
VISION Practical Work – Optical Flow

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Introduction

In this project we implemented the Horn–Schunck and Lucas–Kanade methods and we tested them on datasets. In case we had a ground truth for a specific dataset, we computed some statistics (angular error, end point error and norm error) and we plot them graphically to visualize and compare them better.

For each method, we tried to find the best hyperparameters: in Horn–Schunck tested hyperparameters are α and the number of iterations; while in Lucas–Kanade tested hyperparameters are the type of filter and the size of the window.

Attention: the code repository is made such that to launch the Lucas–Kanade or the Horn–Schunck method there are several arguments to set in input: by doing so, there was no need to create different files for each dataset, even though we tested all the algorithms for each dataset. In this report we show our results.

This report is long only to show better the various pictures.

Horn-Schunck Method

Mysine dataset

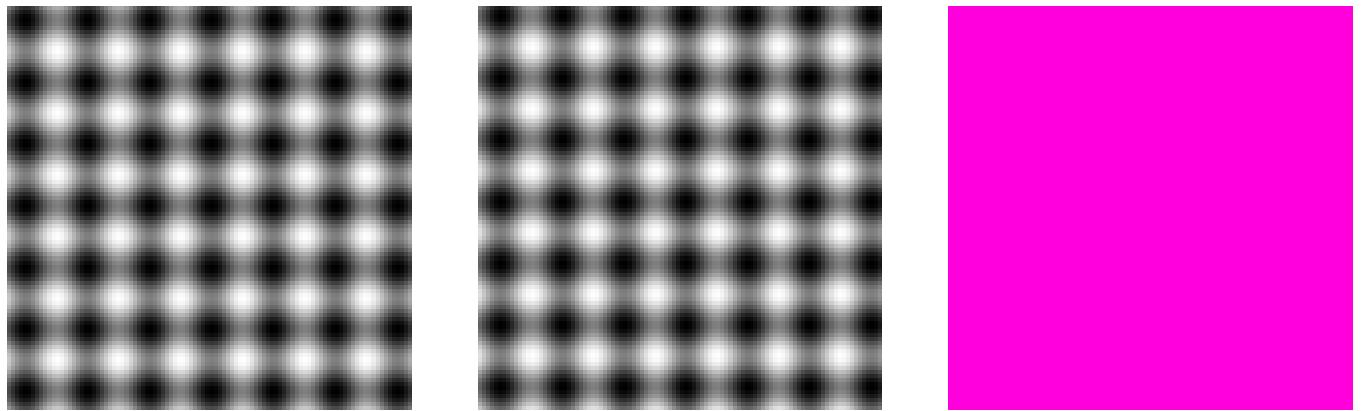


Figure 1: From right, the first two figures represent the mysine dataset; the third is the ground-truth color-map

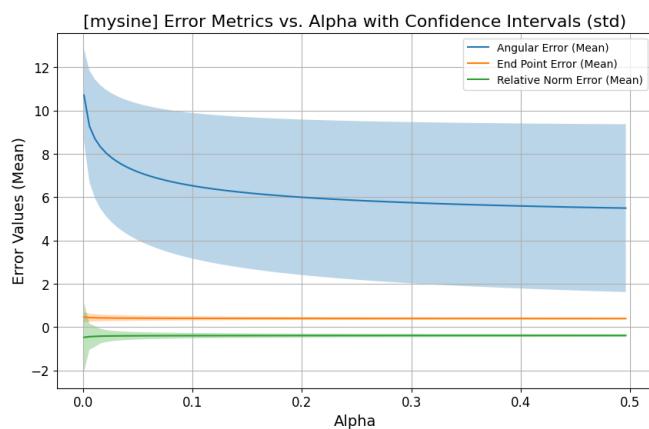


Figure 2: Mean and standard deviation of the errors obtained depending on the α value

Based on figure 2, the best α values found for each error type are:

1. Angular error: $\alpha = 0.496$
2. End point error: $\alpha = 0.496$
3. Norm error: $\alpha = 0.001$

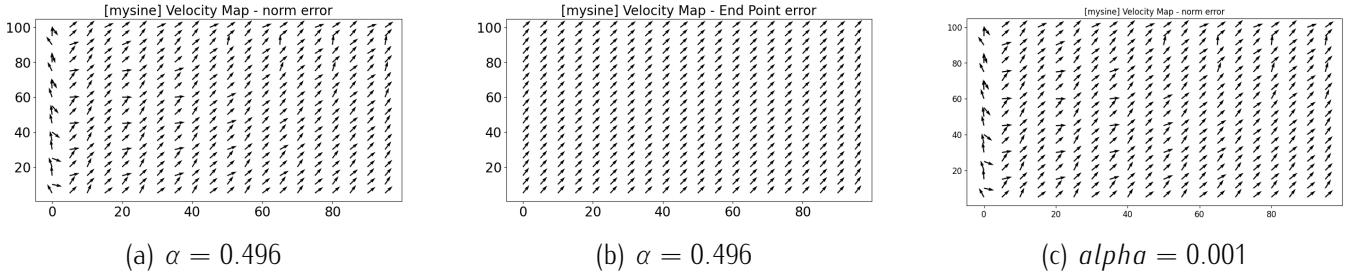


Figure 3: Velocity maps: vector fields of the optical flow obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

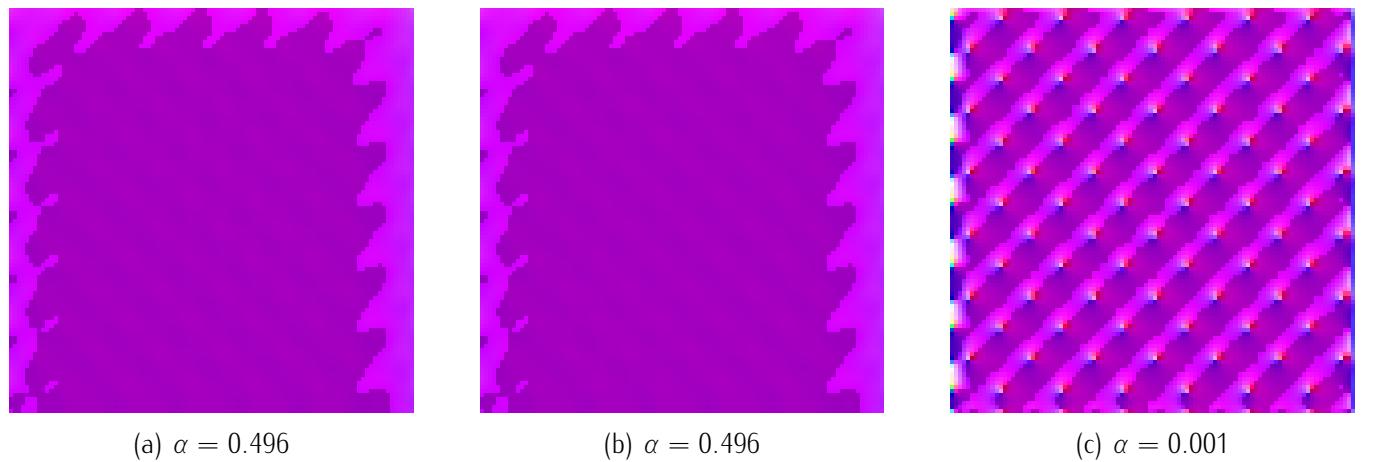


Figure 4: Color maps obtained with different optimizations based on the minimum value obtain for each error type. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Square dataset

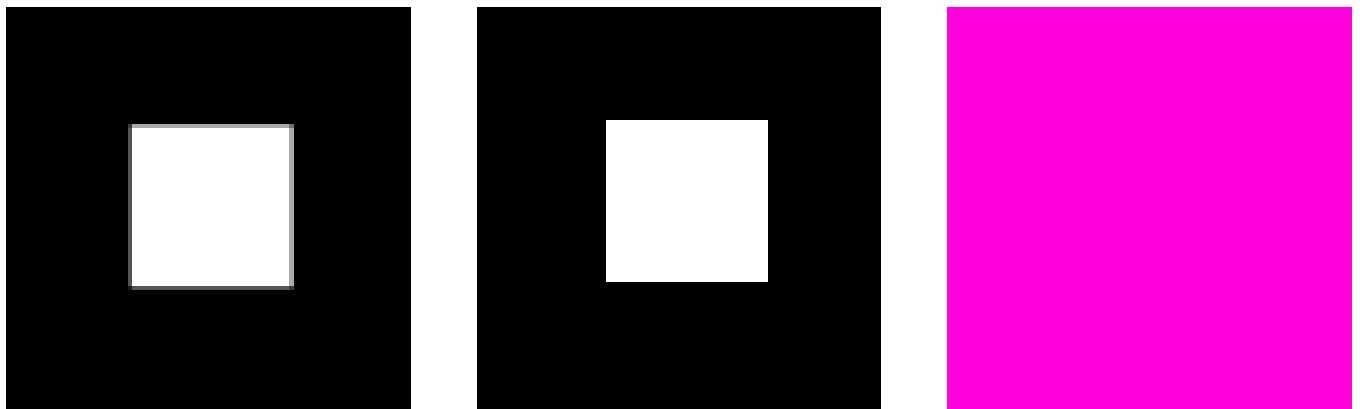


Figure 5: From right, the first two figures represent the square dataset; the third is the ground-truth color-map

