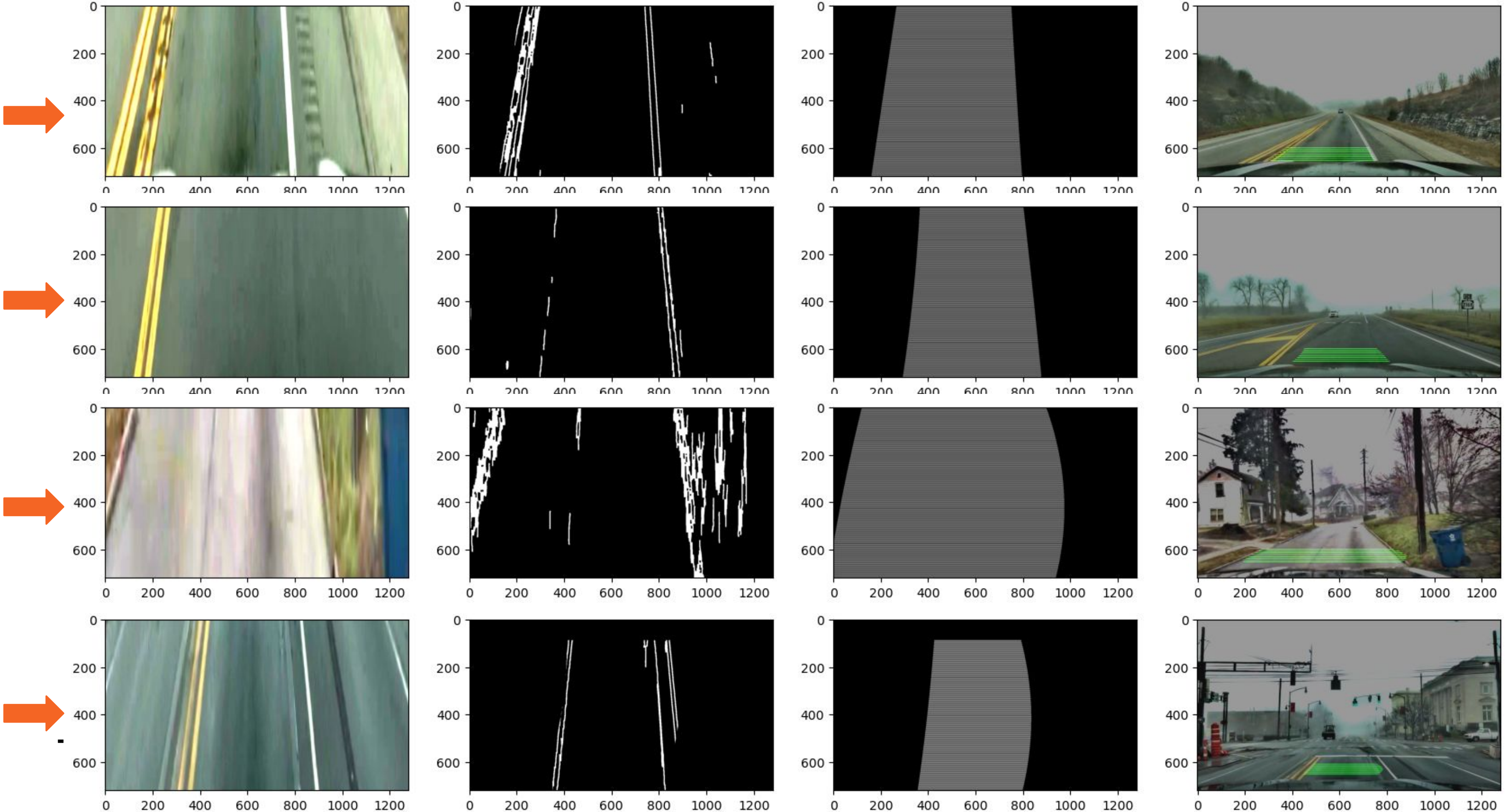
Lane detection : Comparison



Lane detection : Final Outputs Hough

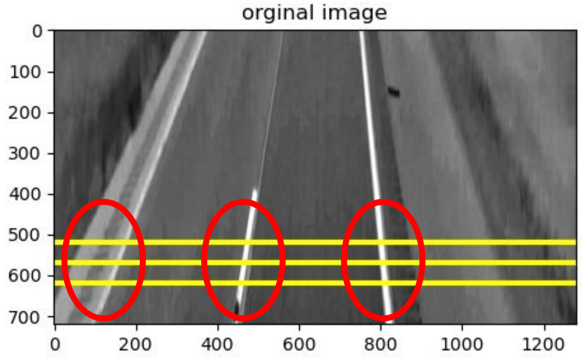


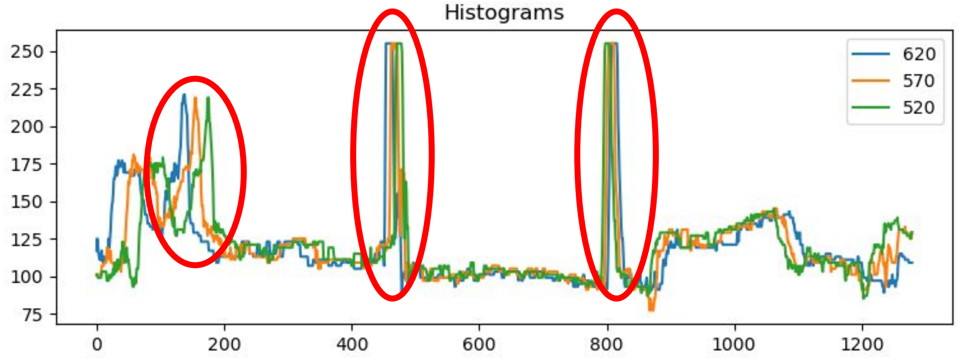
Lane detection : Final Outputs - window sliding

