

Project Presentation

# Increasing Depth of Field by Image Fusion

IMA201

Elaborated by

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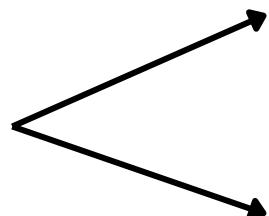
# **PLAN**

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- 02      Guided Filter**
- 03      Image Fusion Algorithm**
- 04      Image Fusion of Colored Images**
- 05      Results Evaluation**
- 06      Evaluation and Potential Improvements**
- 07      Conclusion**

# Guided Filter

$$O_i = a_k I_i + b_k \quad \forall i \in \omega_k$$

where  $\omega_k$  is a square window of size  $(2r+1) \times (2r+1)$ .

$$E(a_k, b_k) = \sum_{i \in \omega_k} \left( (a_k I_i + b_k - P_i)^2 + \epsilon a_k^2 \right)$$

$$a_k = \frac{\frac{1}{|\omega|} \sum_{i \in \omega_k} I_i P_i - \mu_k \bar{P}_k}{\delta_k + \epsilon}$$
$$b_k = \bar{P}_k - a_k \mu_k$$

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$$b_k = \bar{P}_k - a_k \mu_k$$

$$O_i = \bar{a}_i I_i + \bar{b}_i$$

$$\text{where } \bar{a}_i = \frac{1}{|\omega|} \sum_{k \in \omega_i} a_k, \quad \bar{b}_i = \frac{1}{|\omega|} \sum_{k \in \omega_i} b_k$$

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$$a_k = \frac{\frac{1}{|\omega|} \sum_{i \in \omega_k} I_i P_i - \mu_k \bar{P}_k}{\delta_k + \epsilon}$$

$$b_k = \bar{P}_k - a_k \mu_k$$

$$O_i = \bar{a}_i I_i + \bar{b}_i$$

$$\text{where } \bar{a}_i = \frac{1}{|\omega|} \sum_{k \in \omega_i} a_k, \bar{b}_i = \frac{1}{|\omega|} \sum_{k \in \omega_i} b_k$$

$$O_i = \mathbf{a}_k^T \mathbf{I}_i + b_k \quad \forall i \in \omega_k$$

$$\mathbf{a}_k = (\Sigma_k + \epsilon U) \left( \frac{1}{|\omega|} \sum_{i \in \omega_k} \mathbf{I}_i p_i - \boldsymbol{\mu}_k \bar{p}_k \right)$$

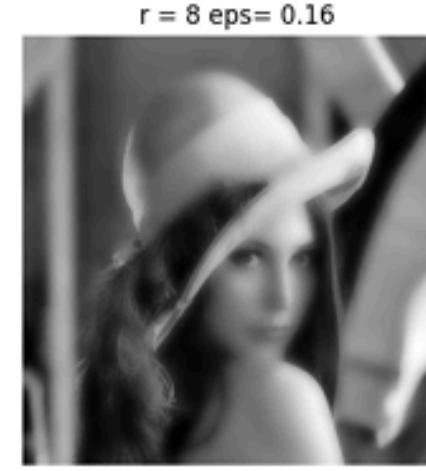
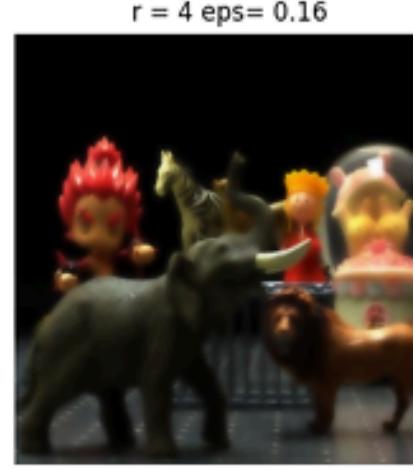
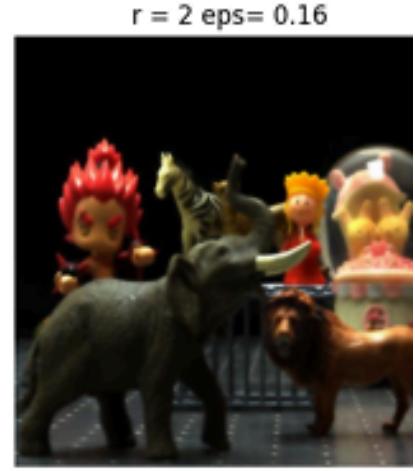
$$b_k = \bar{p}_k - \mathbf{a}_k^T \boldsymbol{\mu}_k$$

$$O_i = \bar{\mathbf{a}}_i^T \mathbf{I}_i + \bar{b}_i$$

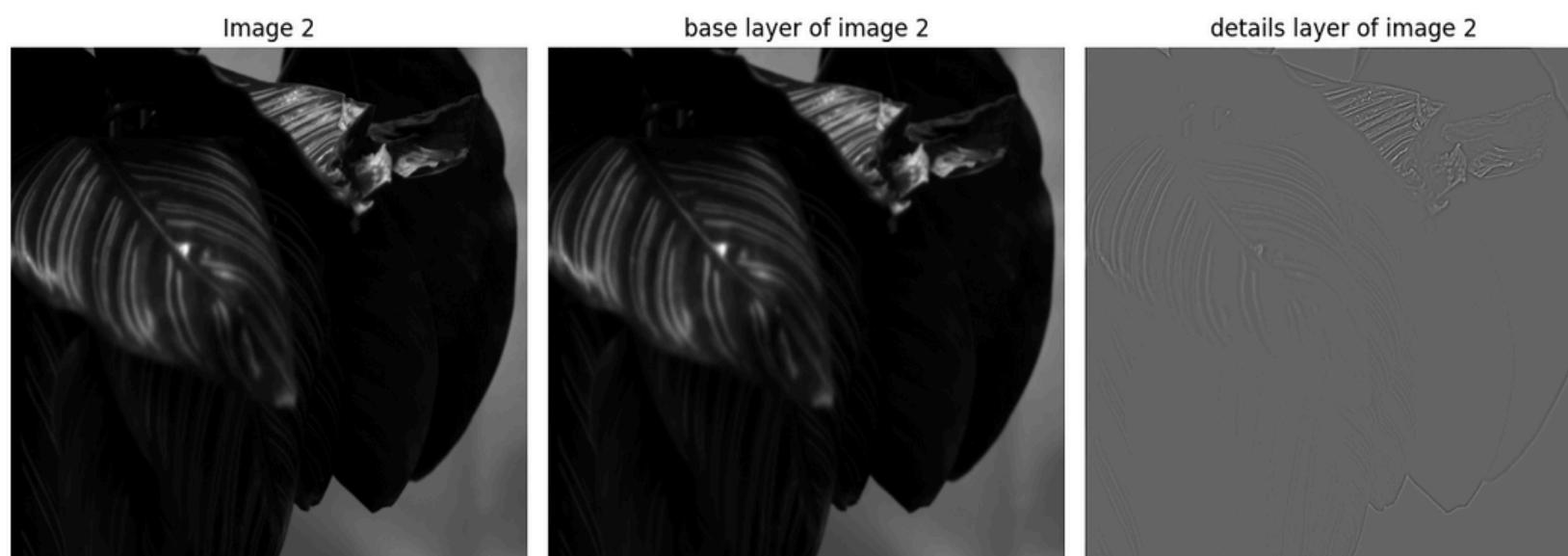
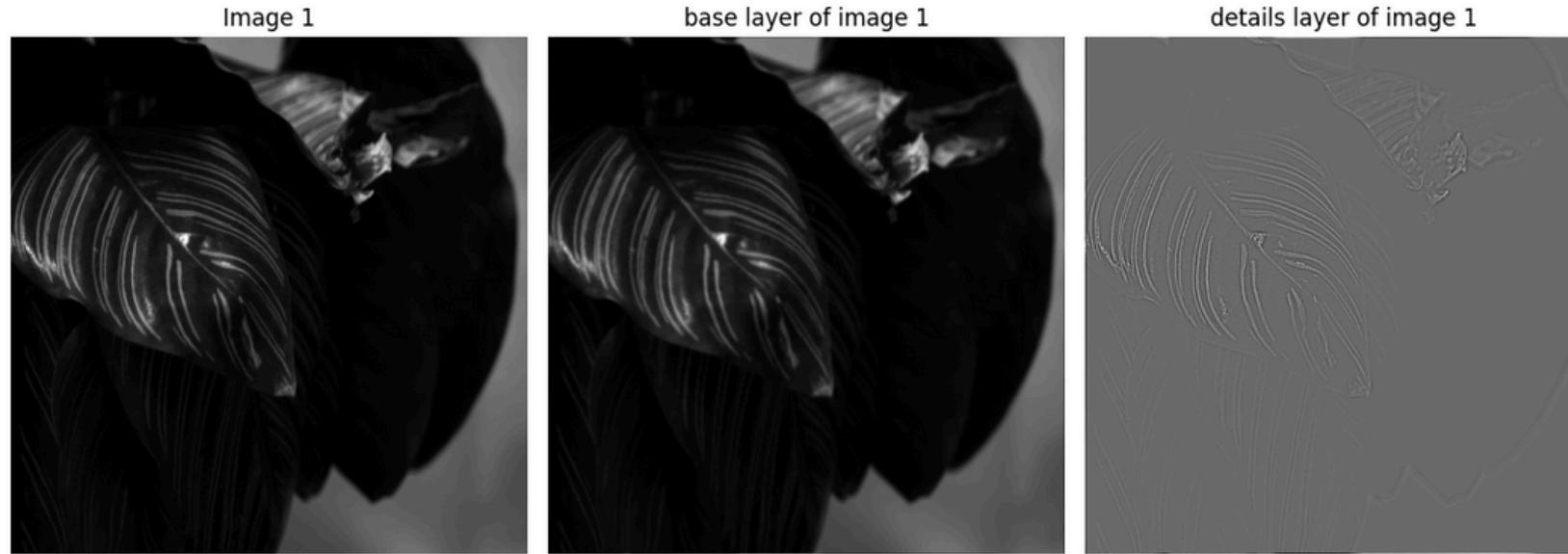
Input : a color image

