Assignment06

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In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import random
import copy
import math
```

In [2]:
```
# Make x and y domain matrix
def make_domain_matrix() :
    x_matrix = np.zeros((M, N), dtype="int")
    y_matrix = np.zeros((M, N), dtype="int")

    for i in range(M) :
        x_matrix[i, :] = i

    for j in range(N) :
        y_matrix[:, j] = j

    return (x_matrix, y_matrix)

# Distance function between two vectors x and y by L1 Norm
def distance_L1(x, y, c) :
    dx = abs(x - c[0])
    dy = abs(y - c[1])
    s  = dx + dy

    return (s)

# Distance function between two vectors x and y by L2 Norm
def distance_L2(x, y, c):

    dx = (x - c[0]) ** 2
    dy = (y - c[1]) ** 2
    s  = dx + dy

    return(s)
```

```
        # Plot image
        def plot_image(label, k) :

            plt.imshow(label, cmap=plt.cm.get_cmap('gist_ncar', k))
            plt.colorbar(ticks=range(k), format='color: %d')
            plt.axis('off')

In [3]: class KMeans() :
            def __init__ (self, k) :
                self.k = k
                self.centroid_xy    = np.zeros((self.k, 2), dtype="double")
                self.centroid_count = np.zeros(self.k, dtype="int")

            def plot_image_center(self) :

                # Cluster image
                plt.imshow(self.cur_label, cmap=plt.cm.get_cmap('gist_ncar', self.k))
                plt.colorbar(ticks=range(self.k), format='color: %d')

                # Previous Centroids as line
                for i in range(self.k) :
                    plt.plot(self.centroid_list[i, :, 0], self.centroid_list[i, :, 1], c='b')

                # Current Centroid as point
                for i in range(self.k) :
                    plt.scatter(self.centroid_xy[i, 1], self.centroid_xy[i, 0], marker='o', c=

                plt.axis('off')
                plt.show()


            def init_centroid(self) :
                for i in range(M) :
                    for j in range(N) :
                        rand_label = random.randint(0, self.k-1)
                        self.cur_label[i][j] = rand_label


            def update_centroid(self) :
                self.centroid_xy    = np.zeros((self.k, 2), dtype="double")
                self.centroid_count = np.zeros(self.k, dtype="int")

                # Sum all x and y by label
                for i in range (M) :
                    for j in range (N) :
                        label = self.cur_label[i][j]
                        self.centroid_xy[label, 0] += i
```

```
                self.centroid_xy[label, 1] += j
                self.centroid_count[label] += 1

        if (self.iter != 0) :
            prev_centroid_list = copy.deepcopy(self.centroid_list)
        self.centroid_list = np.zeros((self.k, self.iter+1, 2), dtype="double")

        # Divide sum of centroid by count = Calculate centroid
        for i in range (self.k) :
            if (self.centroid_count[i] != 0) :
                self.centroid_xy[i , :] /= self.centroid_count[i]
            else :
                self.centroid_xy[i, :] = prev_centroid_list[i, self.iter - 1, :]

            # Store Centroid
            if (self.iter != 0) :
                for j in range (self.iter) :
                    if ((prev_centroid_list[i, j, 0] != 0.0) and (prev_centroid_list[i
                        self.centroid_list[i, j, 0] = prev_centroid_list[i, j, 0]
                        self.centroid_list[i, j, 1] = prev_centroid_list[i, j, 1]

            if (self.centroid_count[i] != 0) :
                self.centroid_list[i, self.iter, 0] = self.centroid_xy[i, 1]
                self.centroid_list[i, self.iter, 1] = self.centroid_xy[i, 0]
            else :
                self.centroid_list[i, self.iter, 0] = self.centroid_list[i, self.iter
                self.centroid_list[i, self.iter, 1] = self.centroid_list[i, self.iter


    def labeling(self, norm) :
        # Label for each entry
        for i in range (M) :
            for j in range (N) :

                # Calculate distance between each centroid and entry
                dist_sum = []
                for t in range (self.k) :
                    if (norm == 1) :
                        dist_sum.append(distance_L1(i, j, self.centroid_xy[t, :]))
                    elif (norm == 2) :
                        dist_sum.append(distance_L2(i, j, self.centroid_xy[t, :]))

                # Find minimum distance and its index
                min_dist  = min(dist_sum)
                min_index = dist_sum.index(min_dist)

                # Put index in the label
                self.cur_label[i][j] = min_index
```

```
    def train(self, norm) :
        self.cur_label  = np.zeros((M, N), dtype="int")
        self.prev_label = np.zeros((M, N), dtype="int")

        self.init_centroid()
        self.iter = 0

        while not (np.array_equal(self.cur_label, self.prev_label)) :

            self.update_centroid()

            print(self.iter)
            self.plot_image_center()

            self.prev_label = copy.deepcopy(self.cur_label)

            self.labeling(norm)

            self.iter += 1

        self.iter += 1
        print(self.iter)
        self.plot_image_center()

        return (self.cur_label)
```

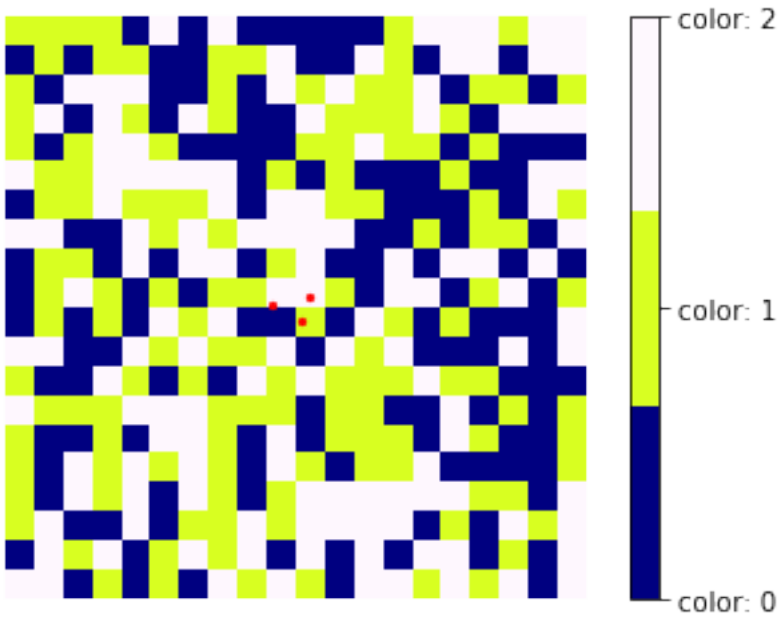
In [4]:
```
# Number of rows(M) and columns(N)
M = 20
N = 20

# Make x and y domain matrix
x_matrix, y_matrix = make_domain_matrix()
```

1.1 K = 3

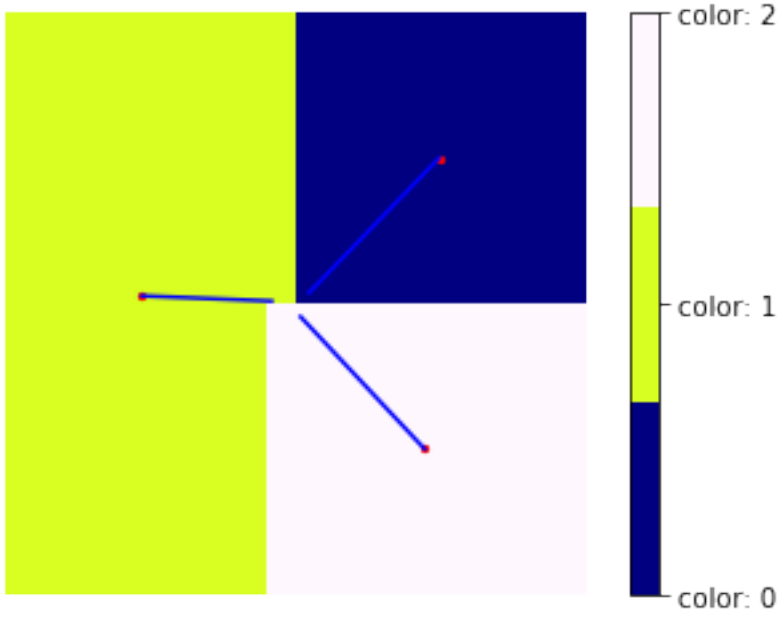
1.1.1 L1 Norm

In [5]:
```
k_num = 3
k_means= KMeans(k_num)
k_num_label = k_means.train(1)
```