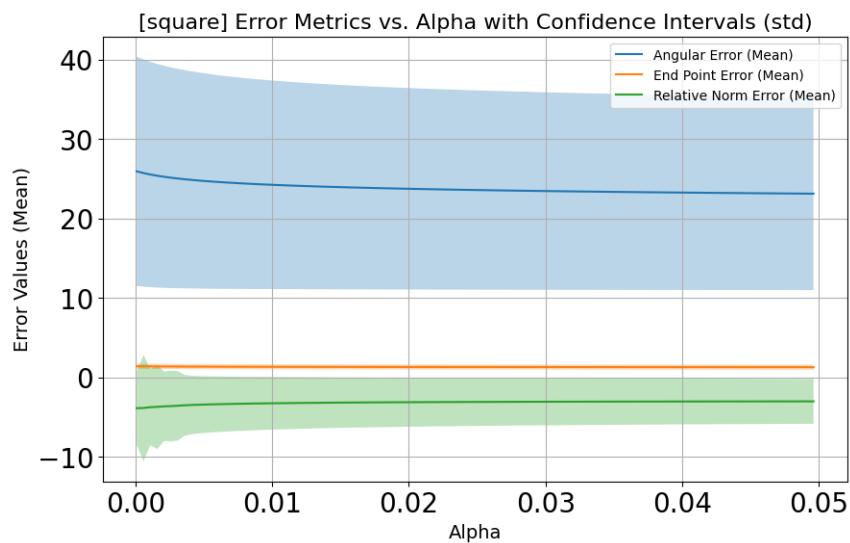


Figure 6: Mean and standard deviation of the errors obtained depending on the α value

Based on figure 6, the best α values found for each error type are:

1. Angular error: $\alpha = 0.496$
2. End point error: $\alpha = 0.496$
3. Norm error: $\alpha = 0.0001$

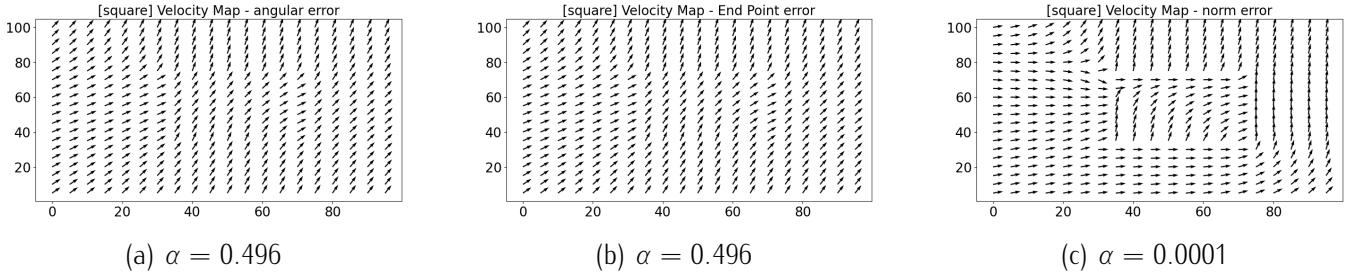


Figure 7: Velocity maps: vector fields of the optical flow obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

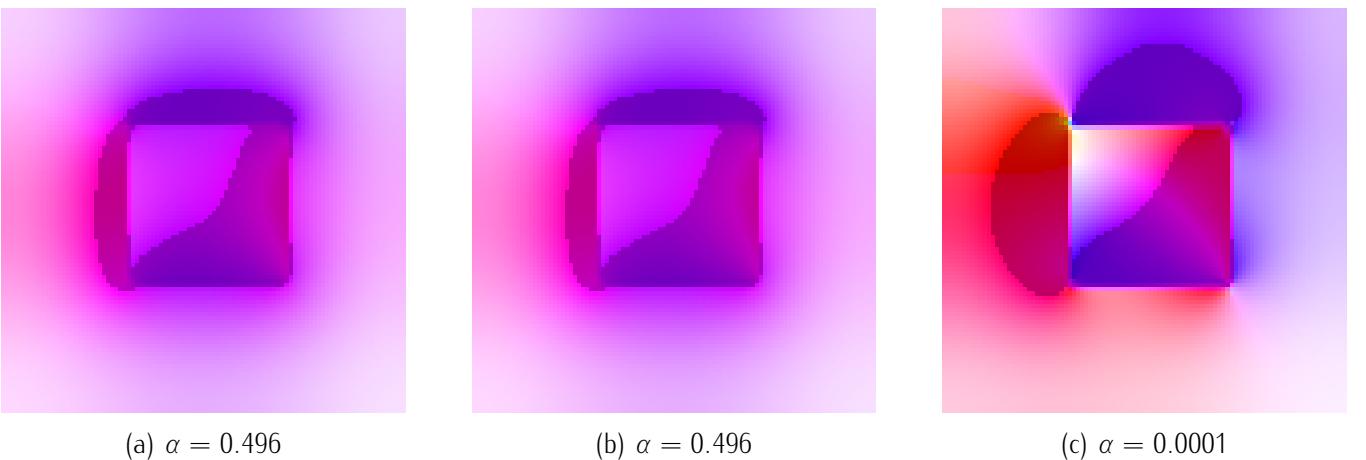


Figure 8: Color maps obtained with different optimizations based on the minimum value obtain for each error type. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Rubberwhale dataset



Figure 9: From right, the first two figures represent the rubberwhale dataset; the third is the ground-truth color-map

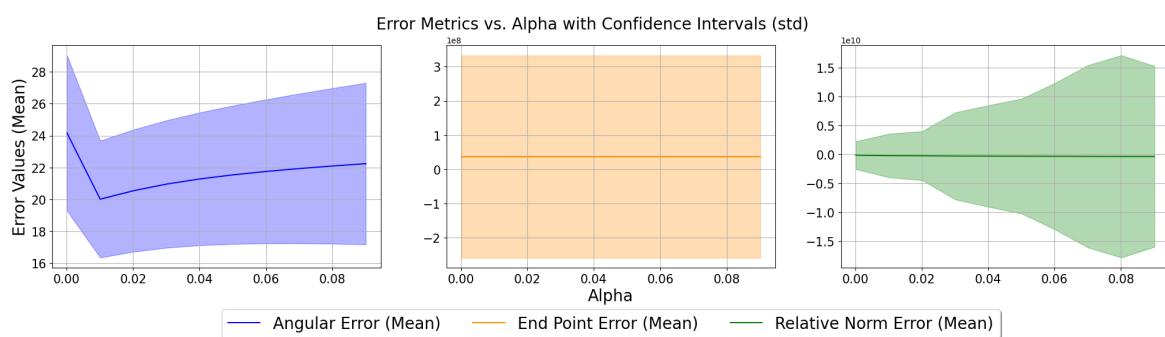


Figure 10: Mean and standard deviation of the errors obtained depending on the α value

Based on figure 10, the best α values found for each error type are:

1. Angular error: $\alpha = 0.01$
2. End point error: $\alpha = 0.01$
3. Norm error: $\alpha = 0.09$

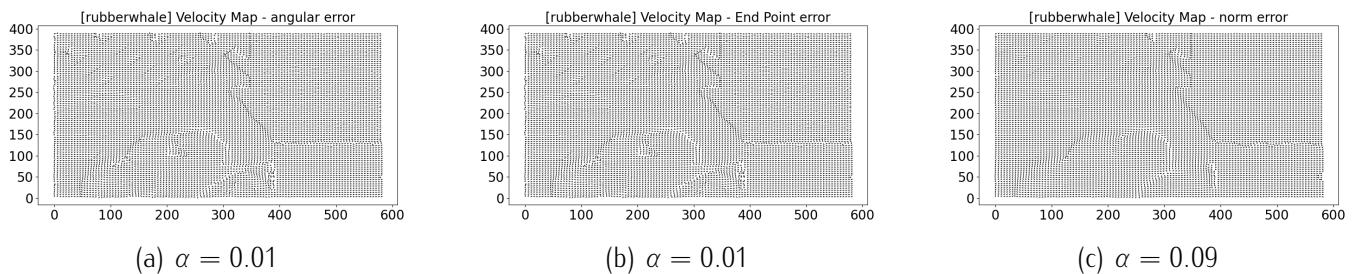


Figure 11: Velocity maps: vector fields of the optical flow obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