# Guided Filter

r and eps are the parameters which decide the filter size and blur degree of the guided filter



# Two-Scale Image Decomposition (Base & Details layer)



$$B_n = I_n * Z$$

$$D_n = I_n - B_n$$

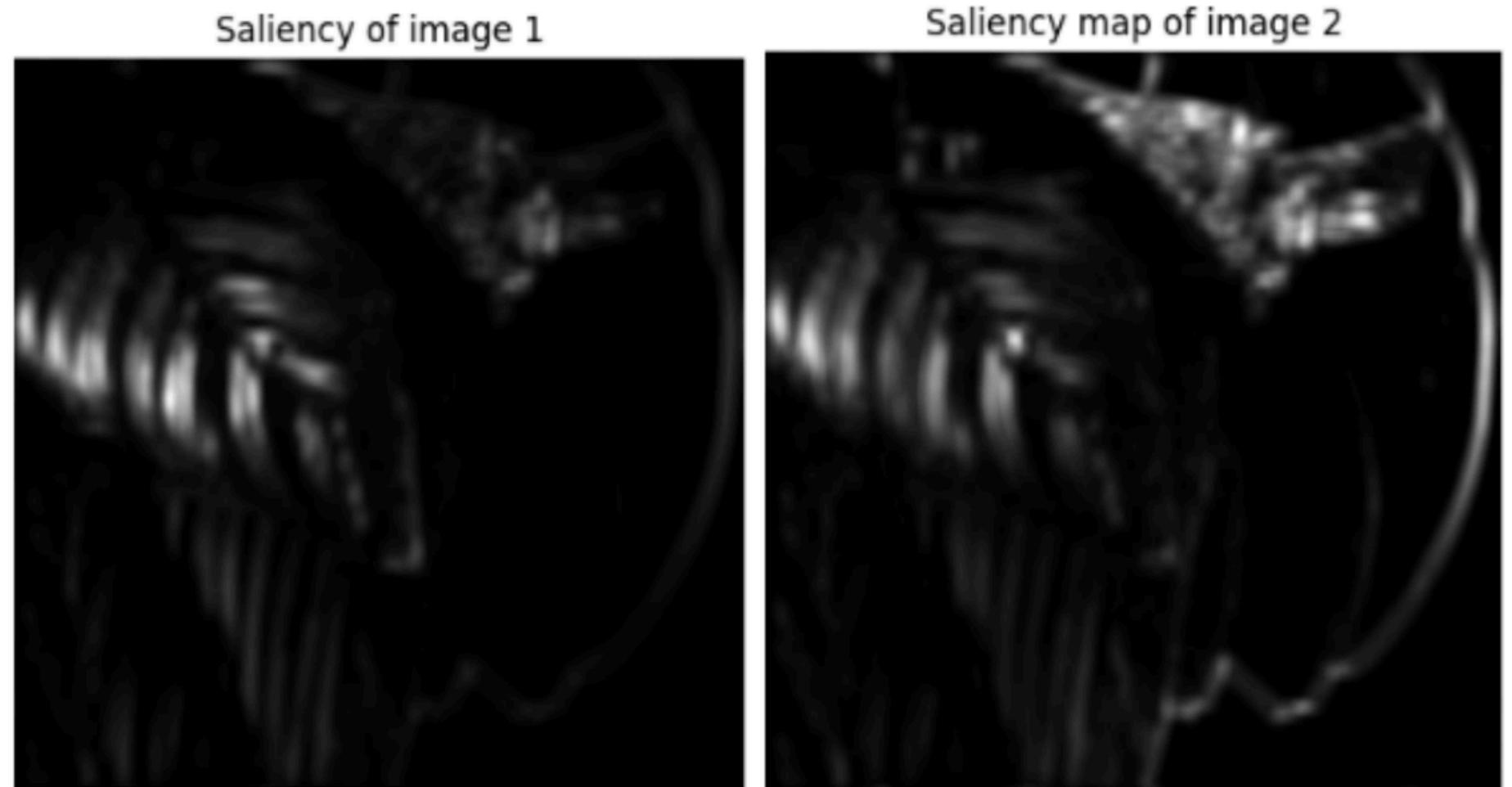
$Z$  is an average filter of size  $9 \times 9$

# Weight Map Construction

## Saliency Map Construction

$$H_n = I_n * L$$

$$S_n = |H_n| * g_r$$



# Weight Map Construction

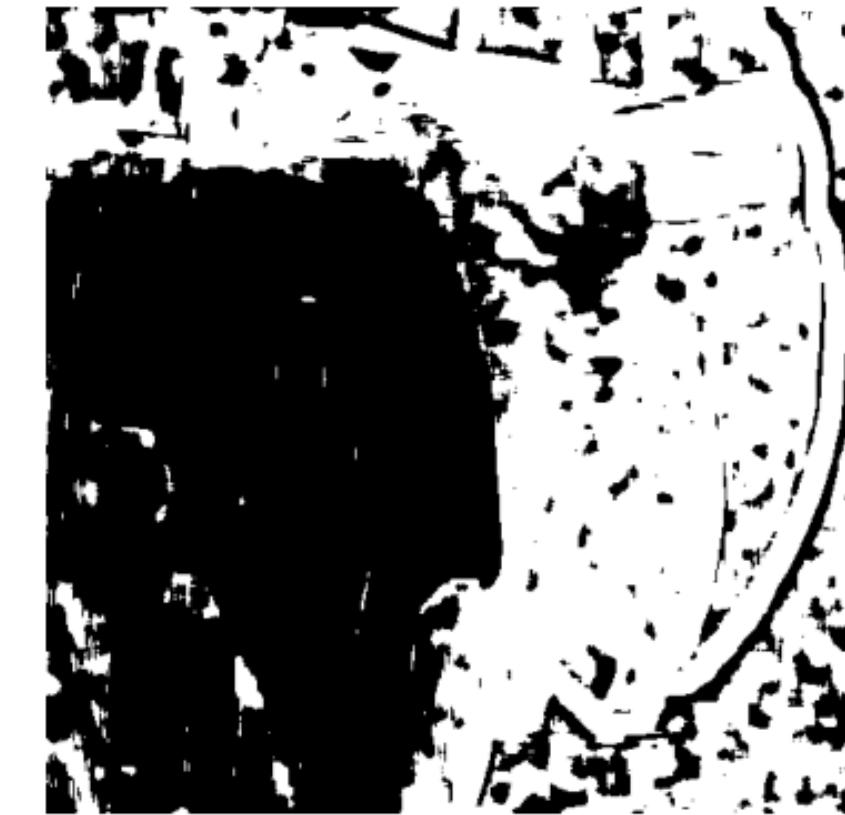
## Saliency Based Weight Maps

$$P_{nk} = \begin{cases} 1 & \text{if } S_{nk} = \max(S_{1k}, S_{2k}, \dots, S_{Nk}) \\ 0 & \text{if not} \end{cases}$$