```
0
```



1



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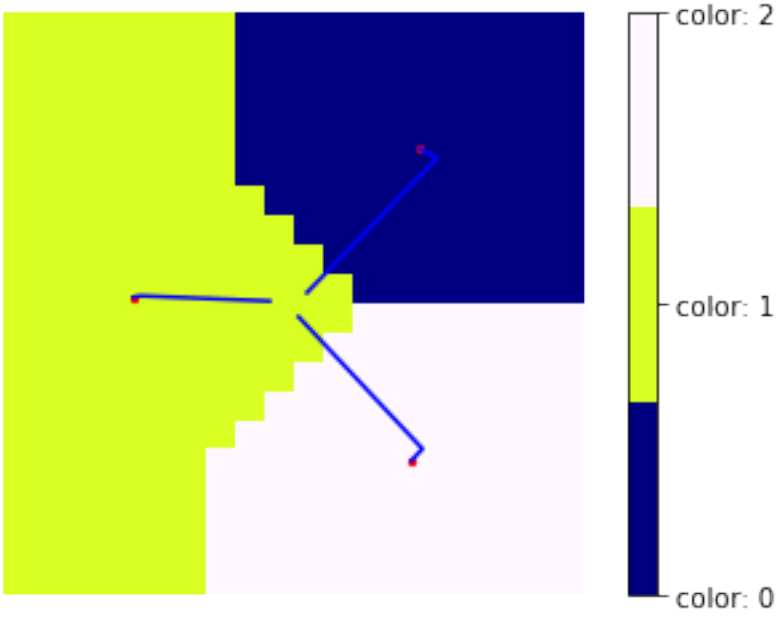

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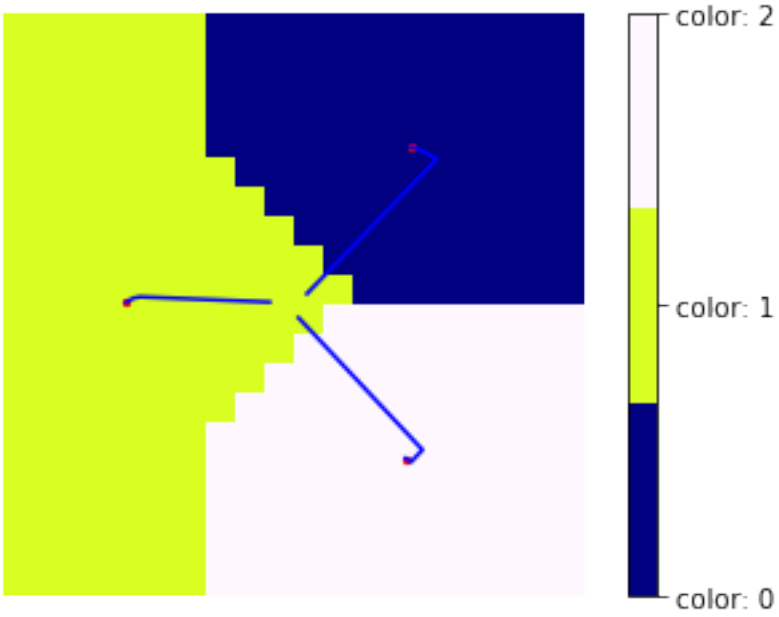

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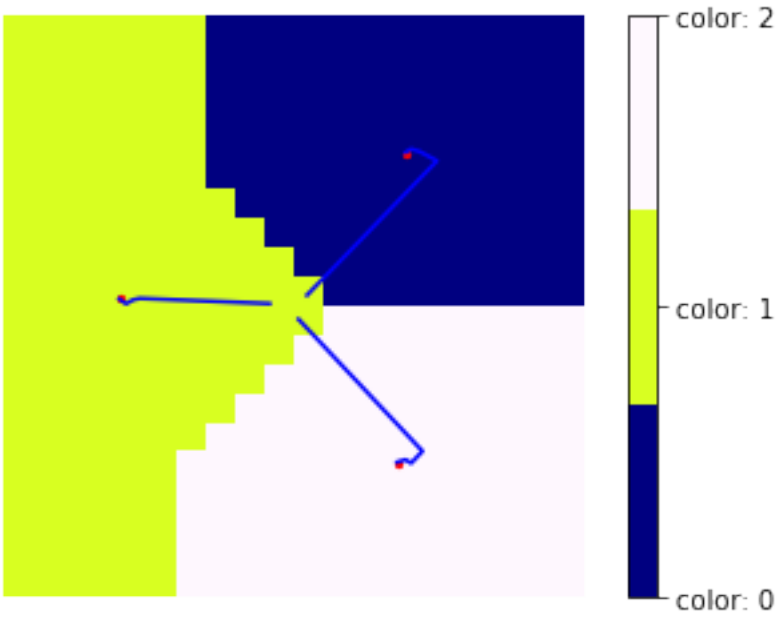

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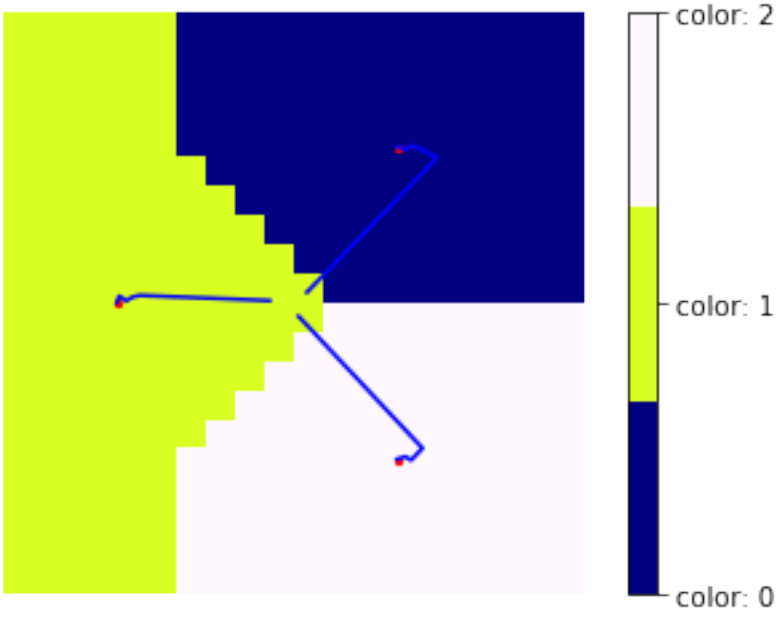

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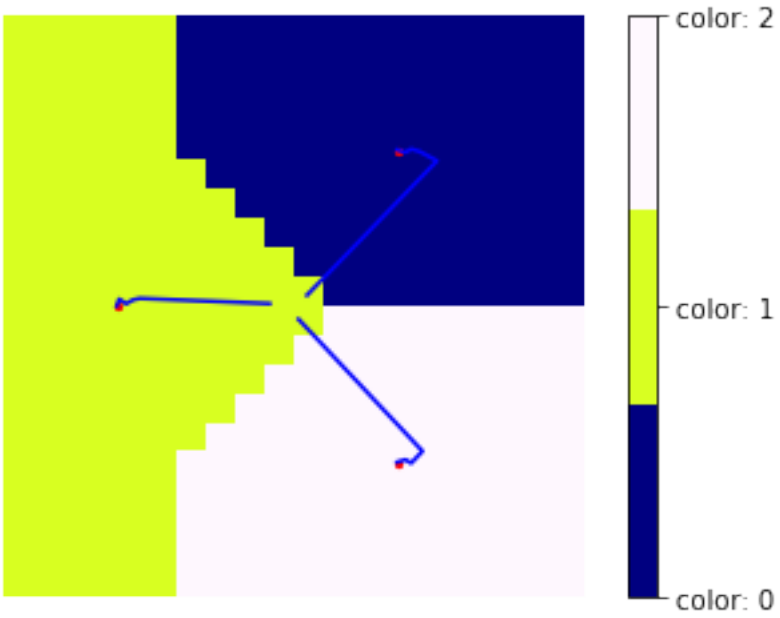