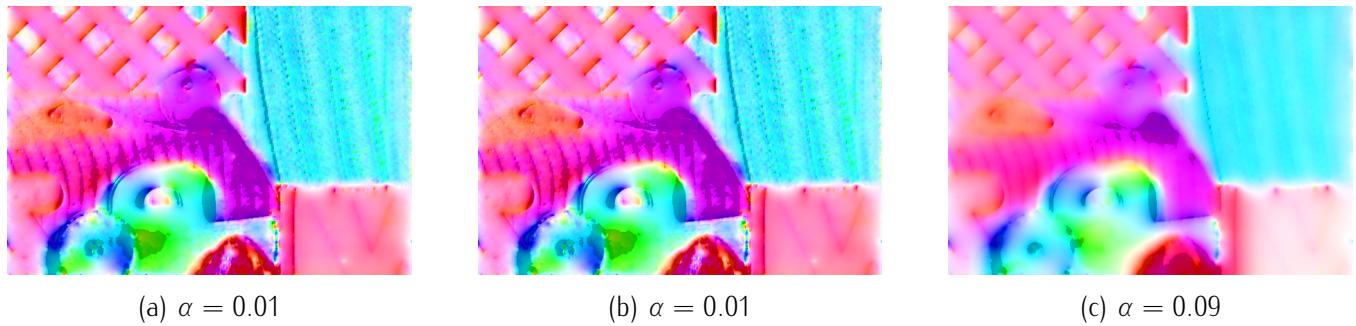


Figure 12: Color maps obtained with different optimizations based on the minimum value obtain for each error type. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Yosemite dataset

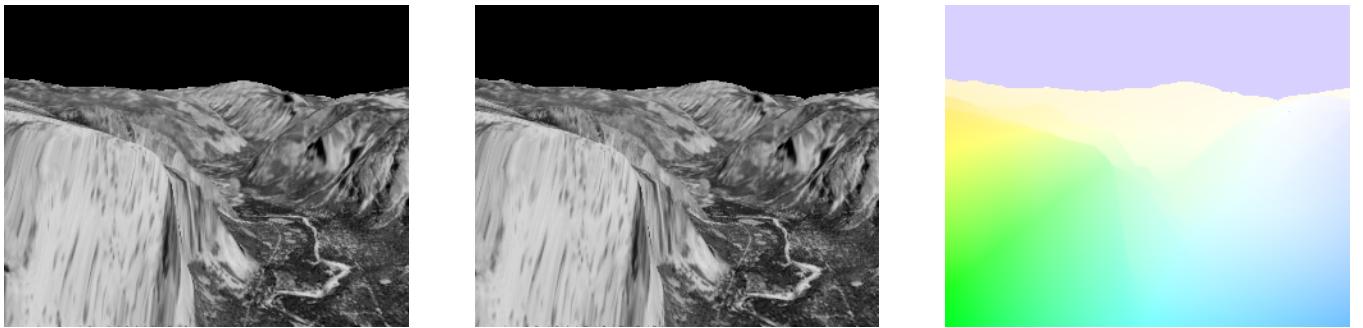


Figure 13: From right, the first two figures represent the yosemite dataset; the third is the ground-truth color-map

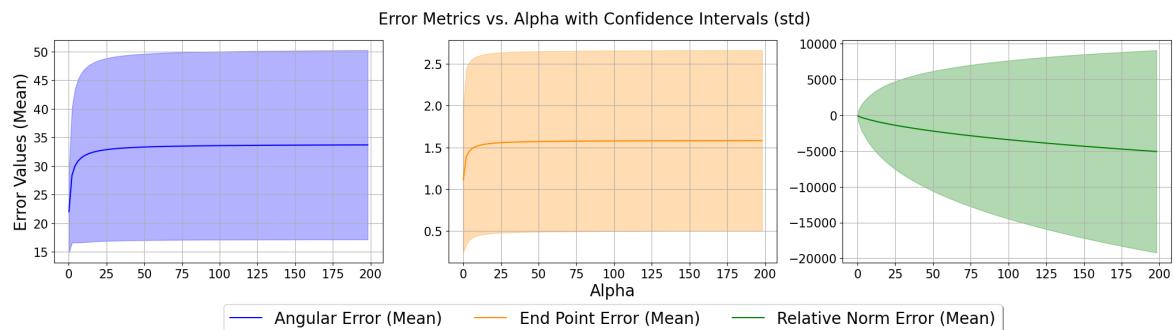


Figure 14: Mean and standard deviation of the errors obtained depending on the α value

Based on figure 14, the best α values found for each error type are:

1. Angular error: $\alpha = 0.1$
2. End point error: $\alpha = 0.1$
3. Norm error: $\alpha = 198.1$

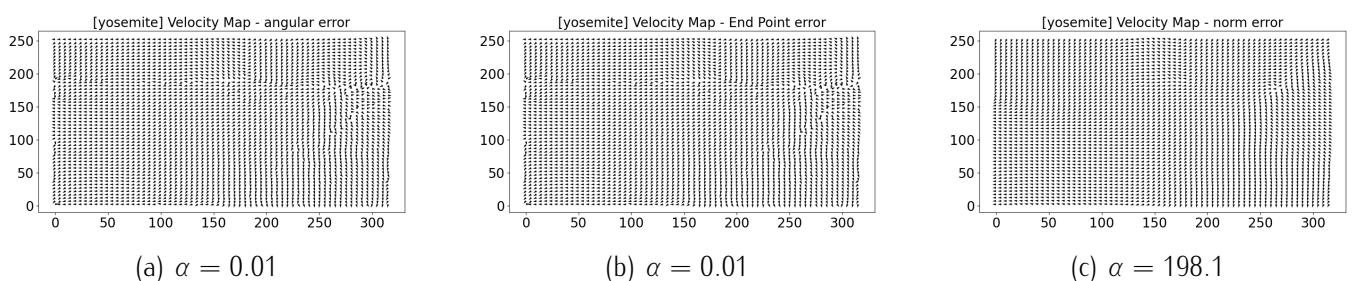
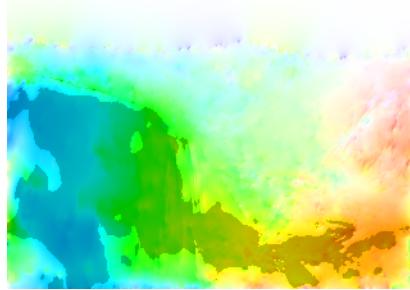
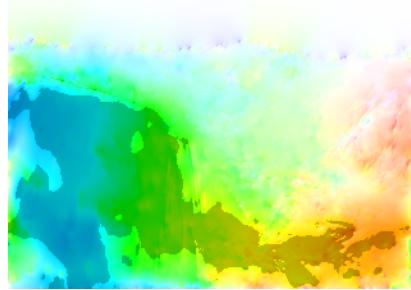


Figure 15: Velocity maps: vector fields of the optical flow obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.



(a) $\alpha = 0.01$



(b) $\alpha = 0.01$

(c) $\alpha = 0.09$

Figure 16: Color maps obtained with different optimizations based on the minimum value obtain for each error type. From left, first image based on angular error, second image based on end point error, third image based on norm error.

The next datasets do not have any ground truth, therefore we studied the change on the color map and the velocity map to find the best configuration of hyperparameters.

Nasa dataset

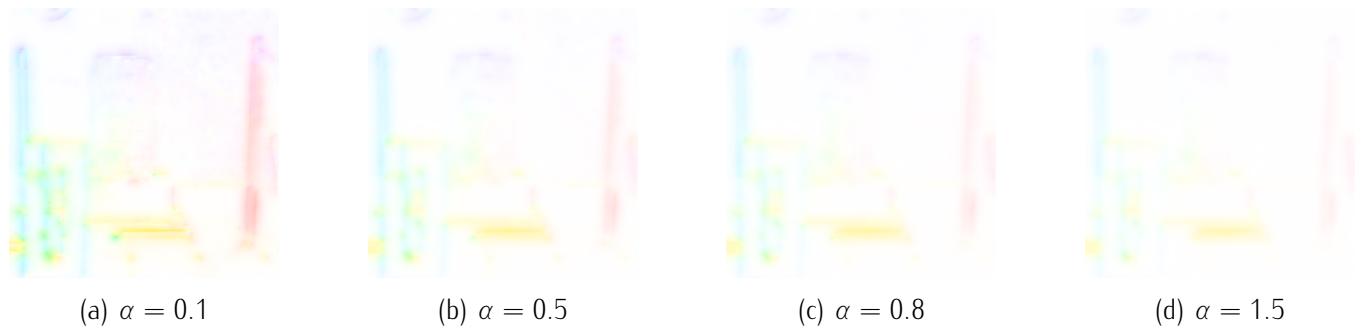


Figure 17: Color maps obtained with different optimizations all with number of iteration set to 100