Weight map of image 1



Weight map of image 2



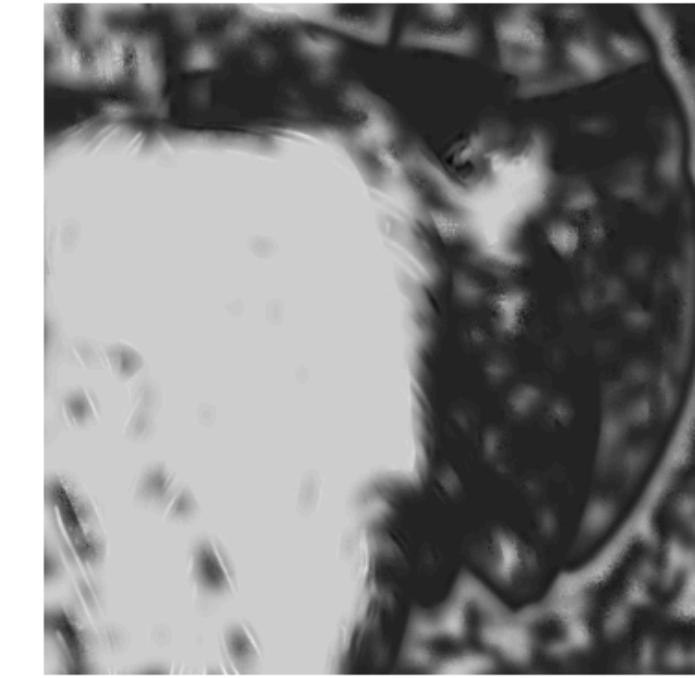
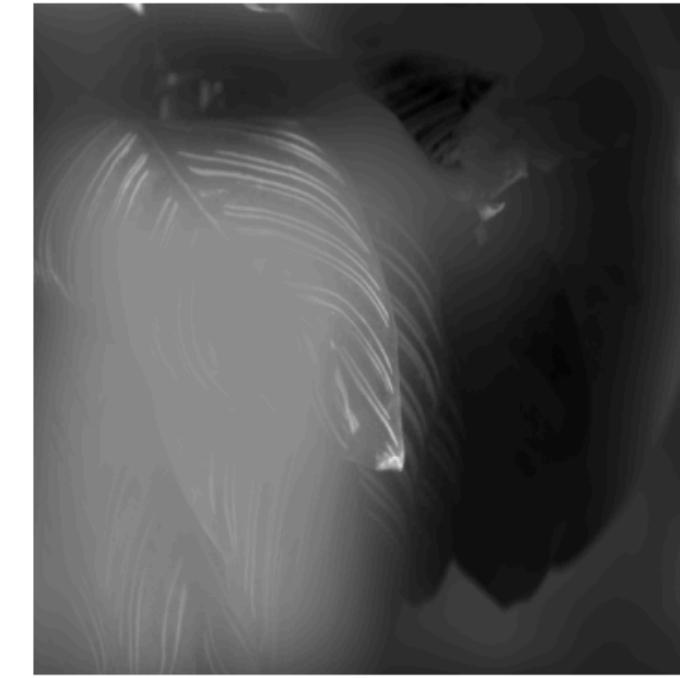
# Weight Map Construction

## Weight Maps Refinement with Guided Filtering

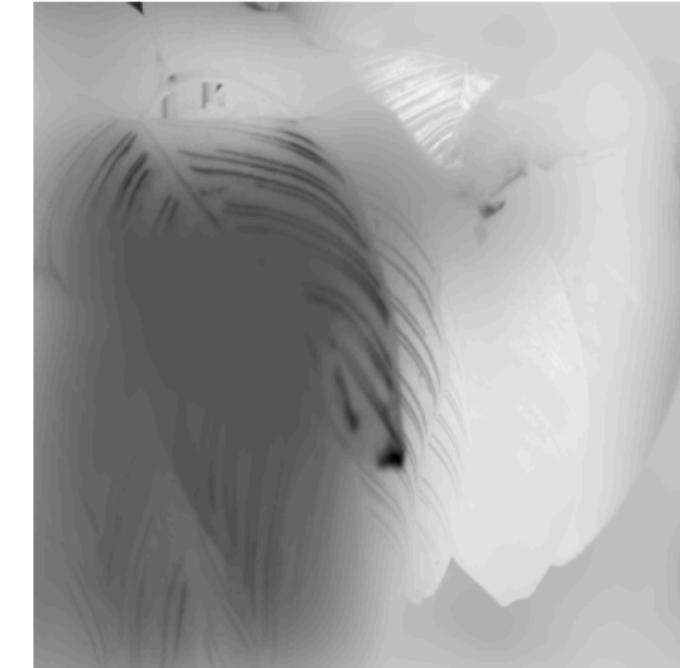
$$W_n^B = G_{r1,1}(P_n, I_n)$$

$$W_n^D = G_{r2,2}(P_n, I_n)$$

Refined weight map of base layer of image 1   Refined weight map of details layer of image 1



Refined weight map of base layer of image 2   Refined weight map of details layer of image 2