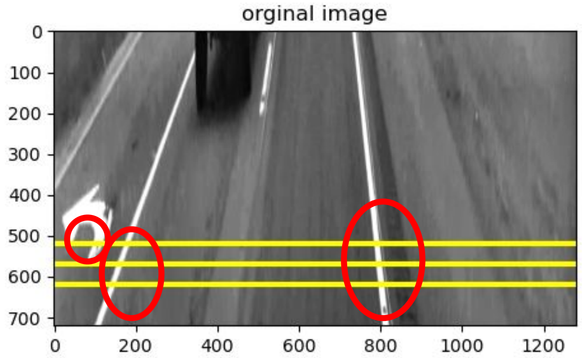


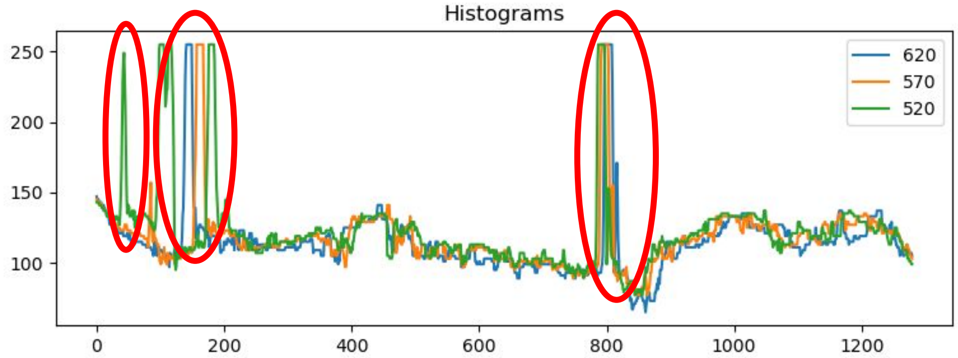
Additional Test

Additional Test : Histogram Analysis

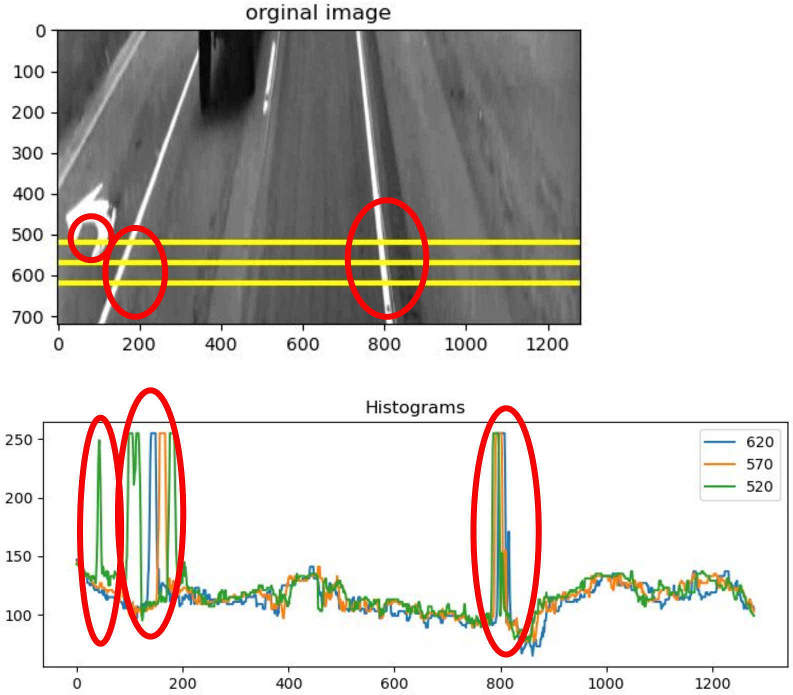


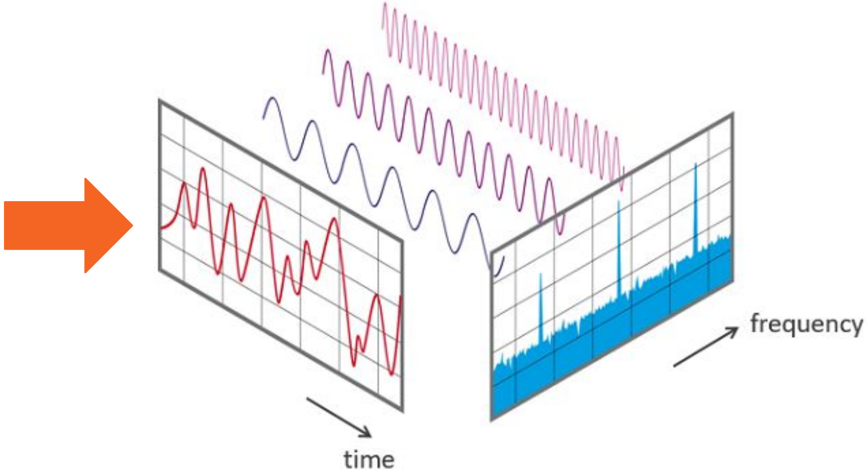






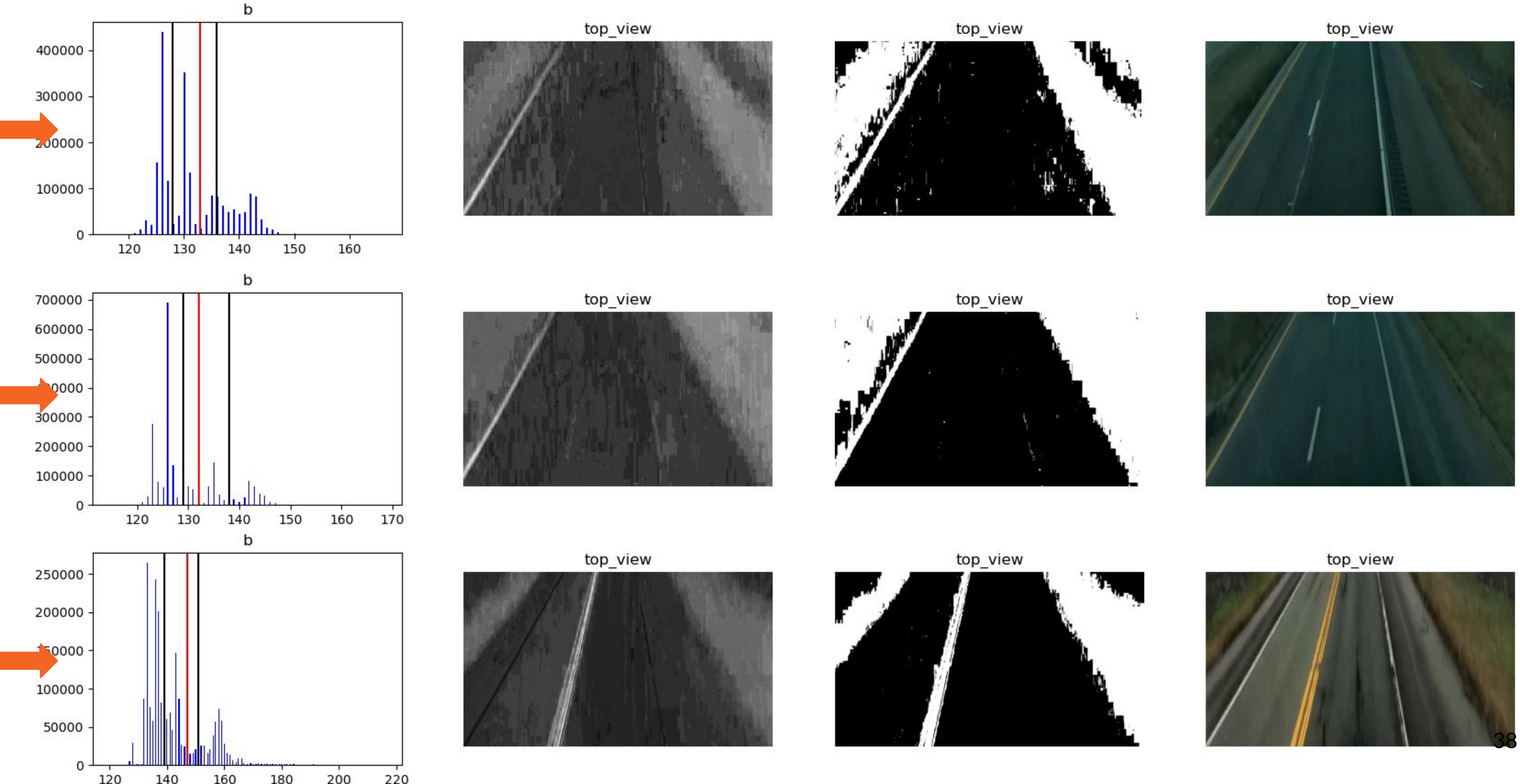
Additional Test : Histogram Analysis





It seems interesting to model the problem as signal processing! E.g. anomaly detection (cracks in roads)