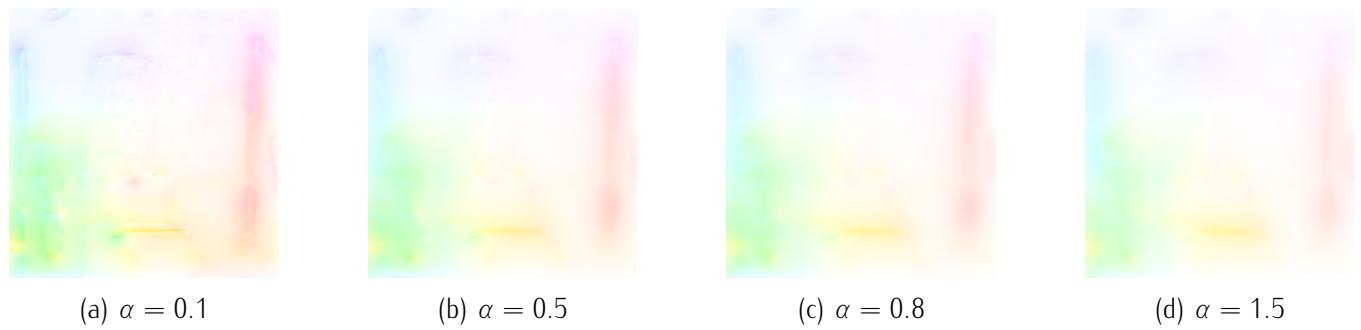


Figure 18: Color maps obtained with different optimizations all with number of iteration set to 1000

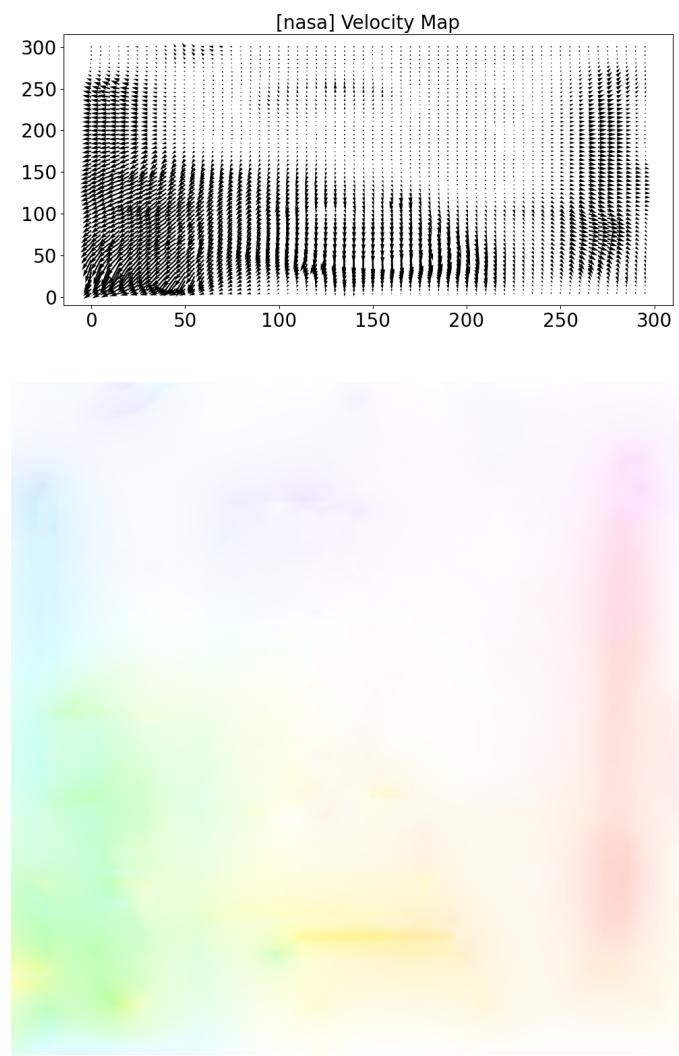


Figure 19: Our best velocity map and correspondent color map with $\alpha = 0.8$ and $n - iterations = 1000$

Rubic dataset

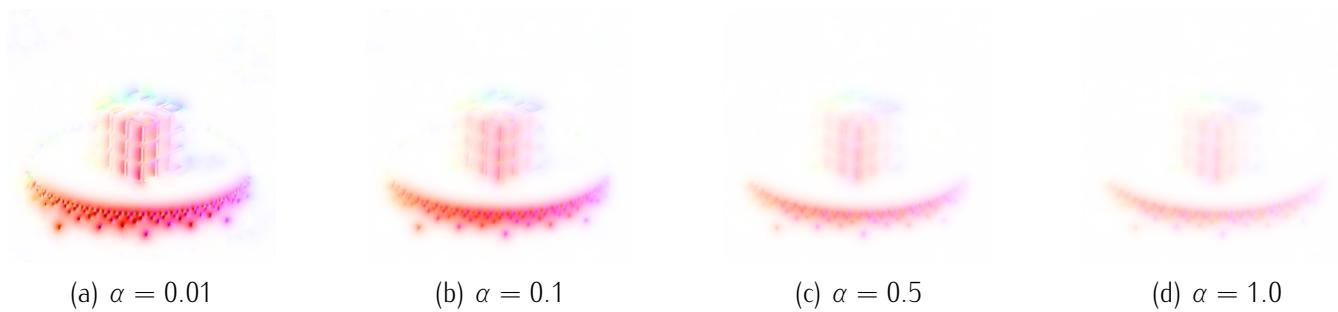


Figure 20: Color maps obtained with different optimizations all with number of iteration set to 100

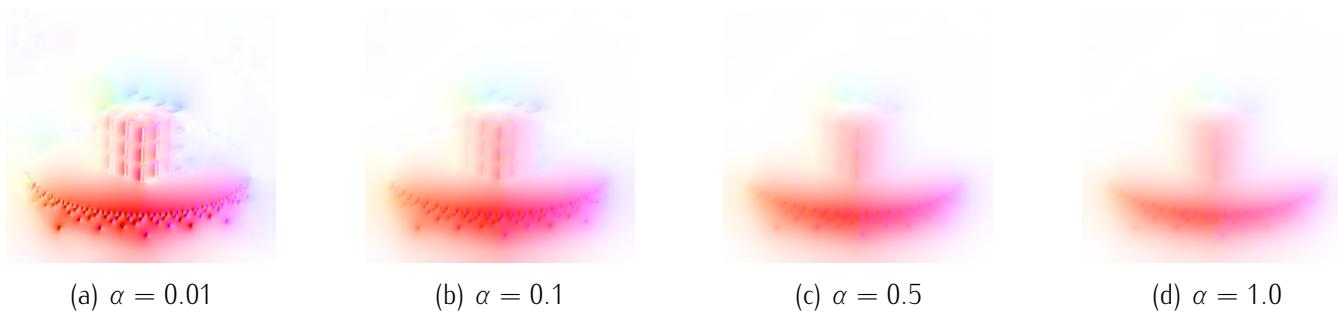


Figure 21: Color maps obtained with different optimizations all with number of iteration set to 1000

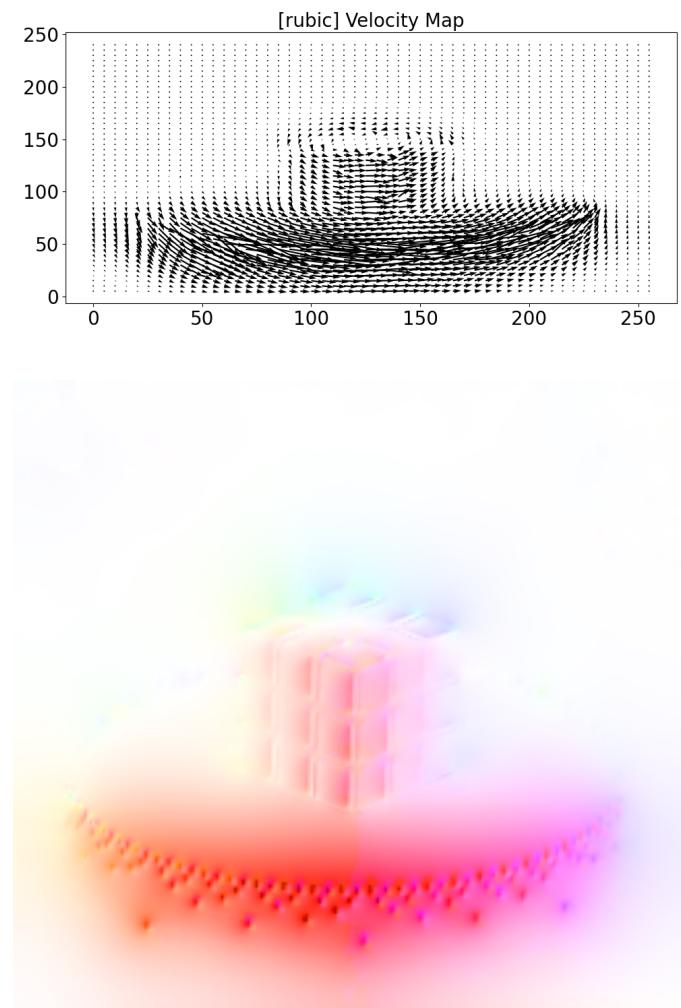


Figure 22: Our best velocity map and correspondent color map with $\alpha = 0.05$ and $n - iterations = 1000$