# Weighted Image Fusion

$$\bar{B} = \sum_{n=1}^N W_n^B B_n$$

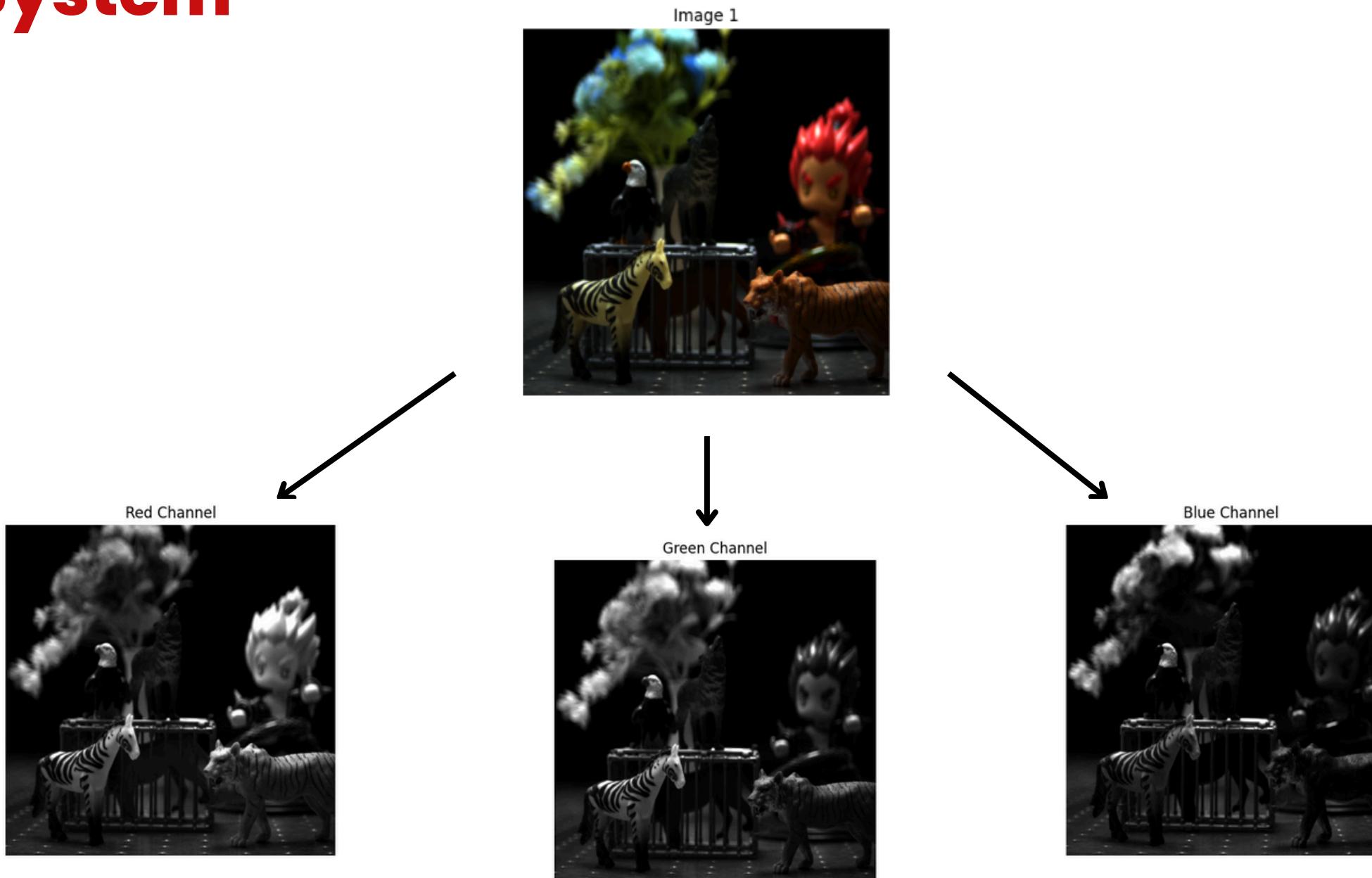
$$\bar{D} = \sum_{n=1}^N W_n^D D_n$$

$$F = \bar{B} + \bar{D}$$



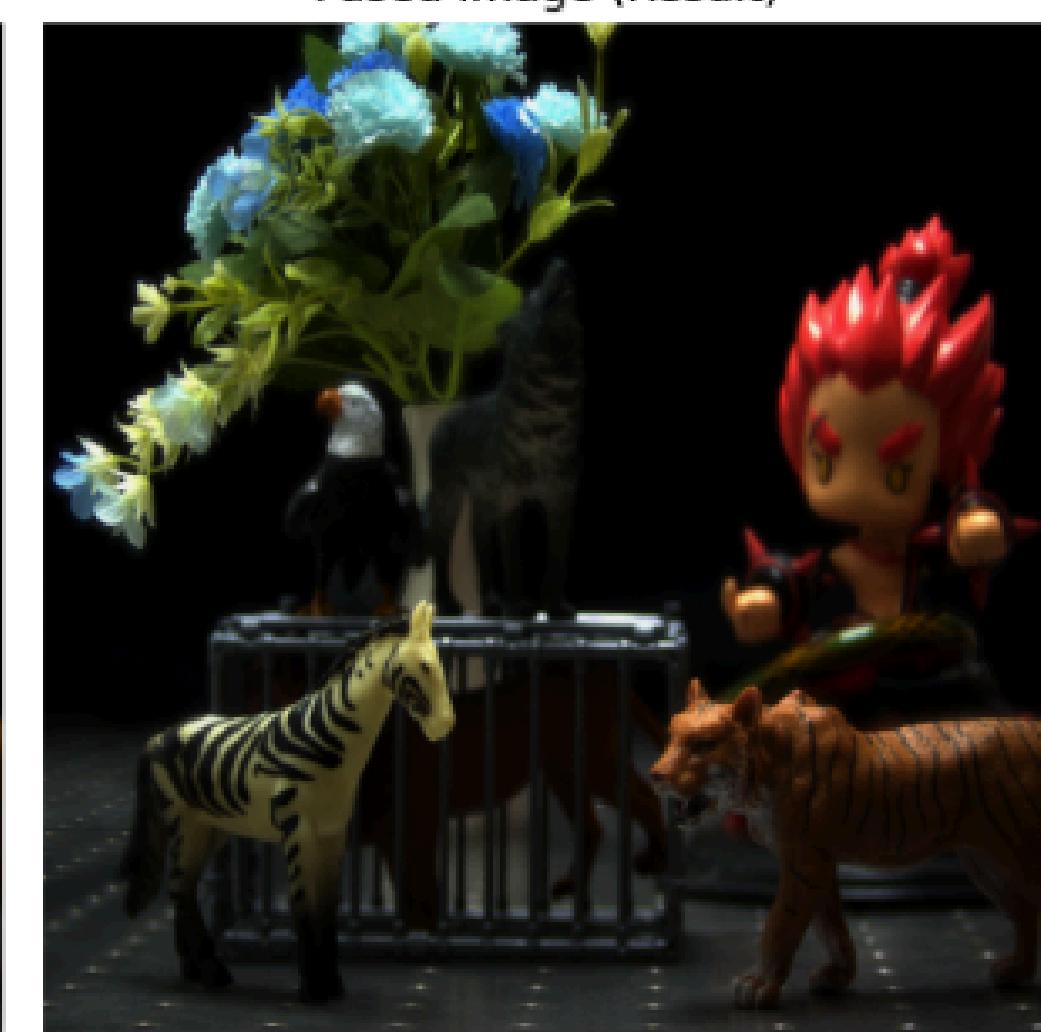
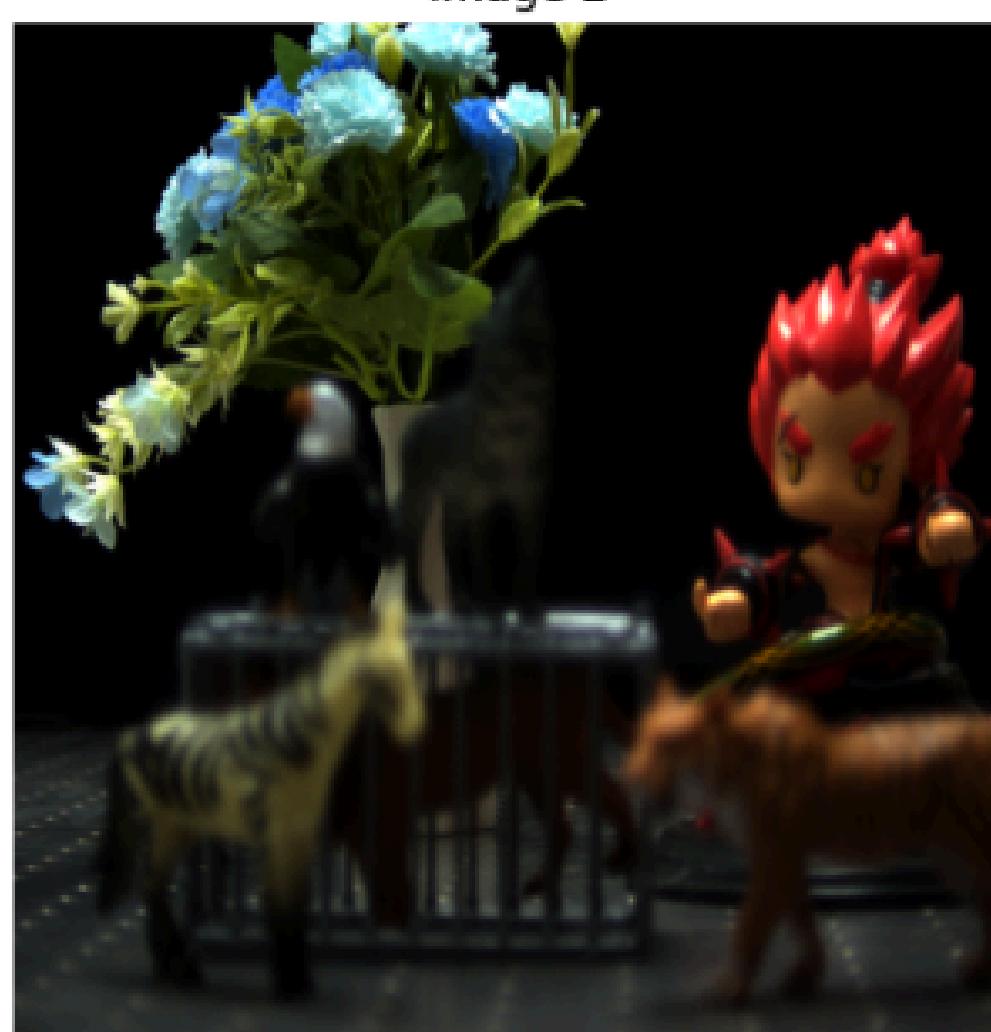
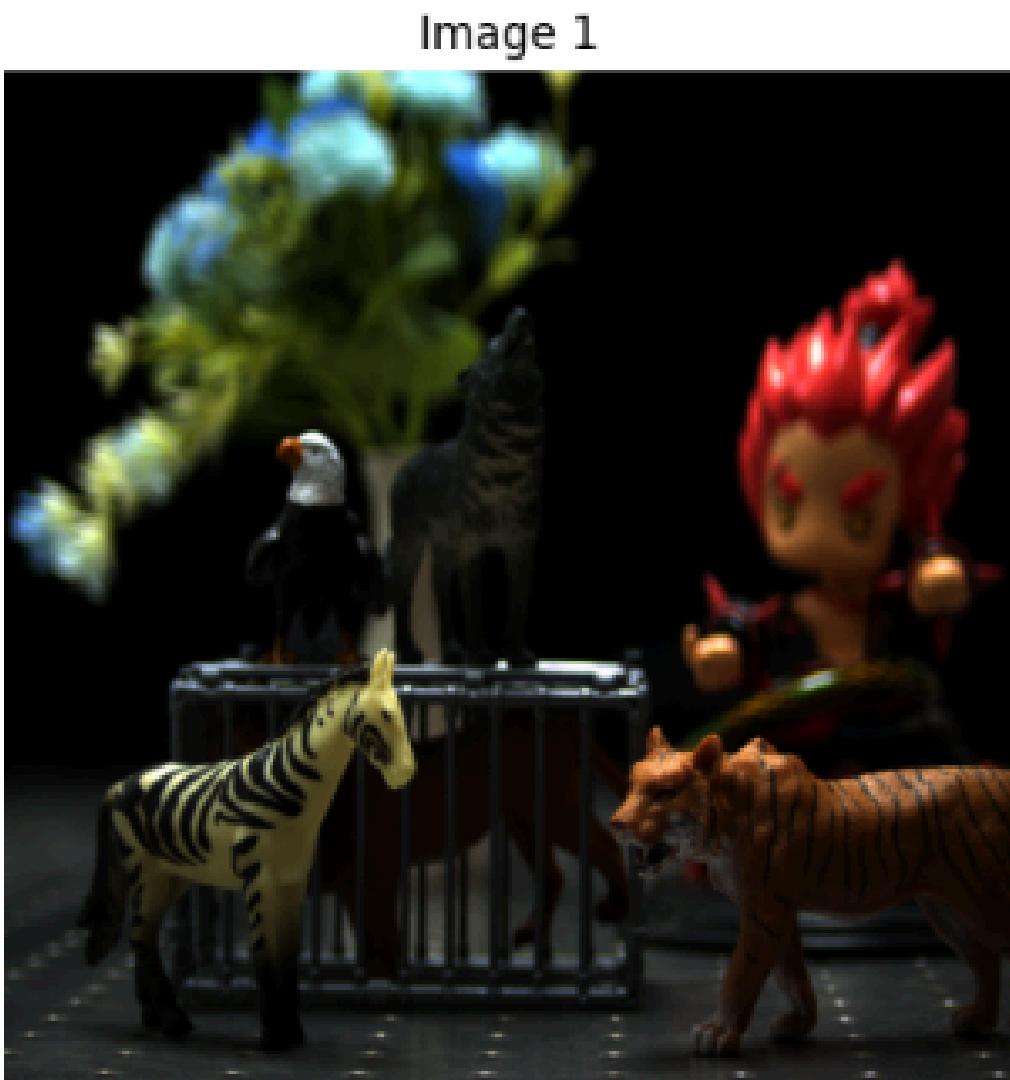
# Colored Images Fusion