Additional Test : Road Segmentation - Color models



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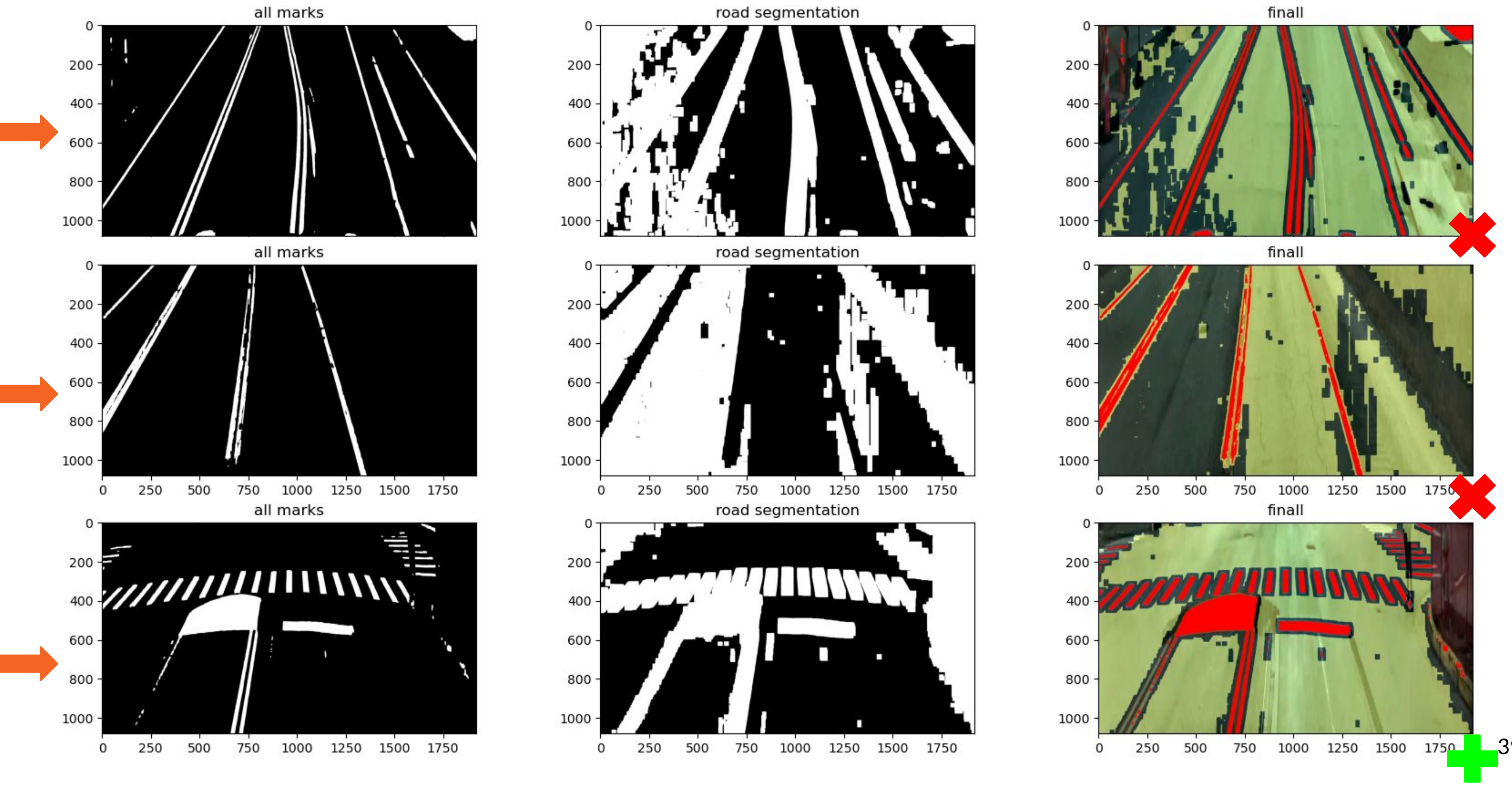