Taxi dataset

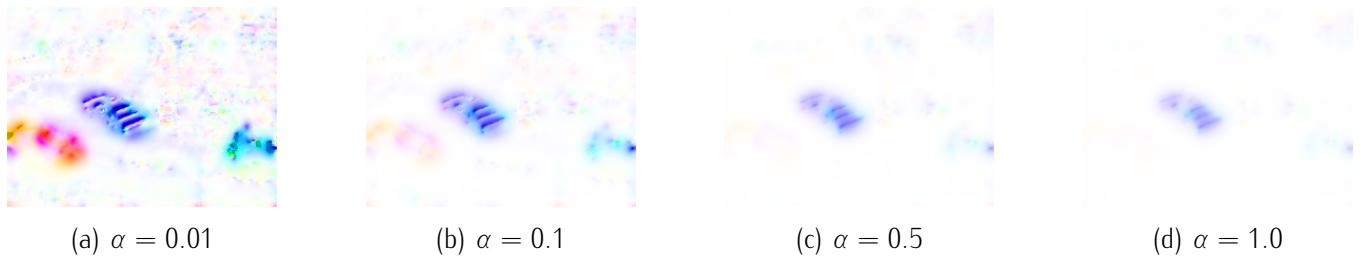


Figure 23: Color maps obtained with different optimizations all with number of iteration set to 100

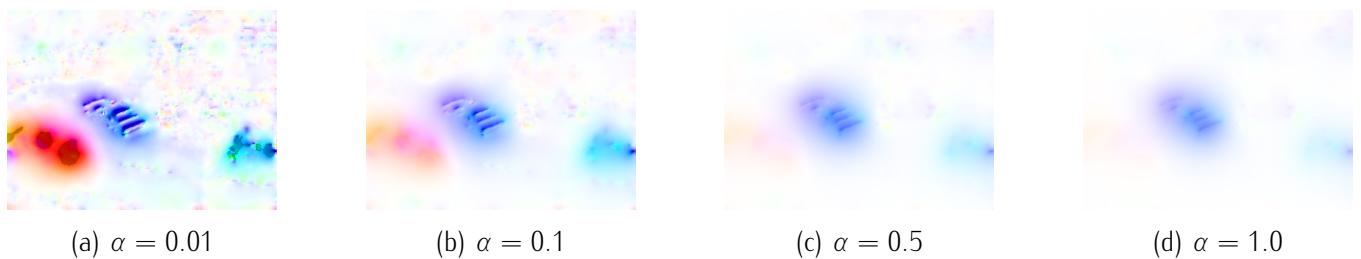


Figure 24: Color maps obtained with different optimizations all with number of iteration set to 1000

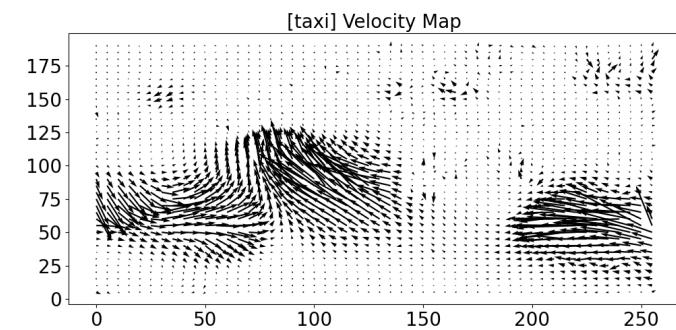


Figure 25: Our best velocity map and correspondent color map with $\alpha = 0.05$ and $n - iterations = 1000$

Lucas-Kanade Method

Mysine dataset

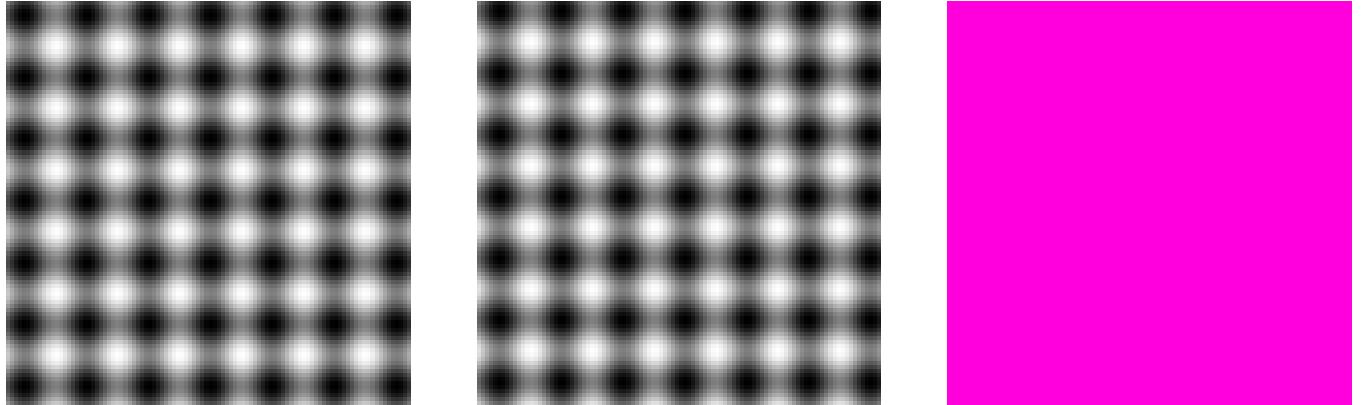


Figure 26: From right, the first two figures represent the mysine dataset; the third is the ground-truth color-map

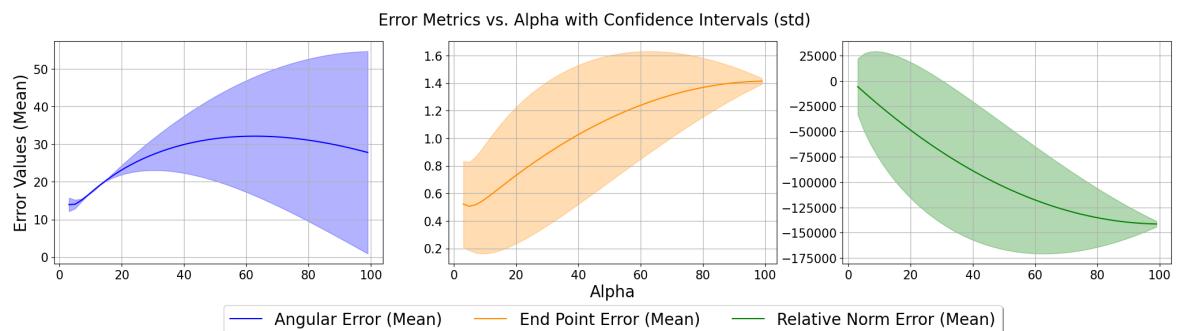


Figure 27: Mean and standard deviation of the errors obtained depending on the α value

Based on figure 27, the best α values found for each error type are:

1. Angular error: $\alpha = 3$
2. End point error: $\alpha = 5$
3. Norm error: $\alpha = 99$

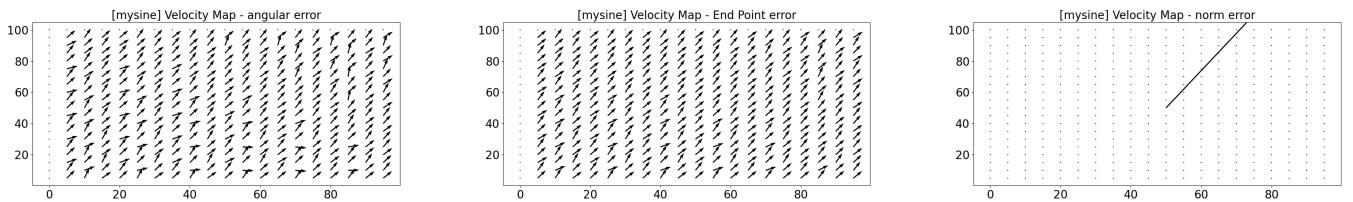


Figure 28: Velocity maps: vector fields of the optical flow obtained with different optimizations.