## RGB Color System



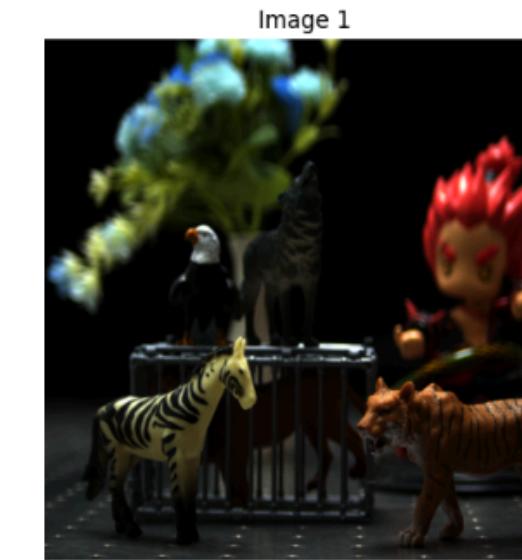
# Colored Images Fusion

## RGB Color System



# Colored Images Fusion

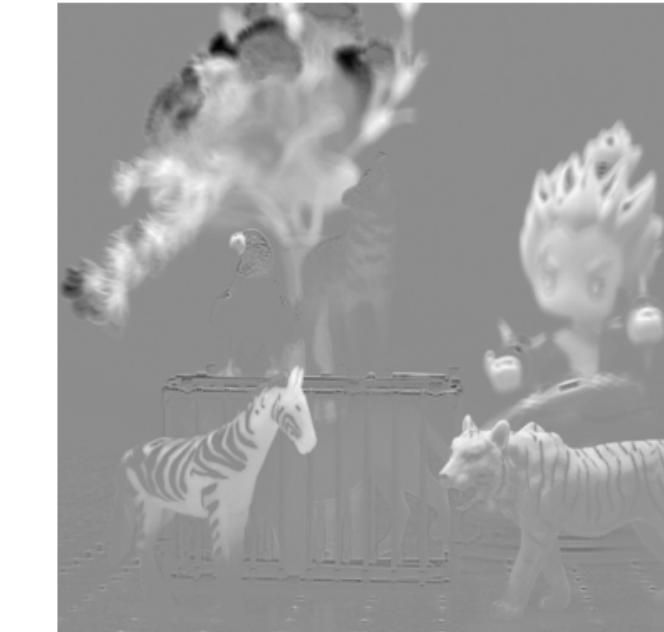
## LAB Color System



A Channel