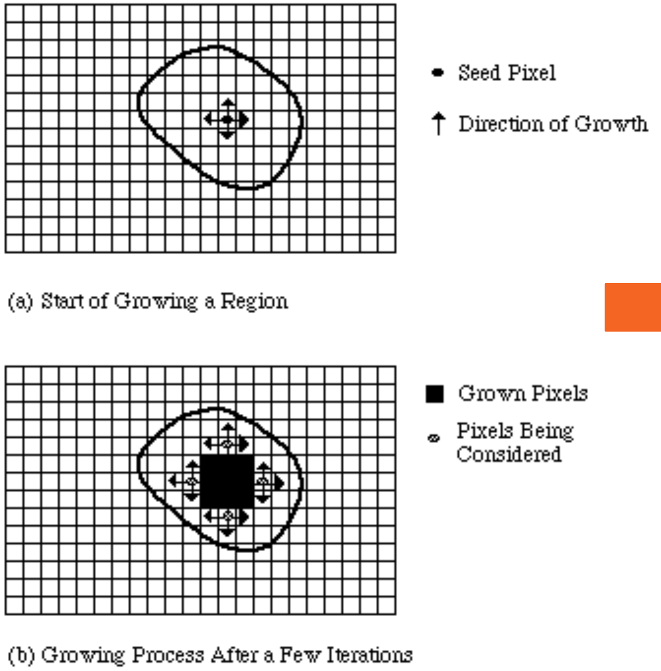
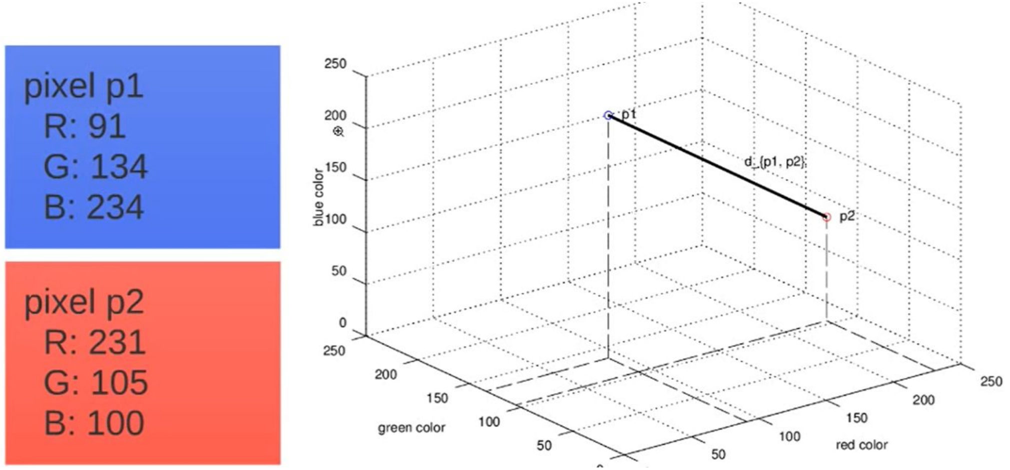
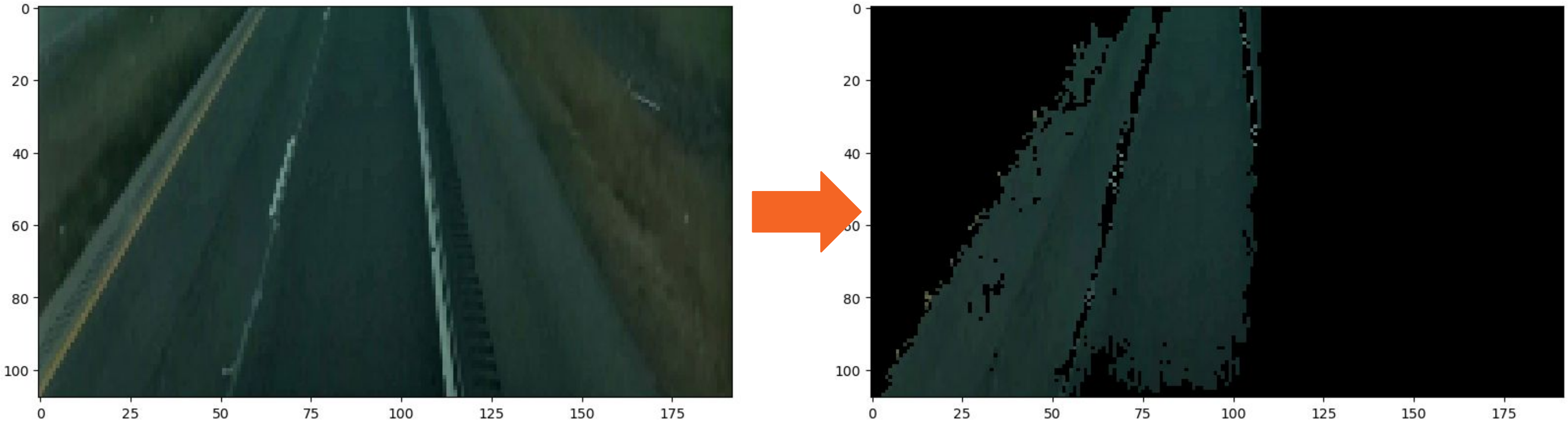