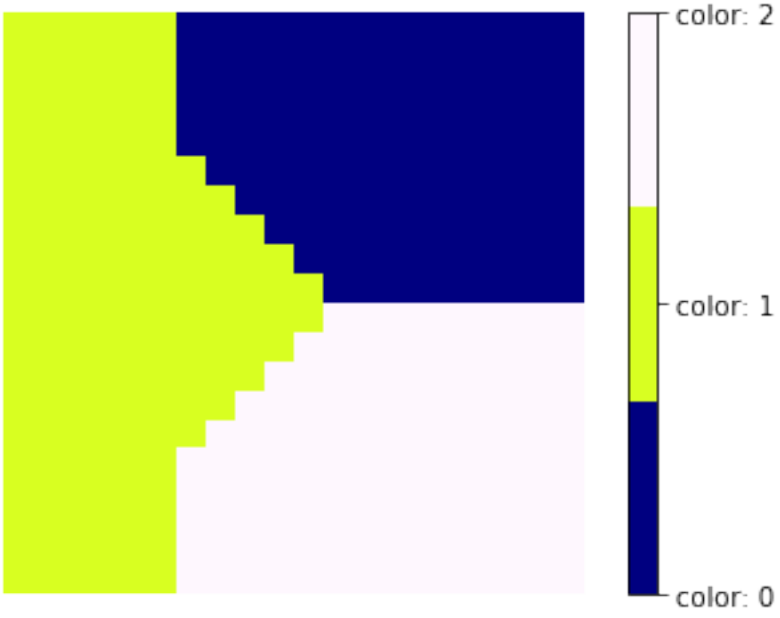


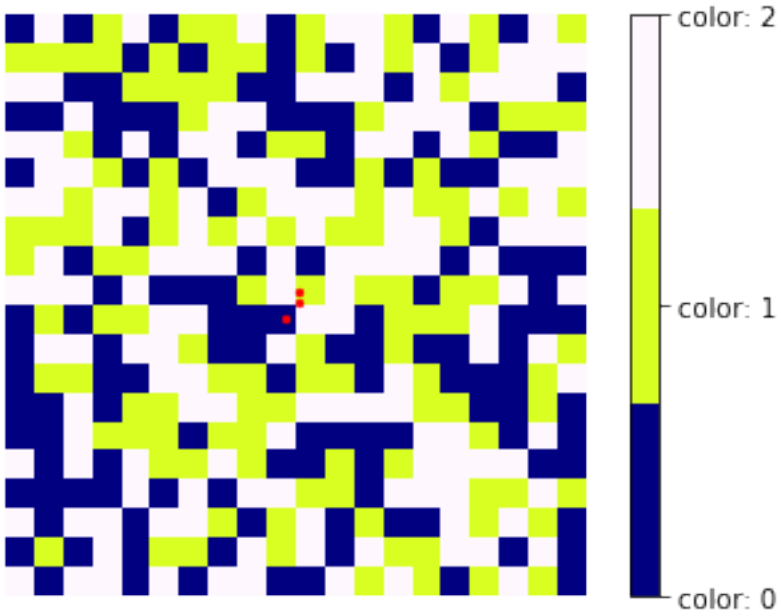
In [6]: plot_image(k_num_label, k_num)



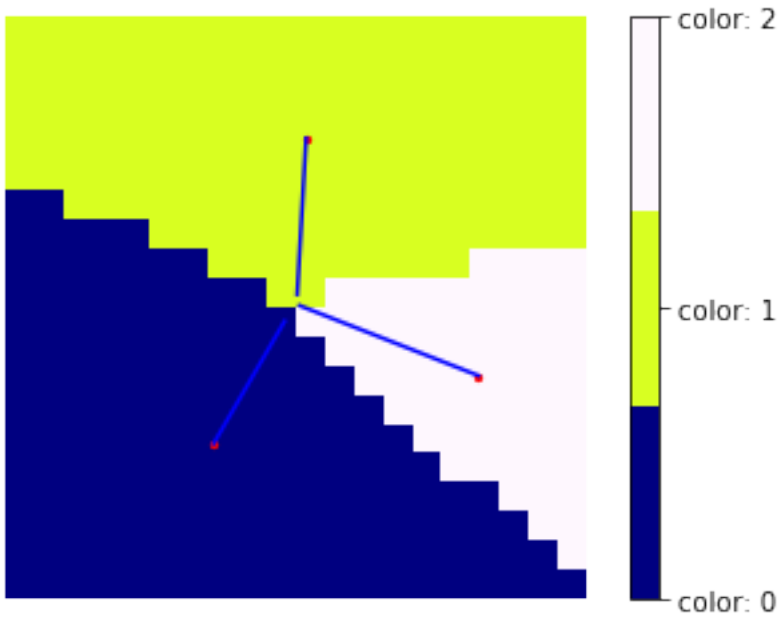
1.1.2 L2 Norm

In [7]:
```
k_means= KMeans(k_num)
k_num_label = k_means.train(2)
```

0



1



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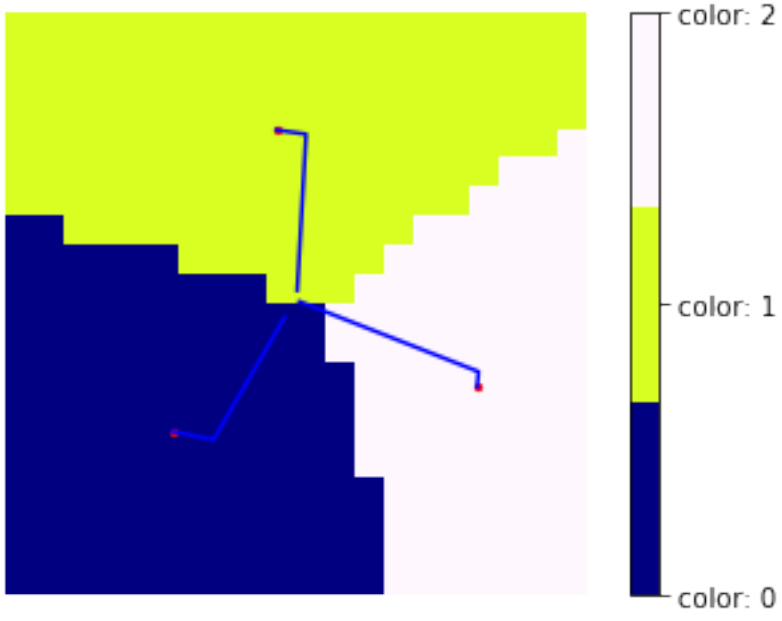

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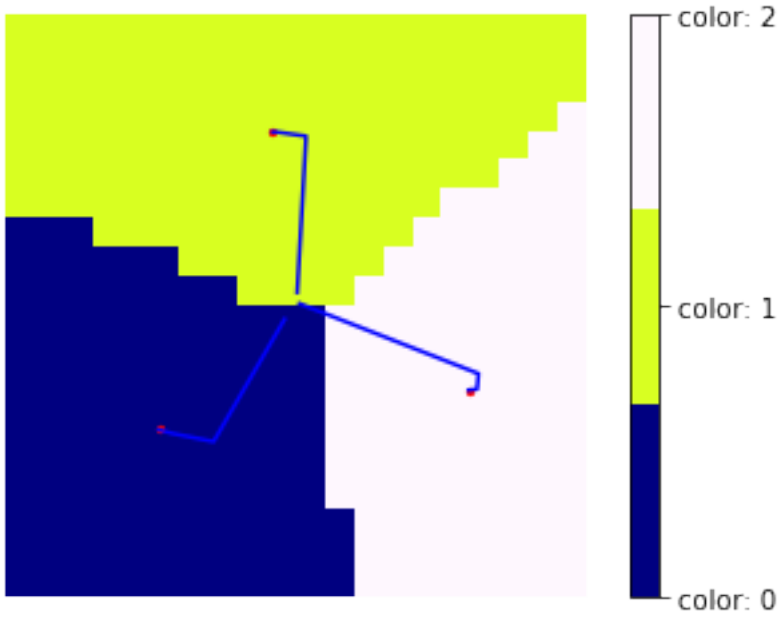