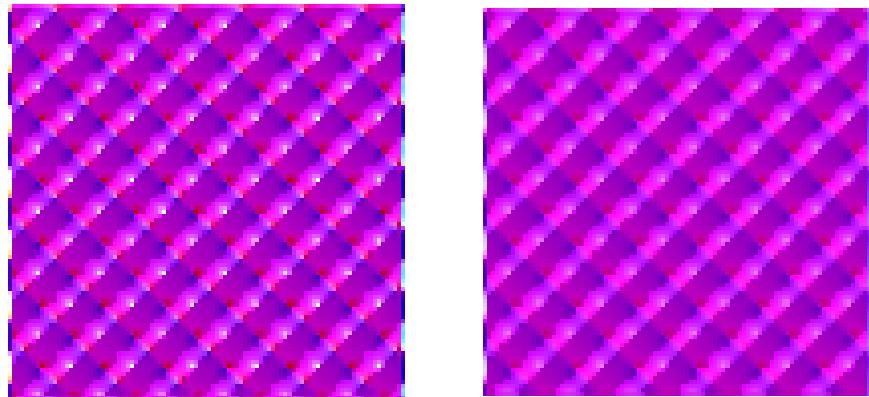


Figure 29: Color maps obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Square dataset

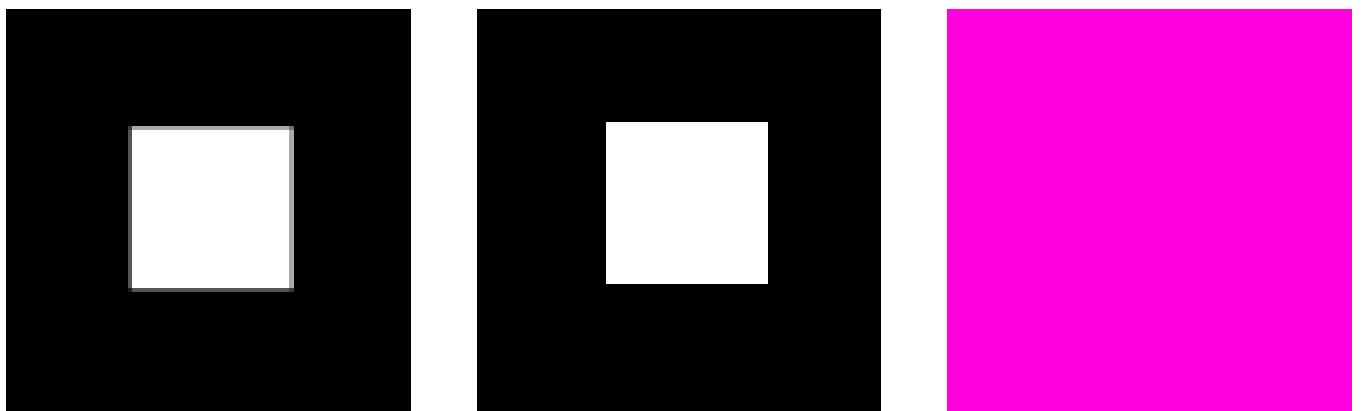


Figure 30: From right, the first two figures represent the square dataset; the third is the ground-truth color-map

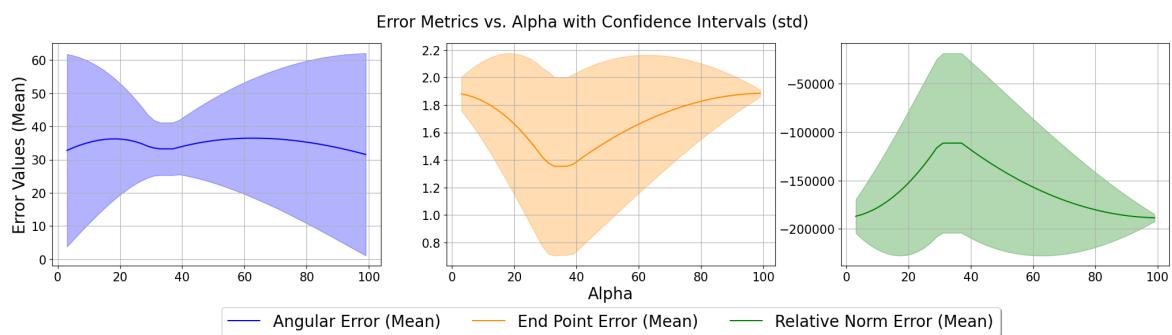


Figure 31: Mean and standard deviation of the errors obtained depending on the α value.

Based on figure 31, the best α values found for each error type are:

1. Angular error: $\alpha = 99$
2. End point error: $\alpha = 33$
3. Norm error: $\alpha = 99$

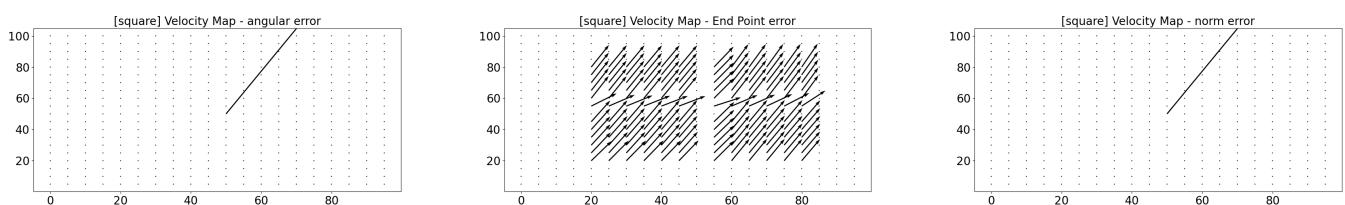


Figure 32: Velocity maps: vector fields of the optical flow obtained with different optimizations.

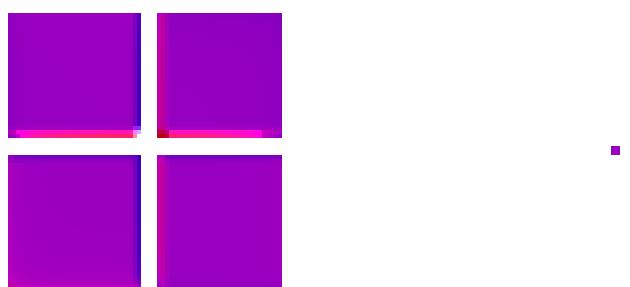


Figure 33: Color maps obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Rubberwhale dataset



Figure 34: From right, the first two figures represent the rubberwhale dataset; the third is the ground-truth color-map

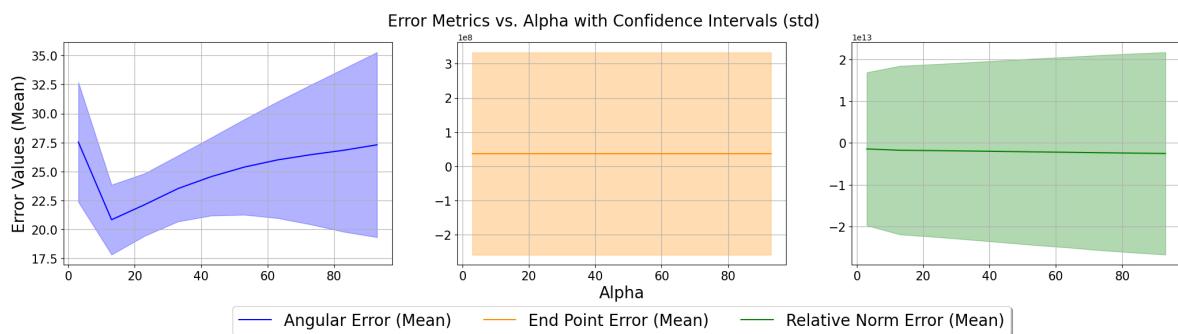


Figure 35: Mean and standard deviation of the errors obtained depending on the α value.

Based on figure 35, the best α values found for each error type are:

1. Angular error: $\alpha = 13$
2. End point error: $\alpha = 13$
3. Norm error: $\alpha = 93$

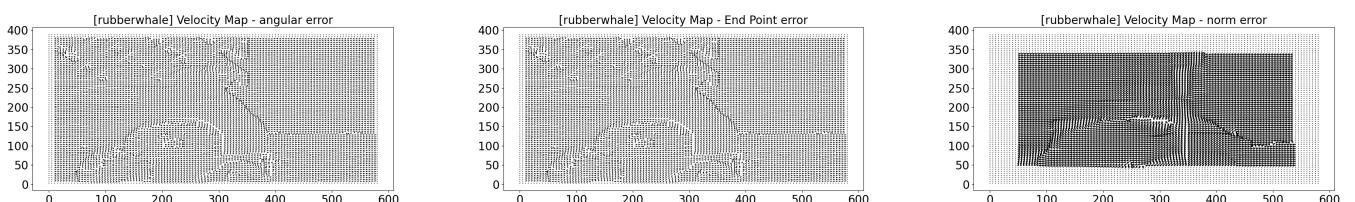


Figure 36: Velocity maps: vector fields of the optical flow obtained with different optimizations.