B Channel

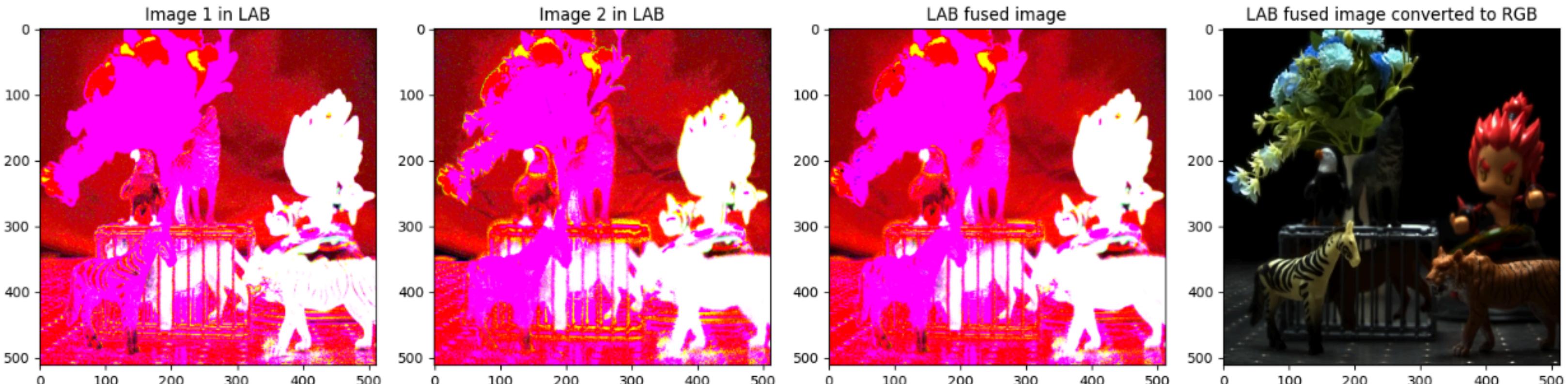


Luminosity Channel



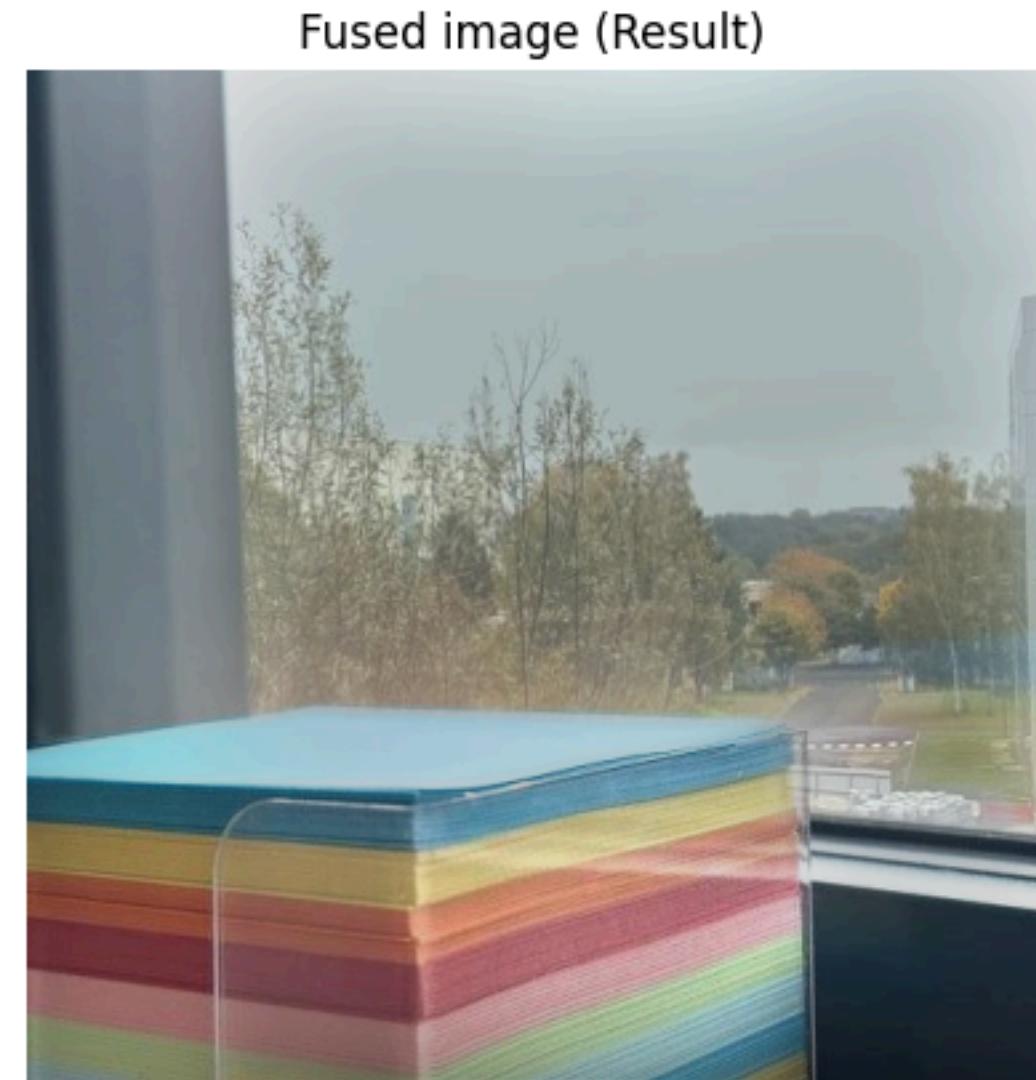
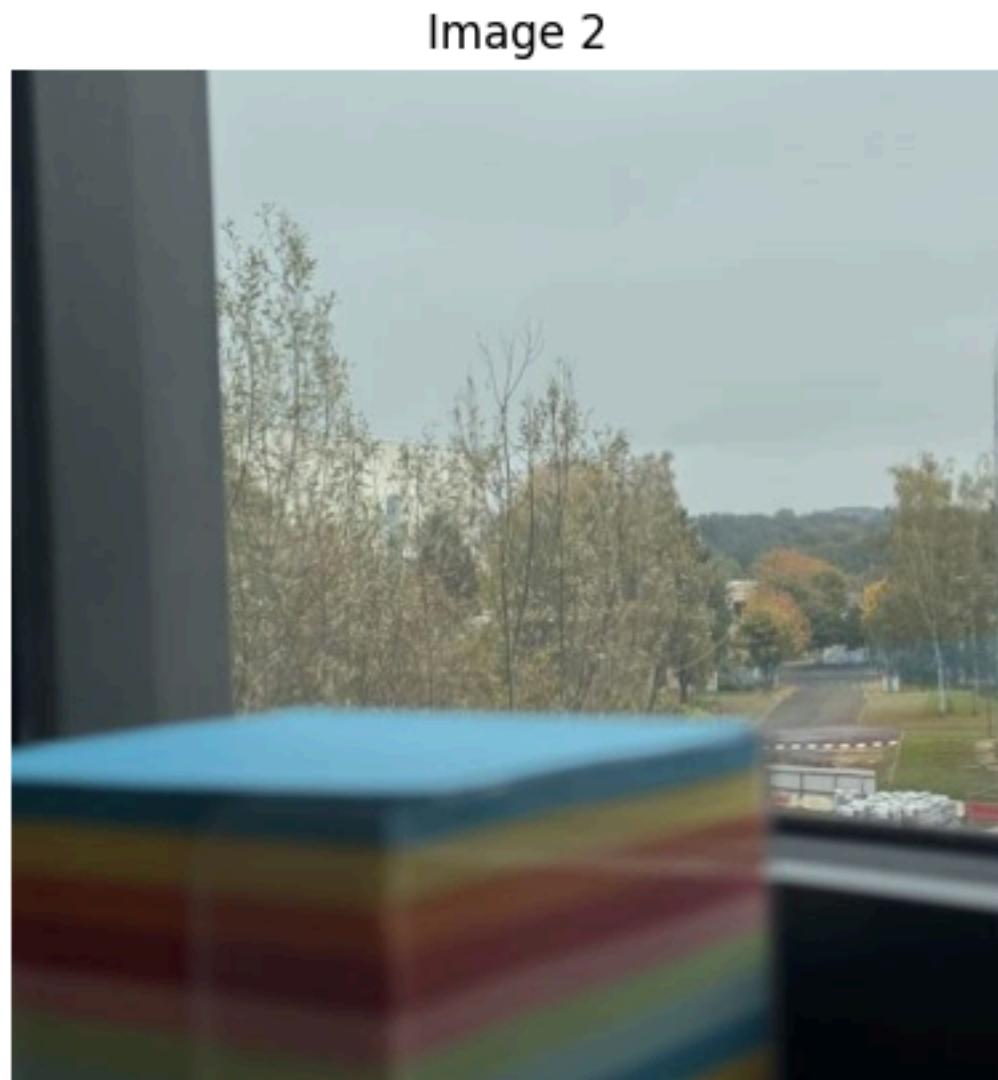
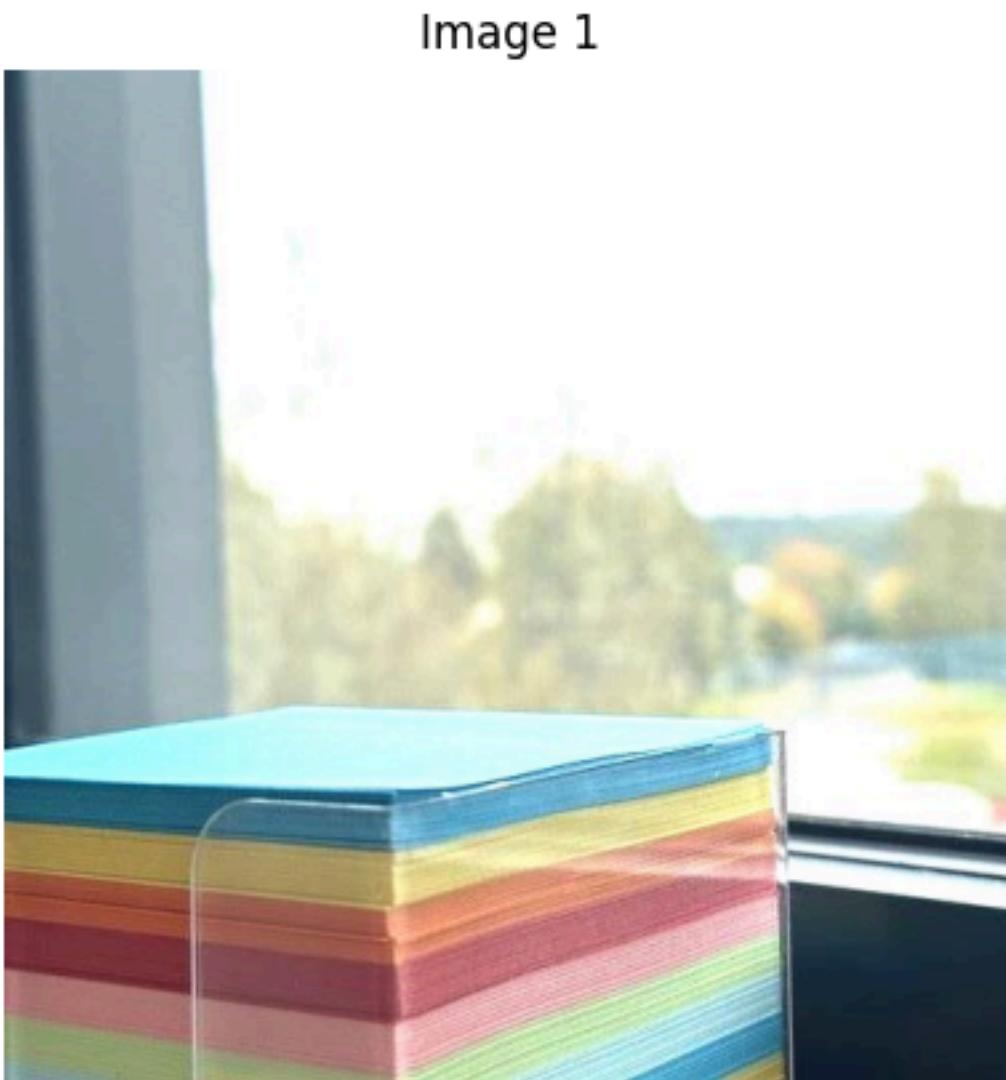
# Colored Images Fusion