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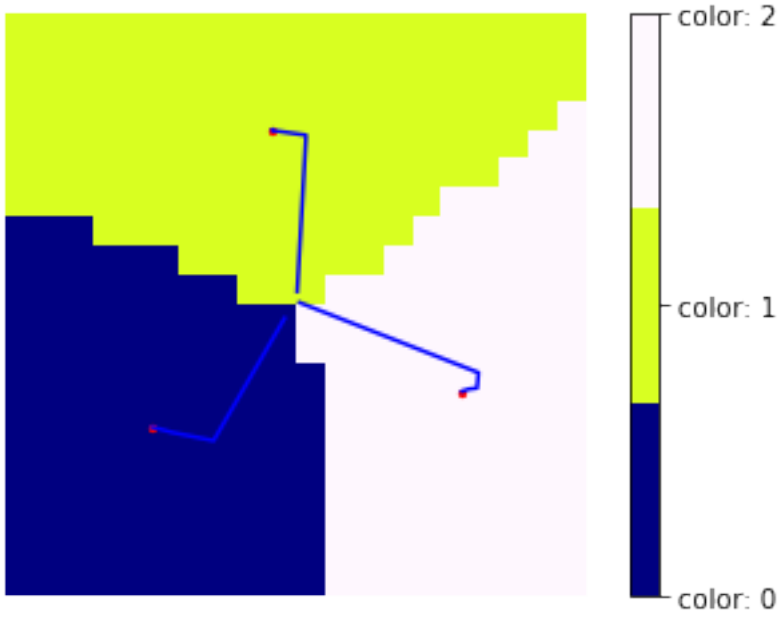

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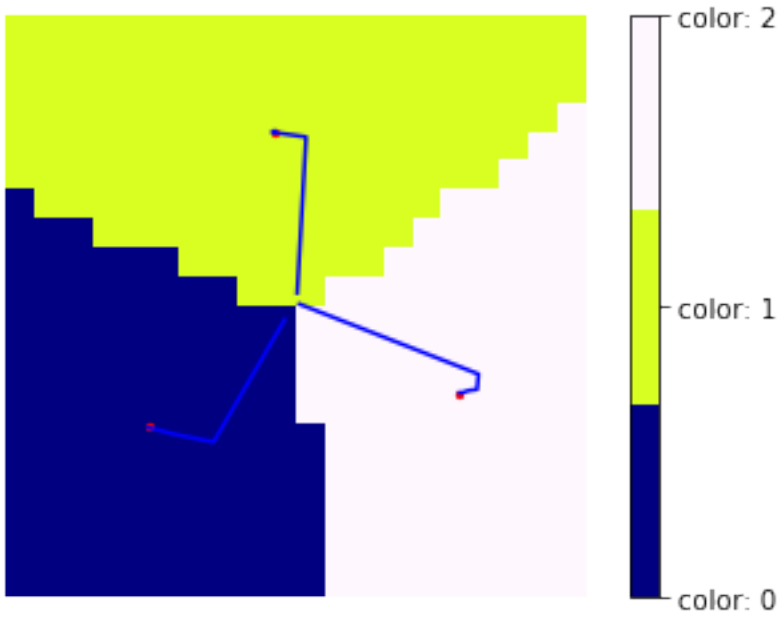

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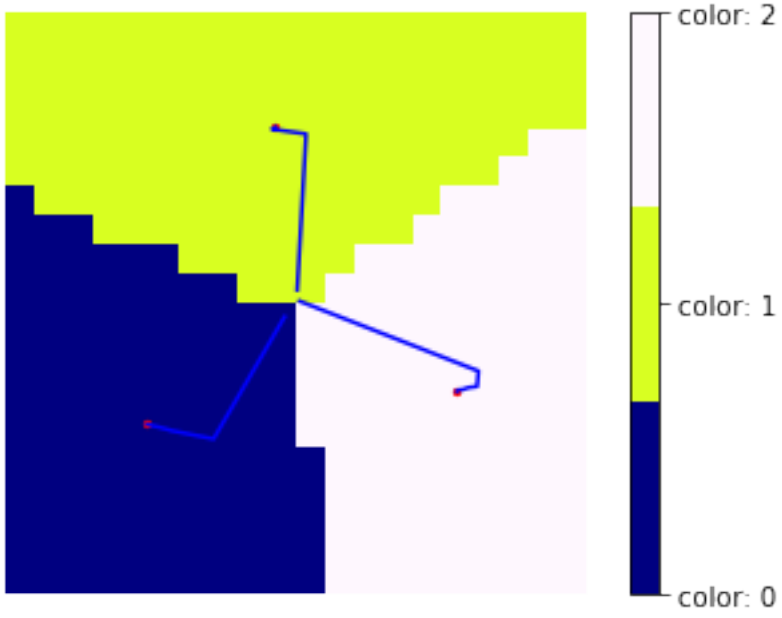

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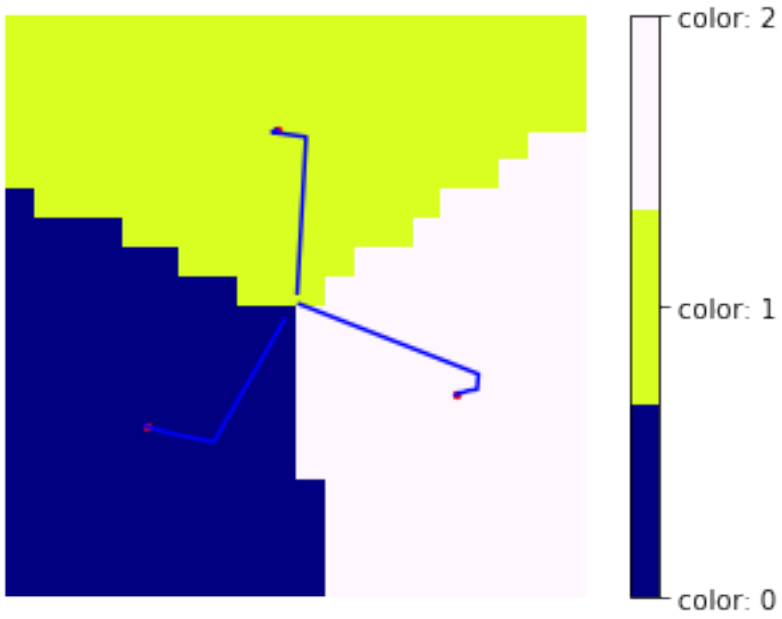

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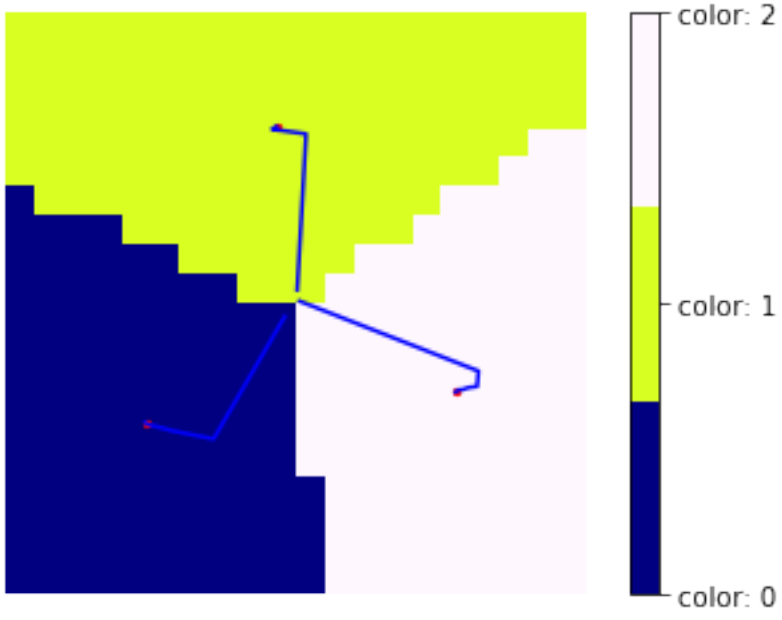
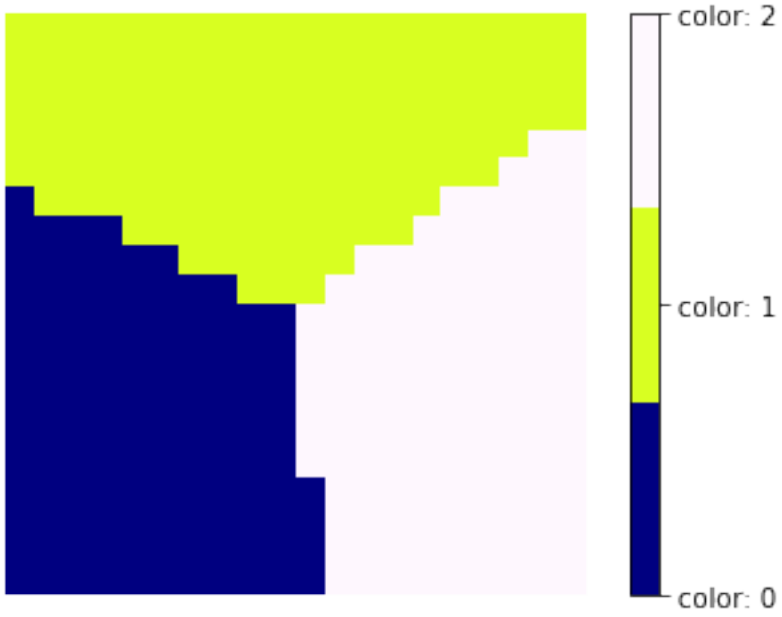