Additional Test : Road Segmentation - Region_Growing





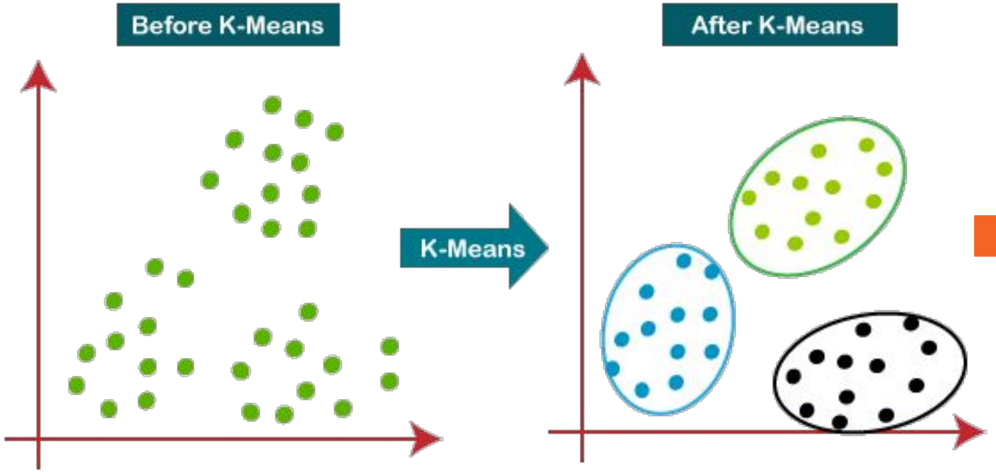
Additional Test : Road Segmentation - Region_Growing