## LAB Color System



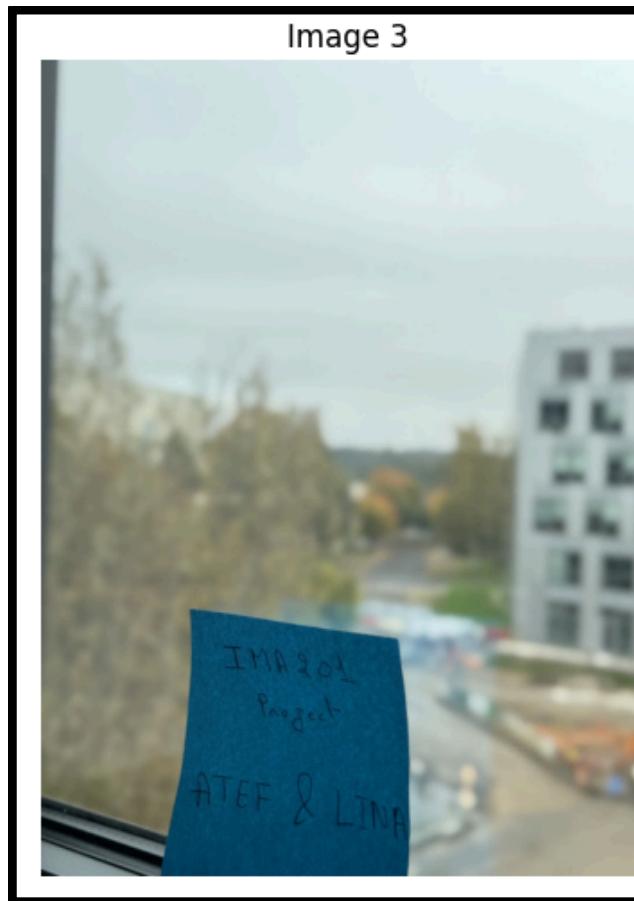
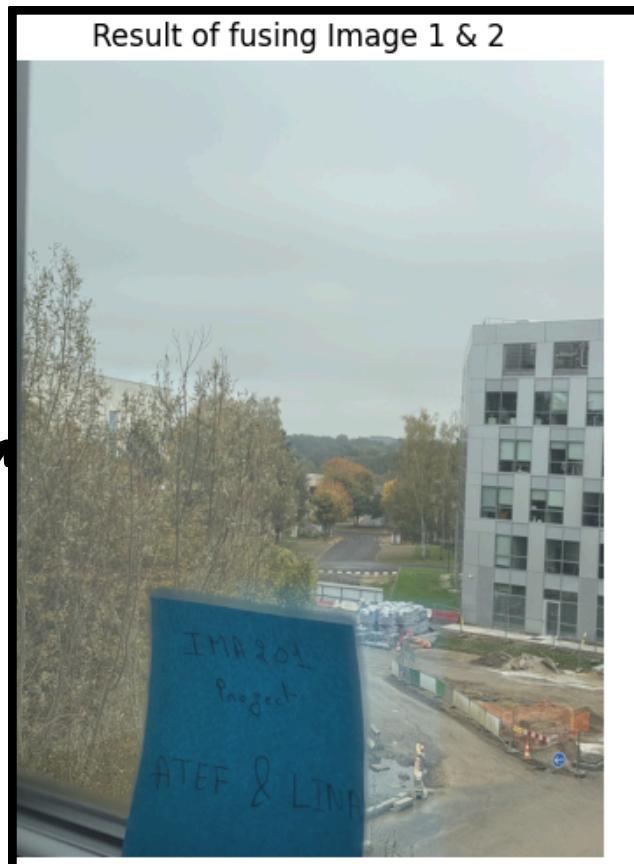
# Experiments