```
In [8]: plot_image(k_num_label, k_num)
```

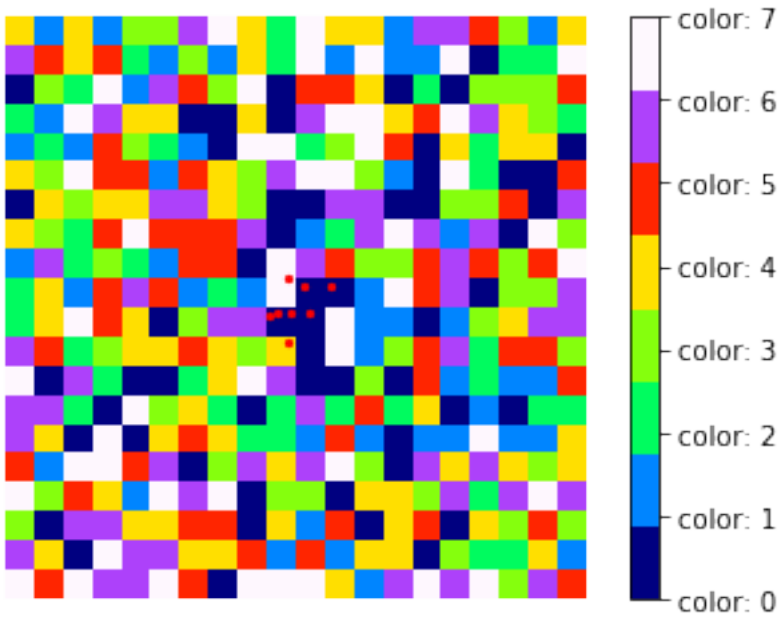


1.2 K = 8

1.2.1 L1 Norm