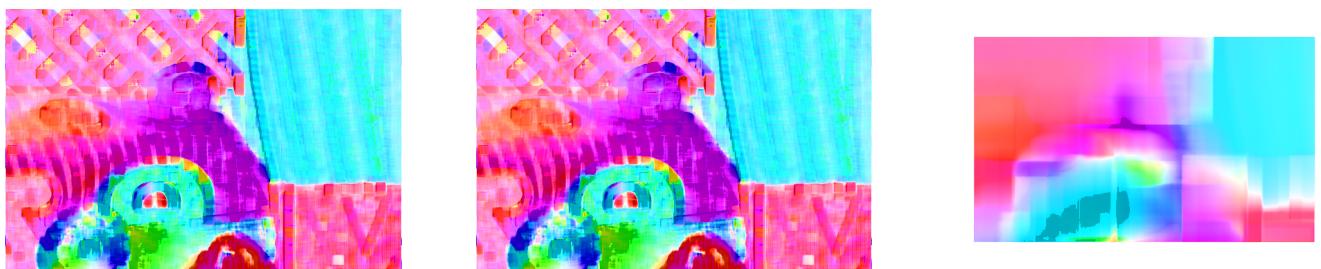


Figure 37: Color maps obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

Yosemite dataset

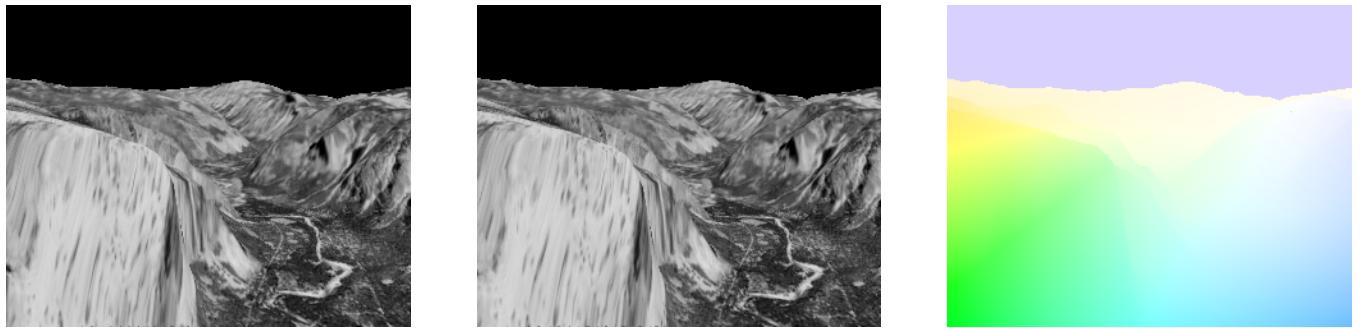


Figure 38: From right, the first two figures represent the yosemite dataset; the third is the ground-truth color-map

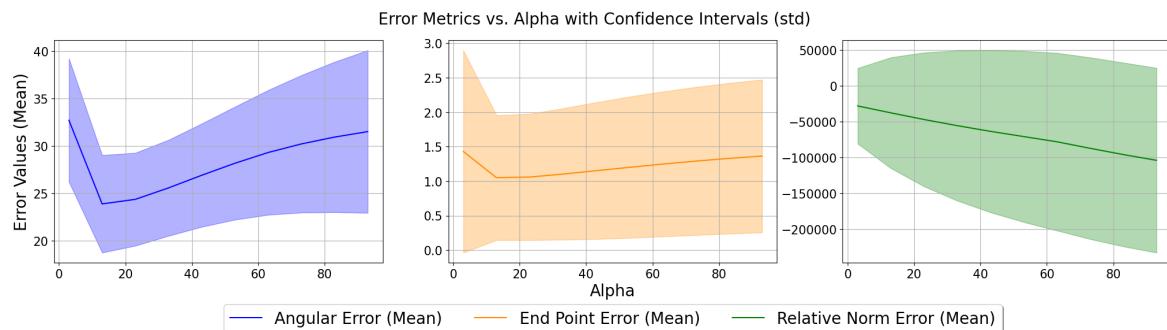


Figure 39: Mean and standard deviation of the errors obtained depending on the α value.

Based on figure 39, the best α values found for each error type are:

1. Angular error: $\alpha = 13$
2. End point error: $\alpha = 13$
3. Norm error: $\alpha = 93$

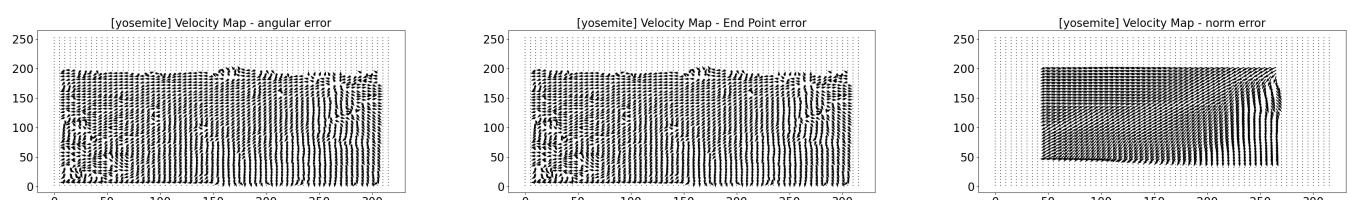


Figure 40: Velocity maps: vector fields of the optical flow obtained with different optimizations.

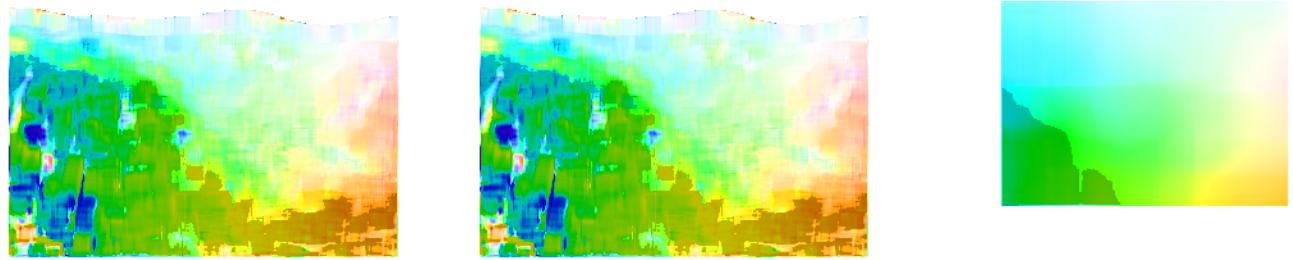
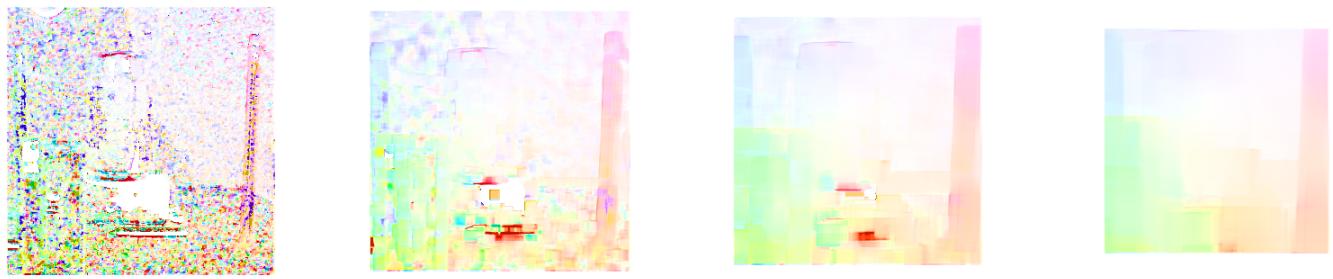


Figure 41: Color maps obtained with different optimizations. From left, first image based on angular error, second image based on end point error, third image based on norm error.

The next datasets do not have any ground truth, therefore we studied the change on the color map and the velocity map to find the best configuration of hyperparameters.

Nasa dataset



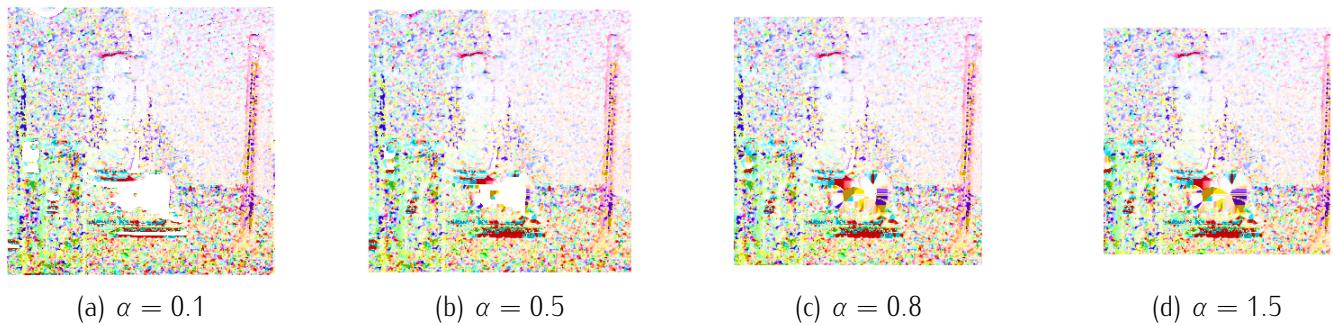
(a) $window = 3$

(b) $window = 10$

(c) $window = 25$

(d) $window = 50$

Figure 42: Color maps obtained with different sizes of window



(a) $\alpha = 0.1$

(b) $\alpha = 0.5$

(c) $\alpha = 0.8$

(d) $\alpha = 1.5$

Figure 43: Color maps obtained with different sizes of window and Gaussian filter