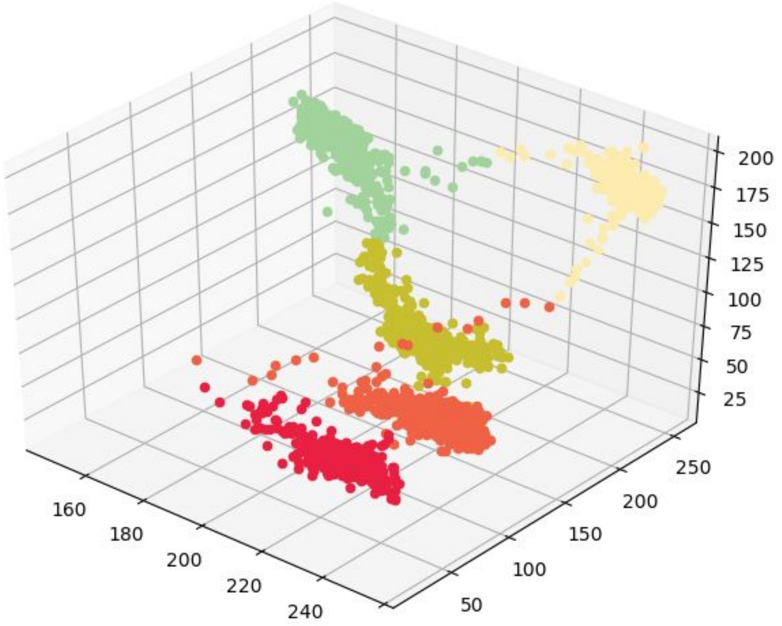


Adv : Good Results in Road Segmentation!

Dis_Adv : High Running Time!

Additional Test : Road Segmentation - K-means Clustering





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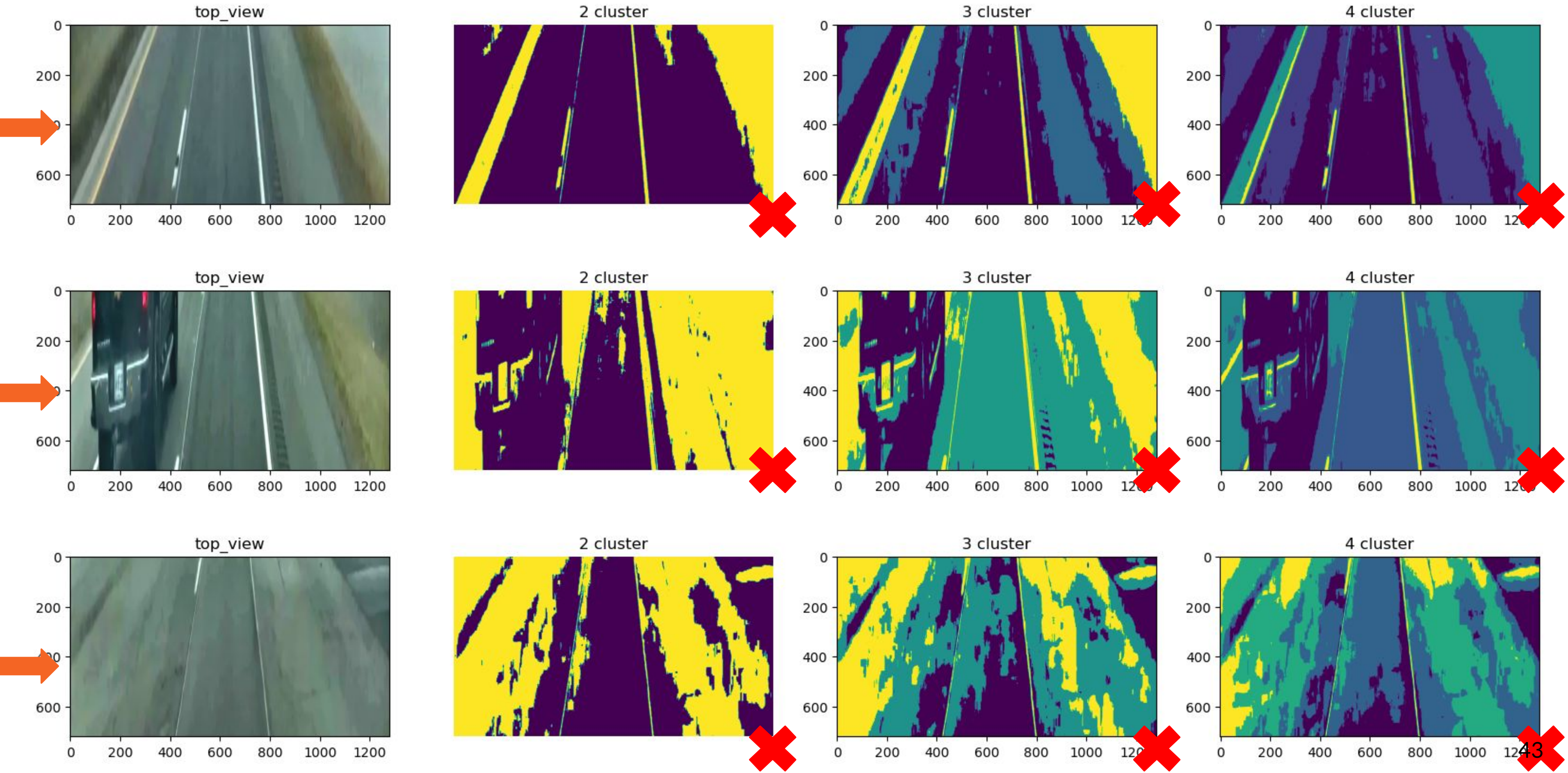