```
In [9]: k_num = 8
        k_means= KMeans(k_num)
        k_num_label = k_means.train(1)
```

```
0
```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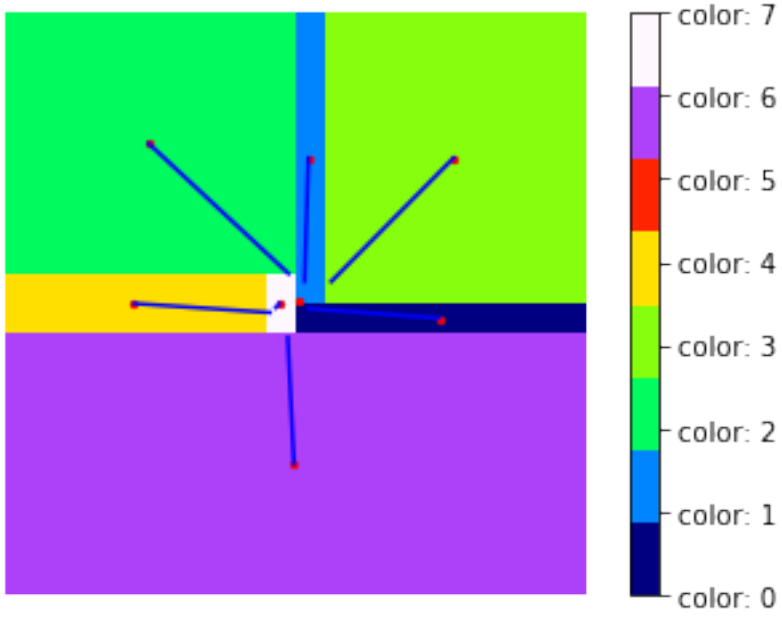
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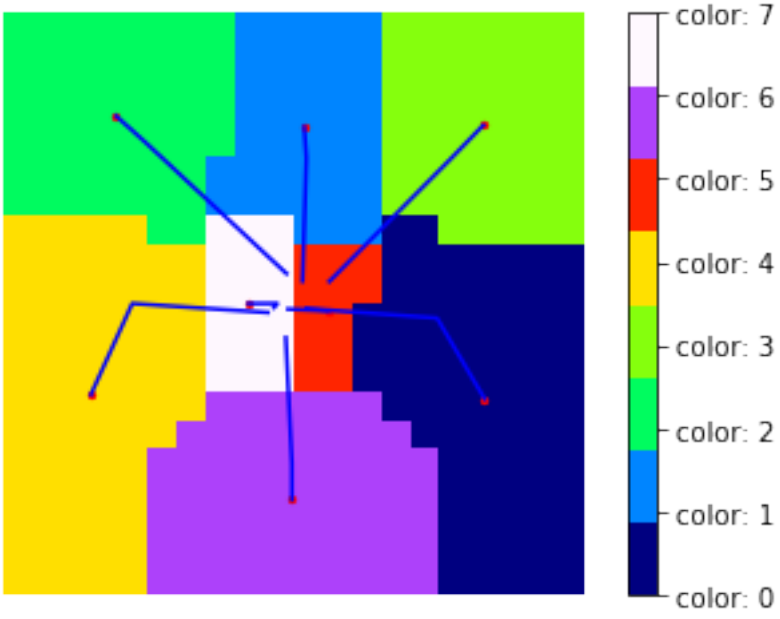
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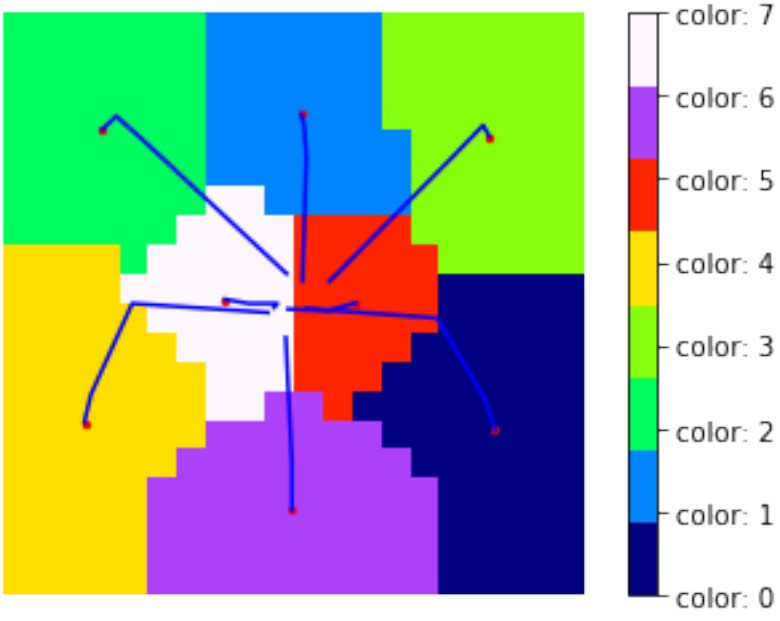
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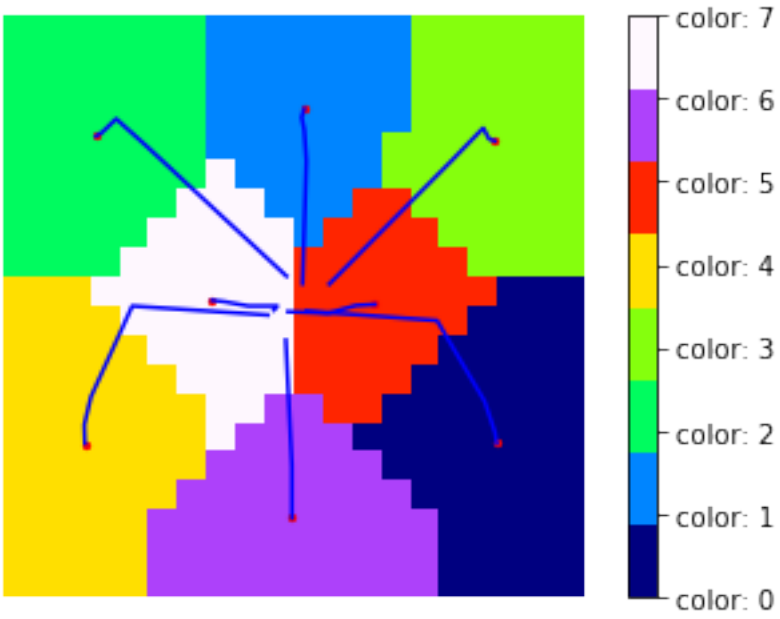
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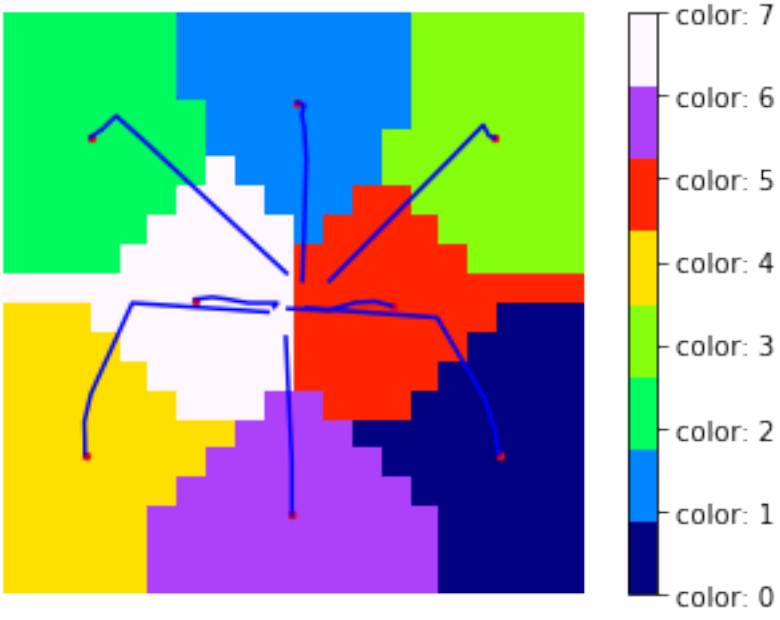
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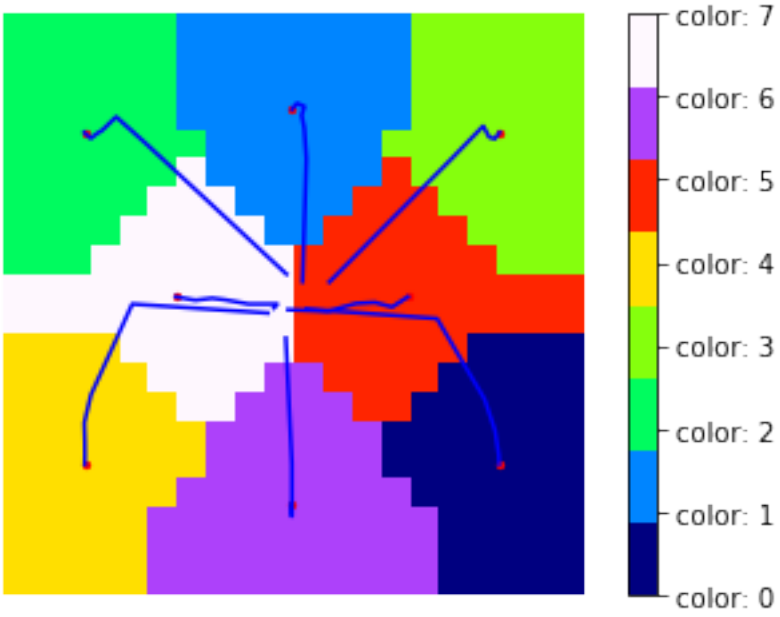
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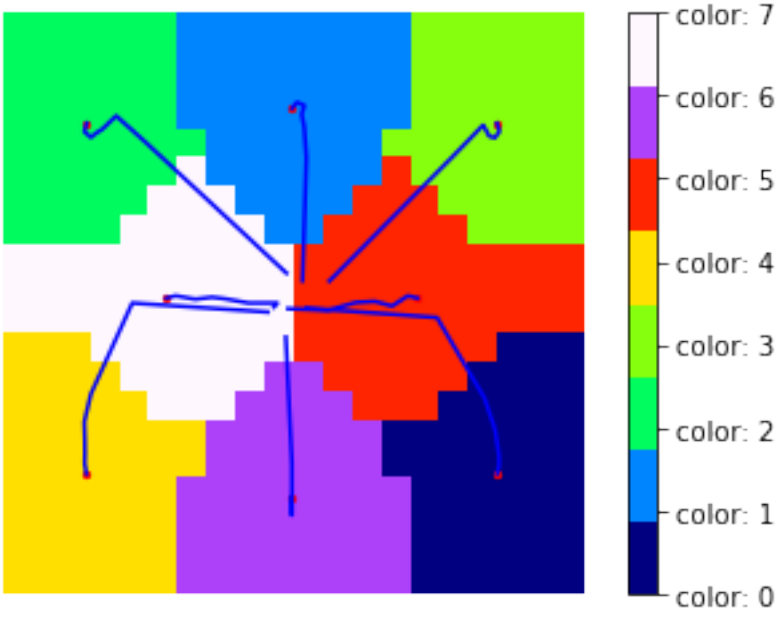
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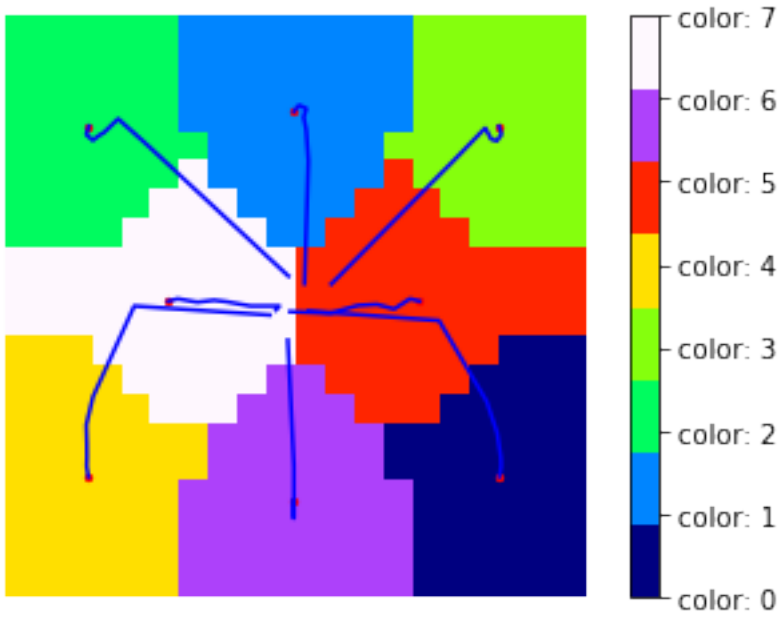
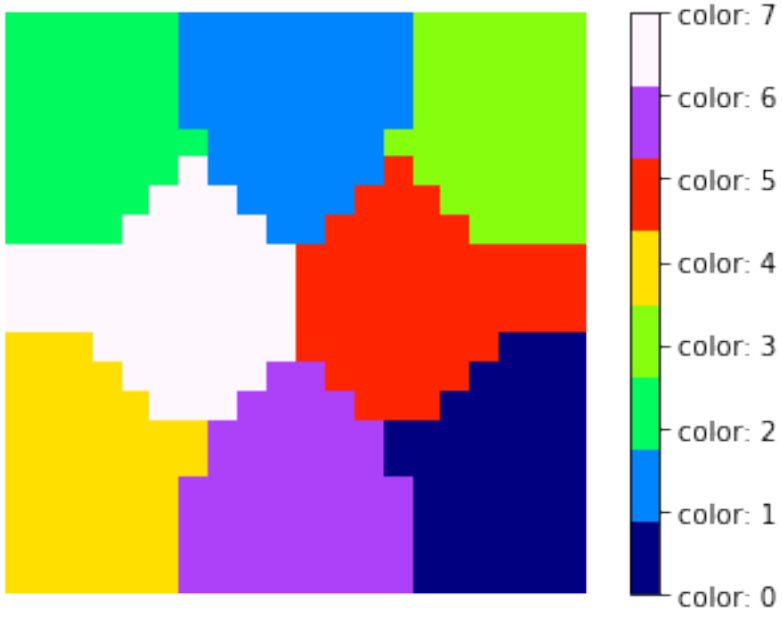


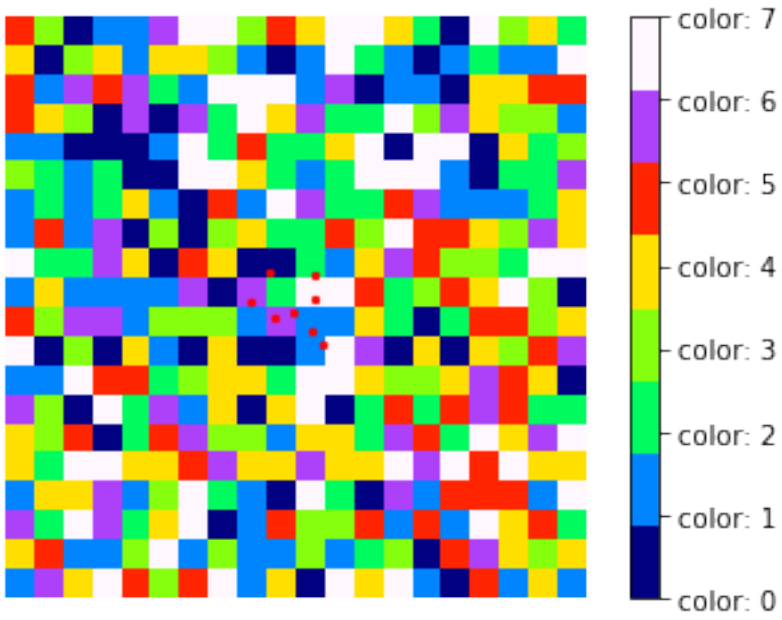
In [10]: `plot_image(k_num_label, k_num)`



1.2.2 L2 Norm