## Multi-exposure images



# Experiments

## Iterative Fusion

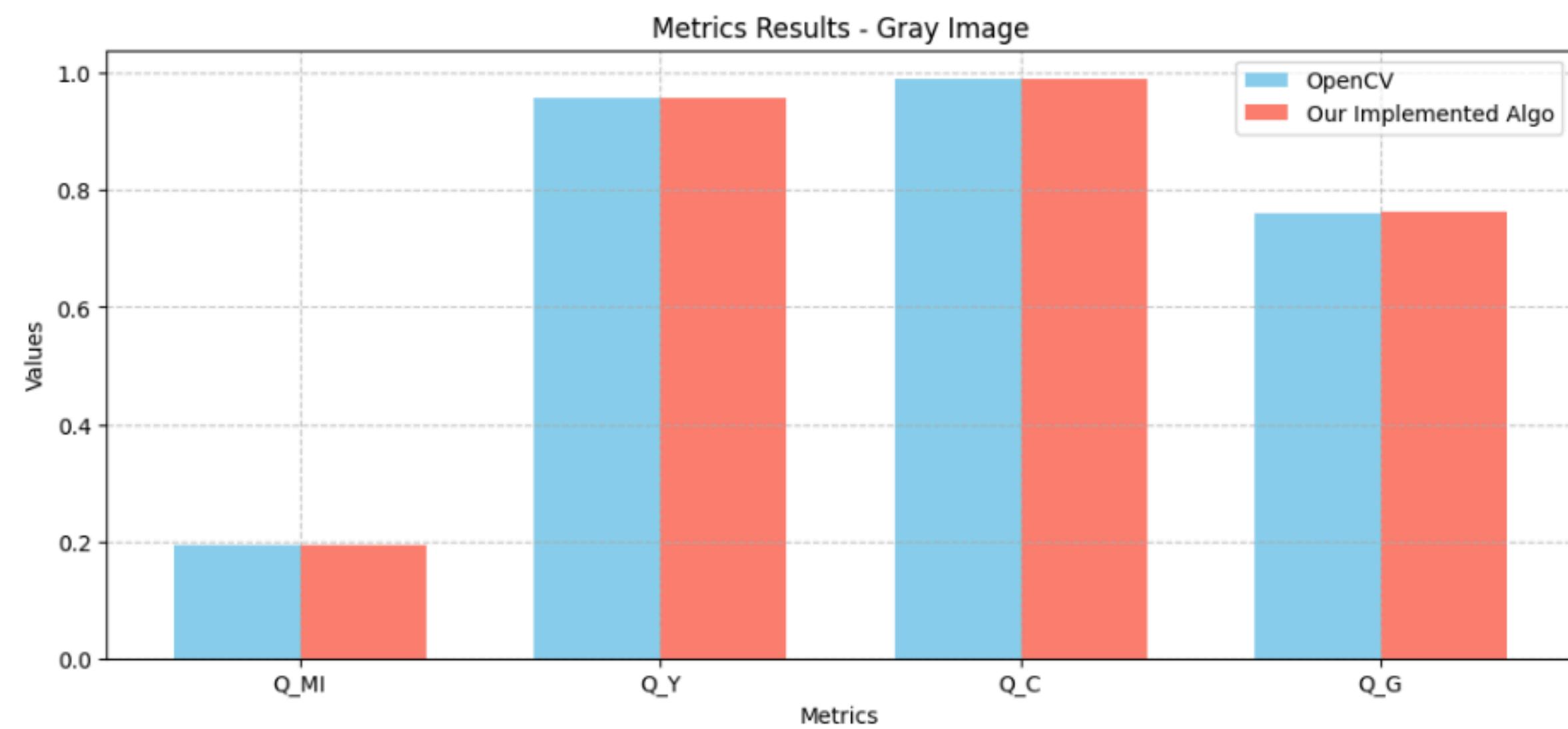


Final result of fusing 3 images



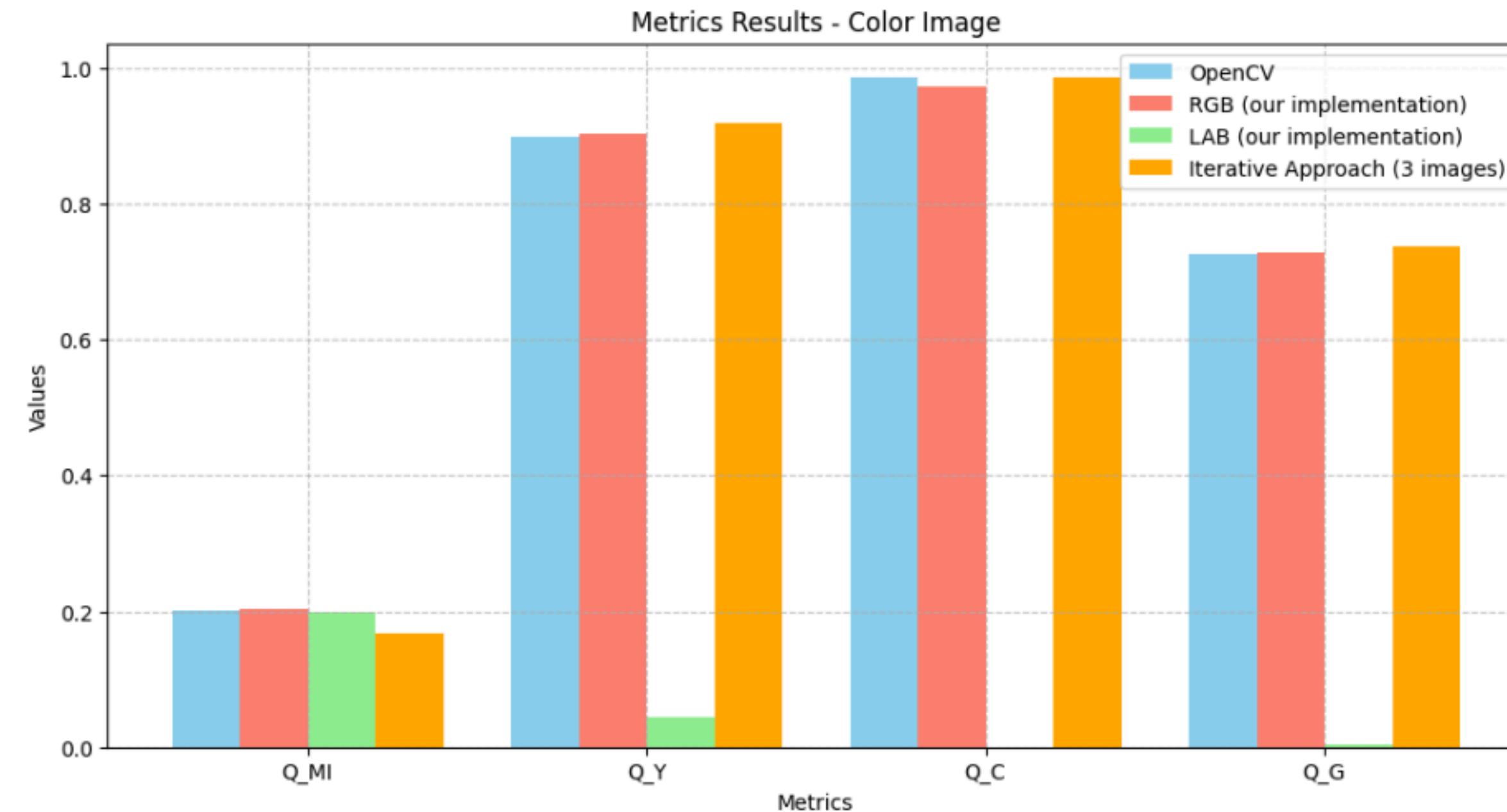
# Results Evaluation

## Gray Images Fusion Evaluation



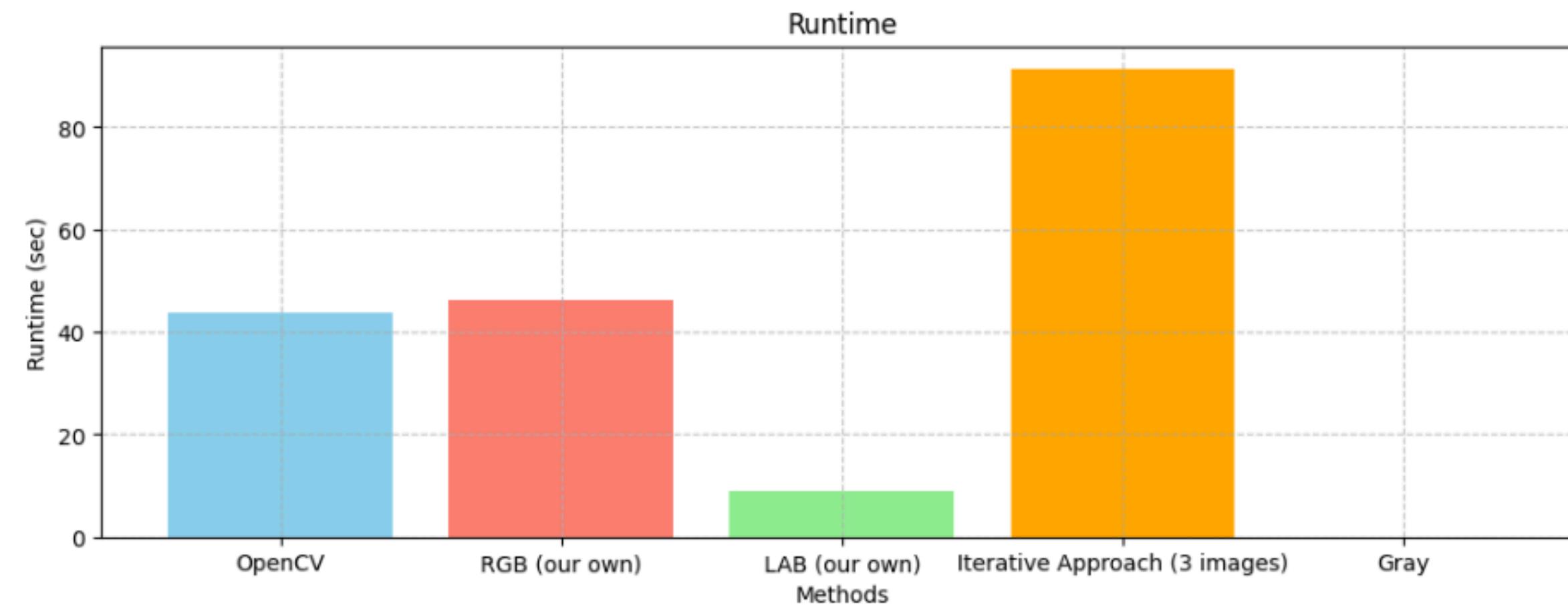
# Results Evaluation

## Colored Images Fusion Evaluation



# Results Evaluation

## Runtime Comparison



# Potential Improvements

 **Algorithm Complexity**



**Alternative Methods**



**Data and Metrics**

**Thank You For  
Your Attention**

## References

- [1] S. Li, X. Kang, and J. Hu, **Image Fusion with Guided Filtering**, IEEE Transactions on Image Processing, vol. 22, no. 7, July 2013.
- [2] K. He, J. Sun, and X. Tang, **Guided Image Filtering**, Proceedings of the European Conference on Computer Vision, Heraklion, Greece, Sep. 2010.
- [3] Used Images: <https://docs.opencv.org/4.x/index.html>
- [4] Used Images: <https://drive.google.com/drive/u/0/folders/1PMS5Rr4SUL1ptnC8qA0aEdGKgcBFvj5i>