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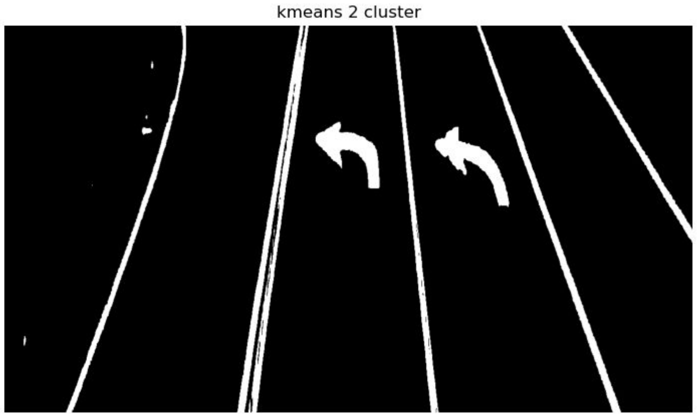


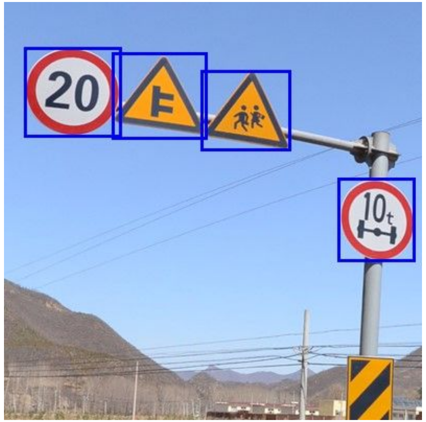
Adv : Good Results in Marks Detection!

Dis_Adv : High Running Time!

Additional Test : Traffic Sign Detection

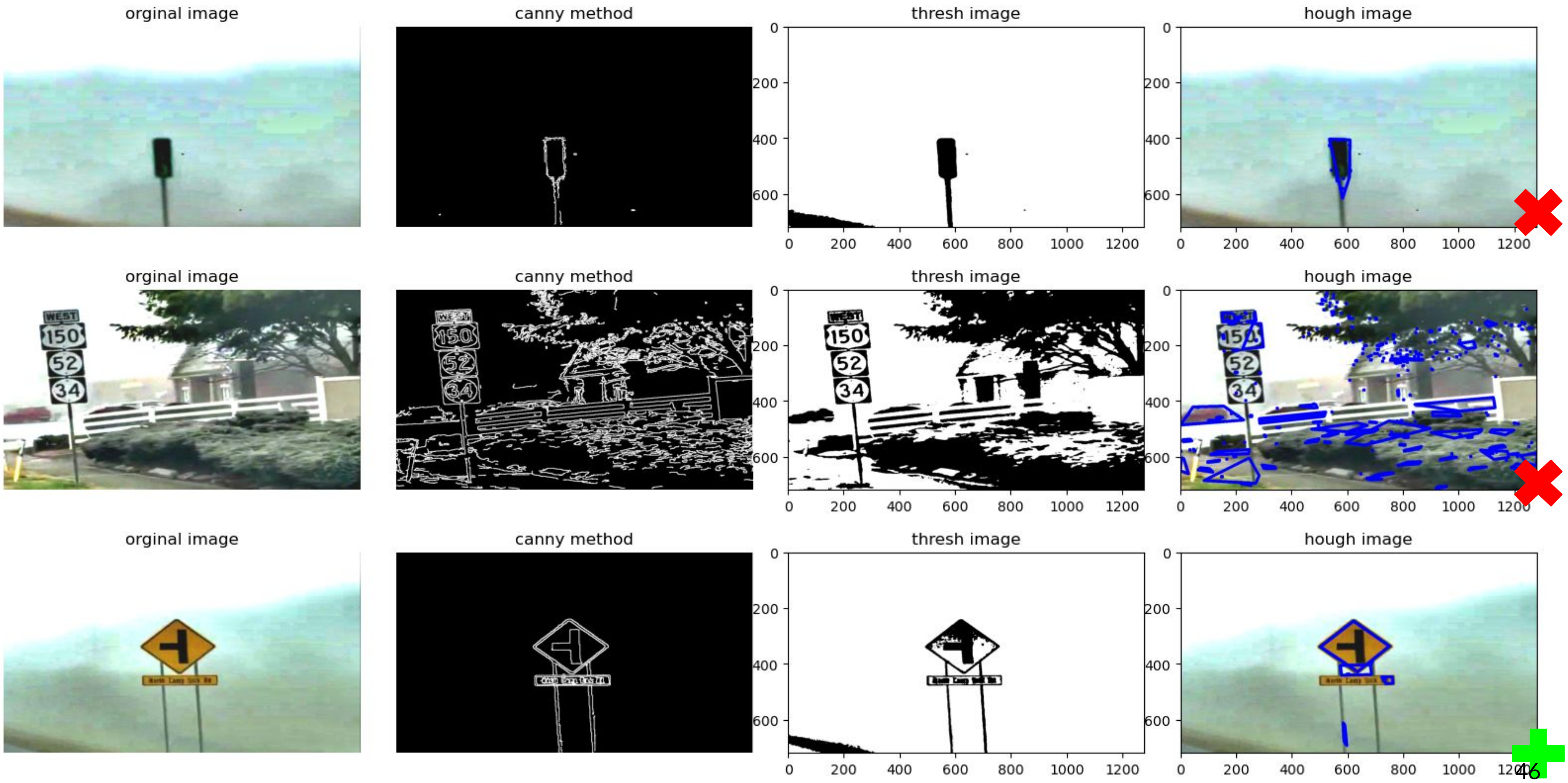
There are several traditional image processing techniques :