```
In [11]: k_means= KMeans(k_num)
         k_num_label = k_means.train(2)
```

0



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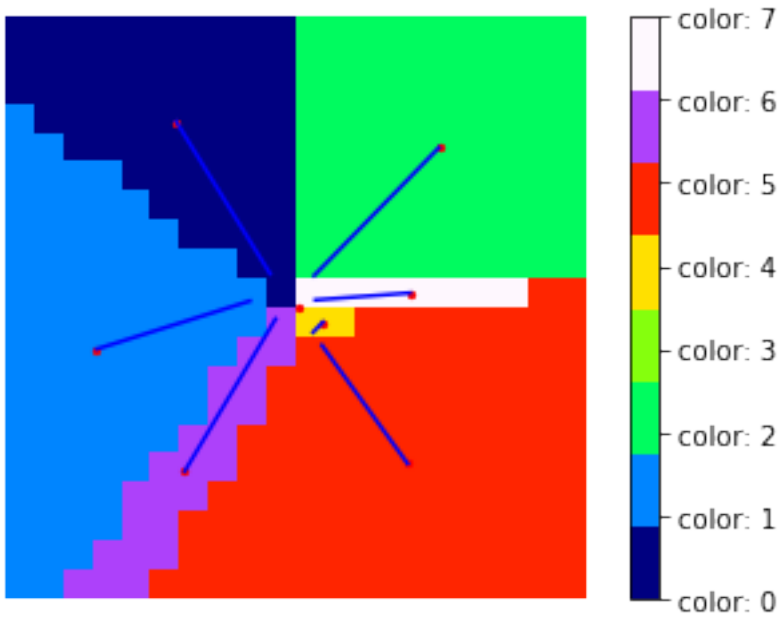
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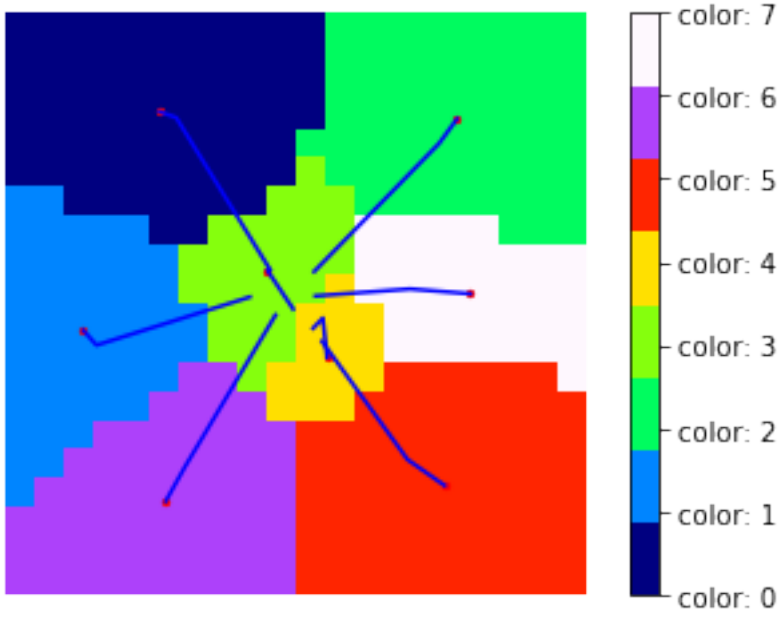
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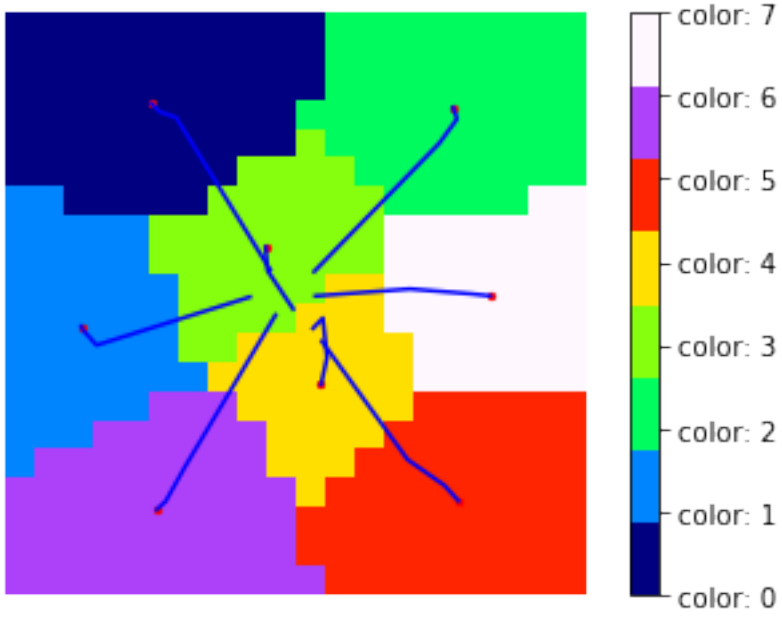
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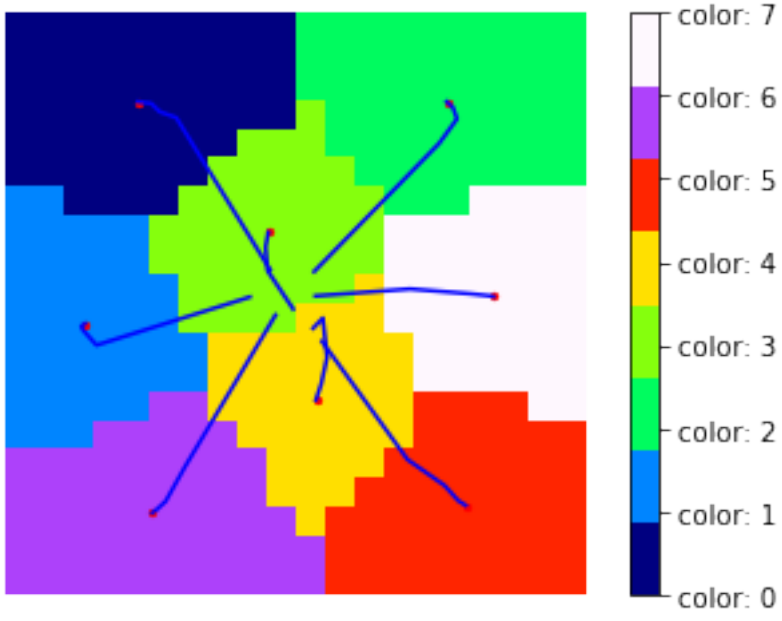
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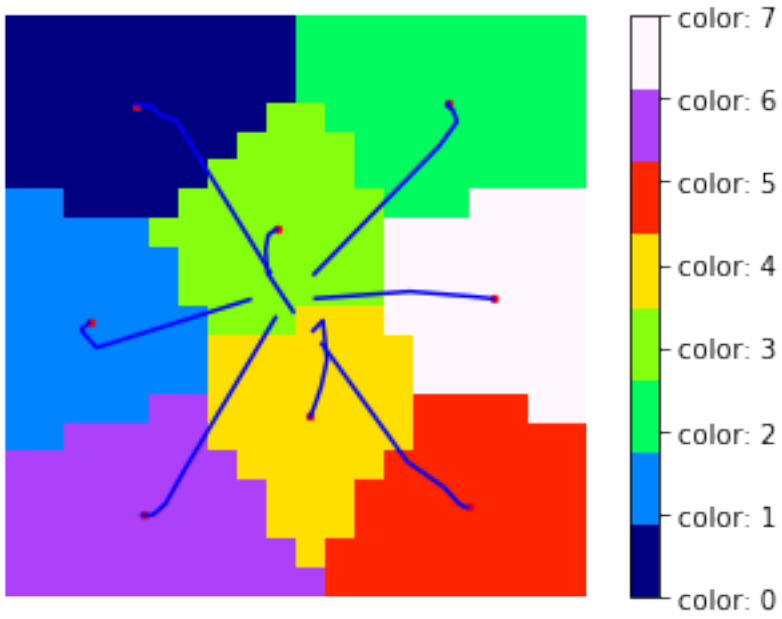