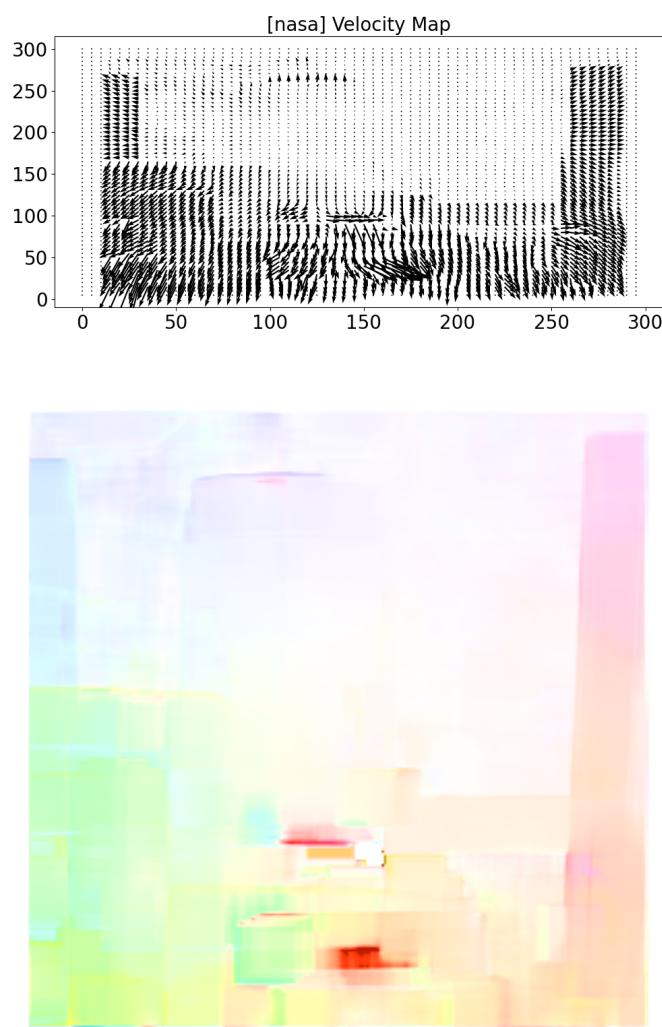


Figure 44: Our best velocity map and correspondent color map with $window = 25$ and without Gaussian filter

Rubic dataset

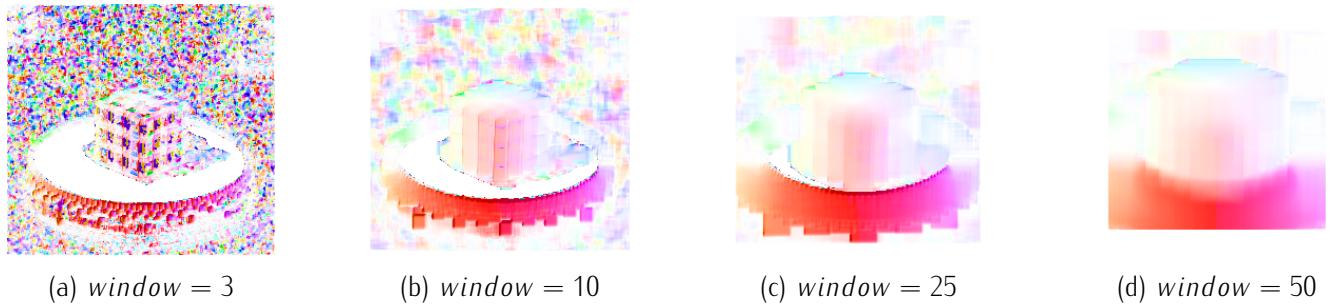


Figure 45: Color maps obtained with different sizes of window.

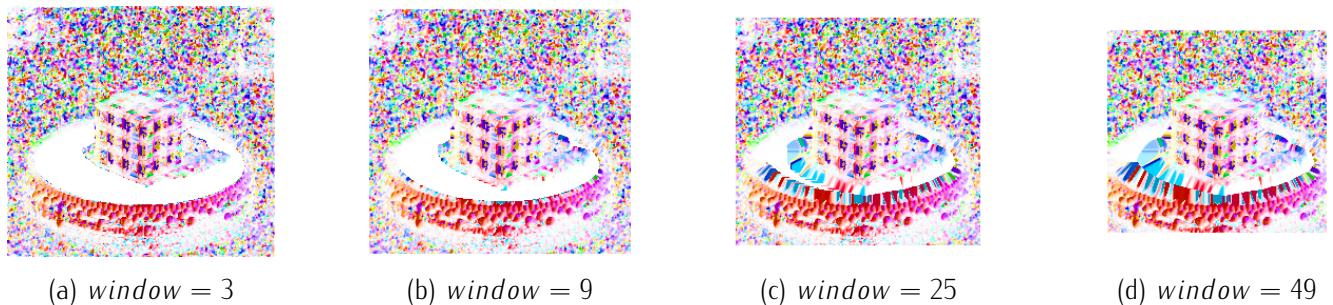


Figure 46: Color maps obtained with different sizes of window and Gaussian filter

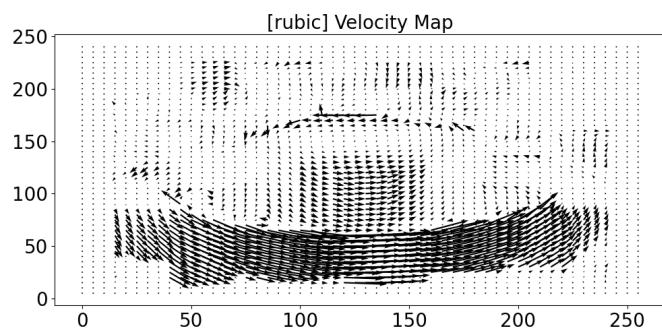


Figure 47: Our best velocity map and correspondent color map with window set to 27

Taxi dataset

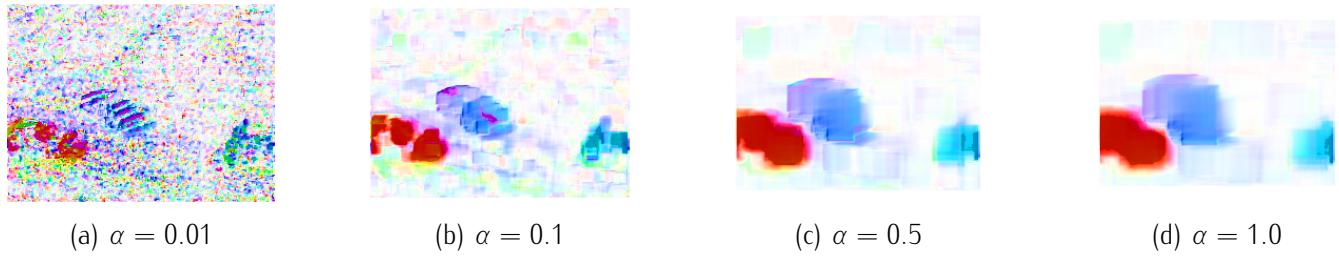


Figure 48: Color maps obtained with different sizes of window.

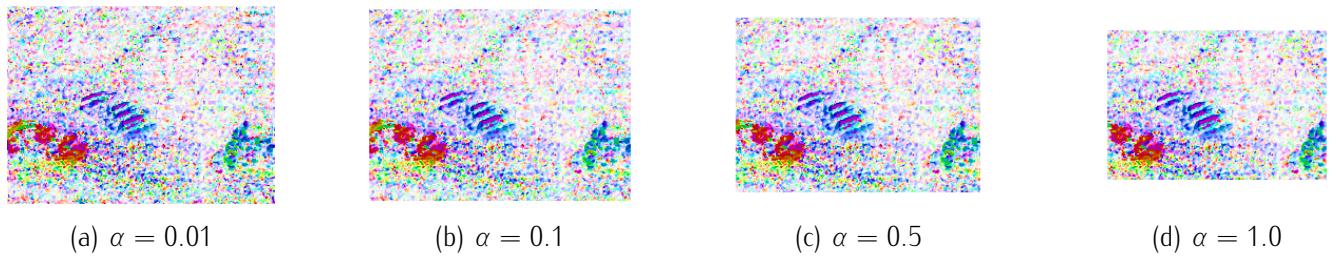


Figure 49: Color maps obtained with different sizes of window.

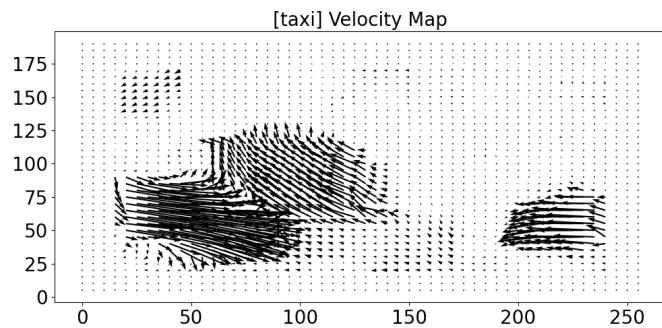


Figure 50: Our best velocity map and correspondent color map with window size of 33 and no Gaussian filter.