- Color-based Segmentation —-> e.g. Red & yellow Signs
- Shape-based Detection —> Contours and Hough methods



These techniques are good for images with good quality and low noisiness!

Additional Test : Traffic Sign Detection

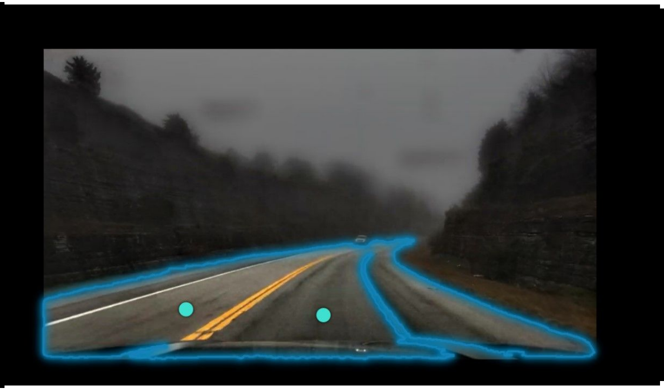


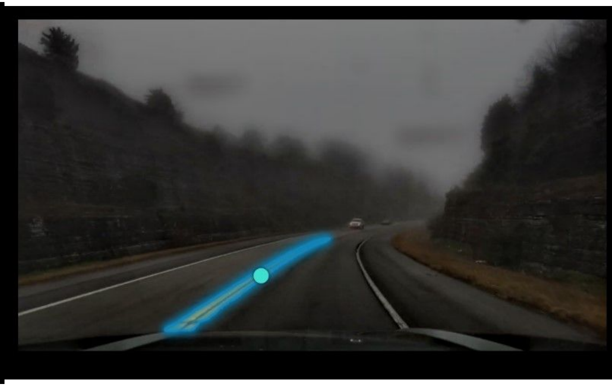
Additional Test : Traffic Sign Detection

Deep Learning?!

Additional Test : Deep Learning Test

All the materials we talked, are necessary to get good results in deep learning models!





Compression

Compression

Redundancy Removal: we are able to remove unimportant segments for better compression rate and rapid transmission.

JPEG Compression (80%)

PNG FILE

572 KB

JPG FILE

74 KB

Final Results

Final Result

References

- Meng, G., Wang, Y., Duan, J., Xiang, S., & Pan, C. (2013). Efficient image dehazing with boundary constraint and contextual regularization. Proceedings of the IEEE international conference on computer vision, 617-624.
- Gautam, S., Gandhi, T. K., & Panigrahi, B. K. (2020). An Improved Air-Light Estimation Scheme for Single Haze Images Using Color Constancy Prior. IEEE Signal Processing Letters, 27, 1695-1699. doi: 10.1109/LSP.2020.3025462.
- Raikwar, S. C., & Tapaswi, S. (2020). Lower Bound on Transmission Using Non-Linear Bounding Function in Single Image Dehazing. IEEE Transactions on Image Processing, 29, 4832-4847. doi: 10.1109/TIP.2020.2975909.
- Towards Data Science. (n.d.). Image segmentation with classical computer vision-based approaches. Retrieved from https://towardsdatascience.com/image-segmentation-with-classical-computer-vision-based-approaches-80c75d6d995f
- Korting, T. (n.d.). Region-growing-segmentation. Retrieved from https://github.com/tkorting/youtube/blob/master/region-growing-segmentation/main.m
- Towards Data Science. (n.d.). Image segmentation with clustering. Retrieved from https://towardsdatascience.com/image-segmentation-with-clustering-b4bbc98f2ee6
- Ayca, Y. (n.d.). Image-Segmentation. Retrieved from https://github.com/YCAyca/Image-Segmentation/tree/main/Clustering
- Cao, J., Song, C., Song, S., Xiao, F., & Peng, S. (2019). Lane Detection Algorithm for Intelligent Vehicles in Complex Road Conditions and Dynamic Environments. Sensors, 19(14), 3166. doi: 10.3390/s19143166
- YouTube. (n.d.). Lane Detection for Autonomous Driving: Conventional and CNN approaches. Retrieved from https://www.youtube.com/watch?v=xIRT3rgWrFQ