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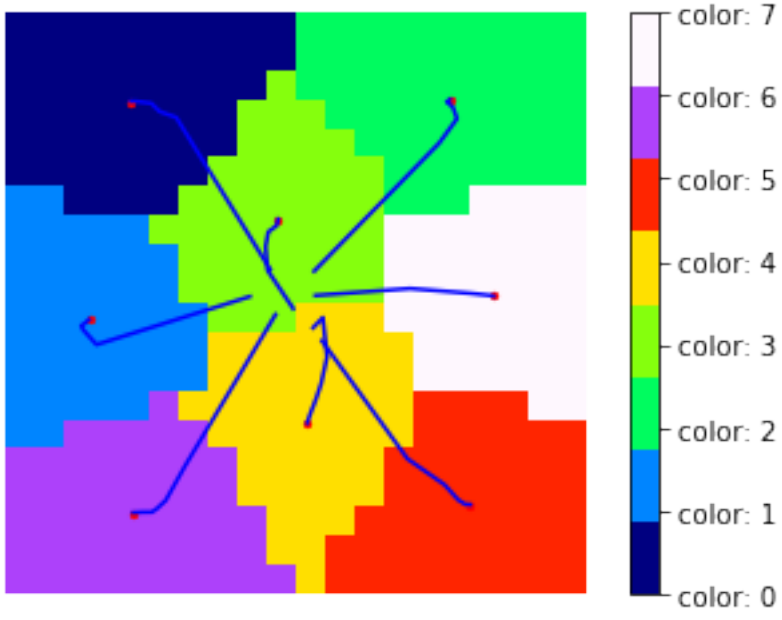
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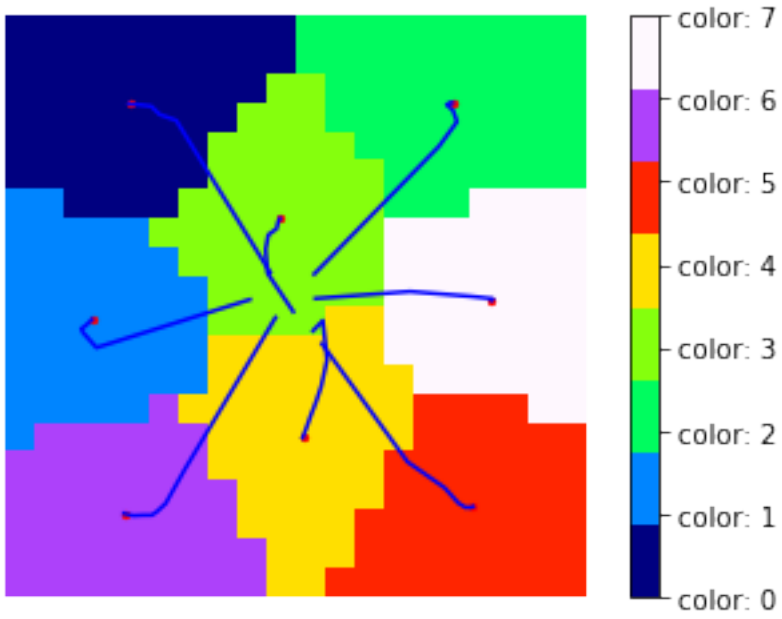
7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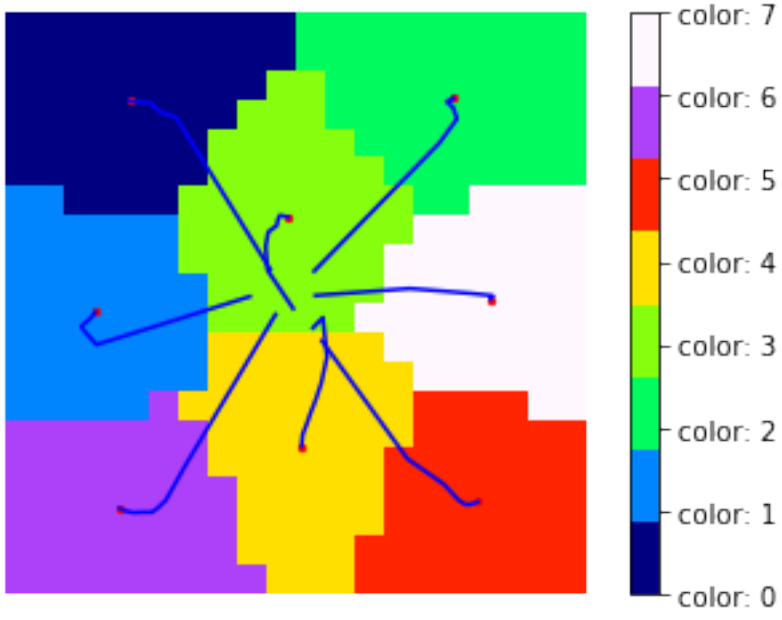
8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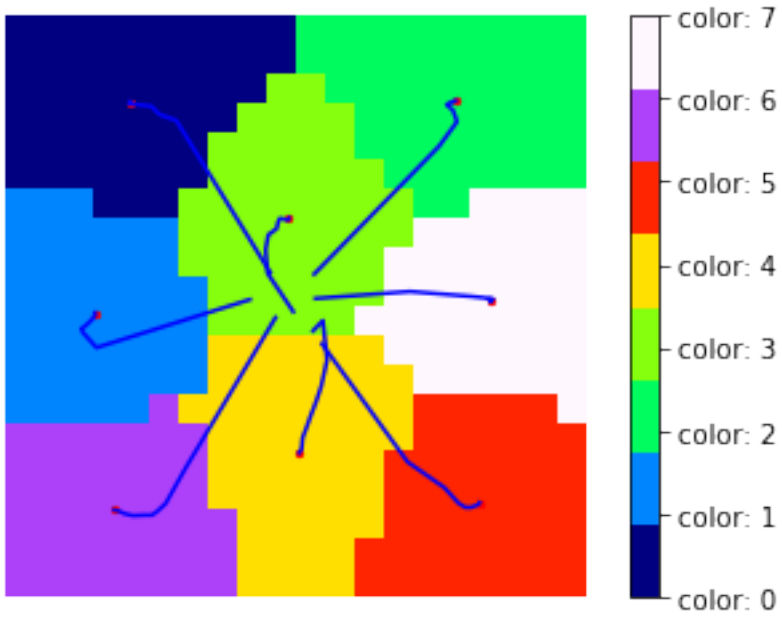
9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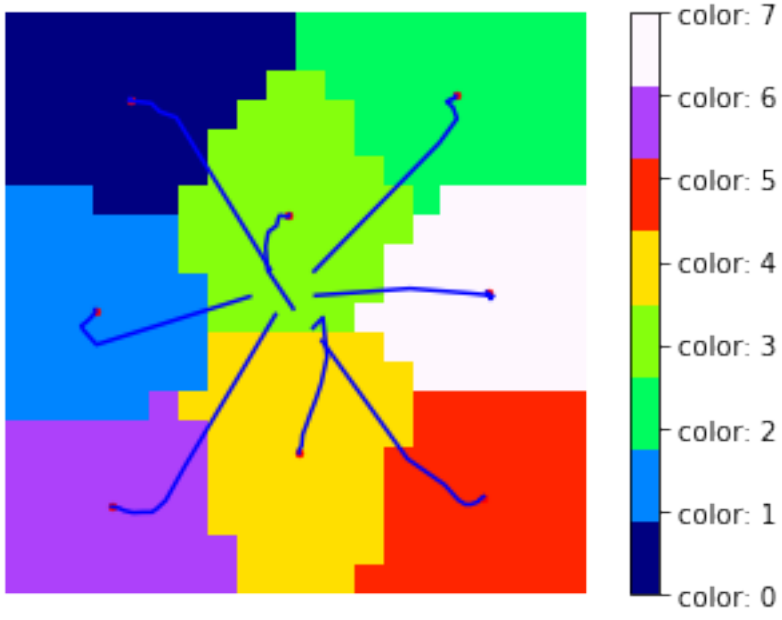
10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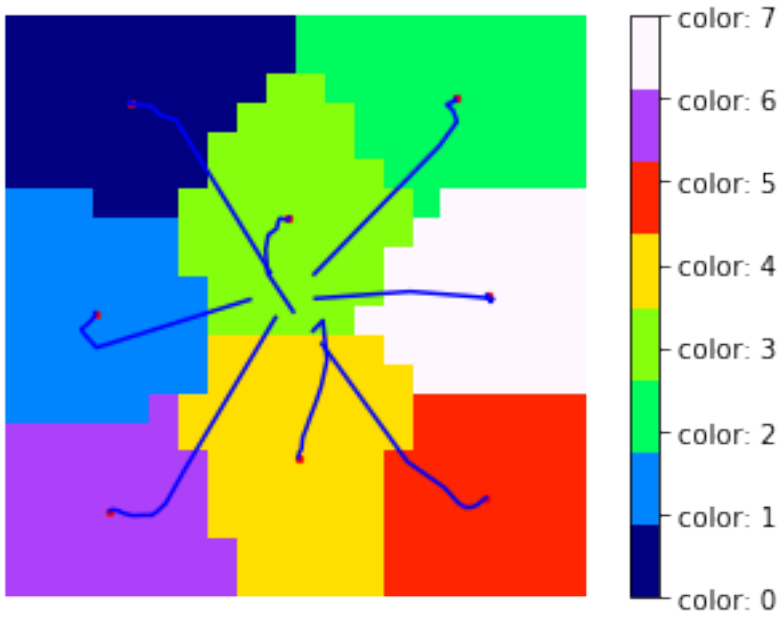
11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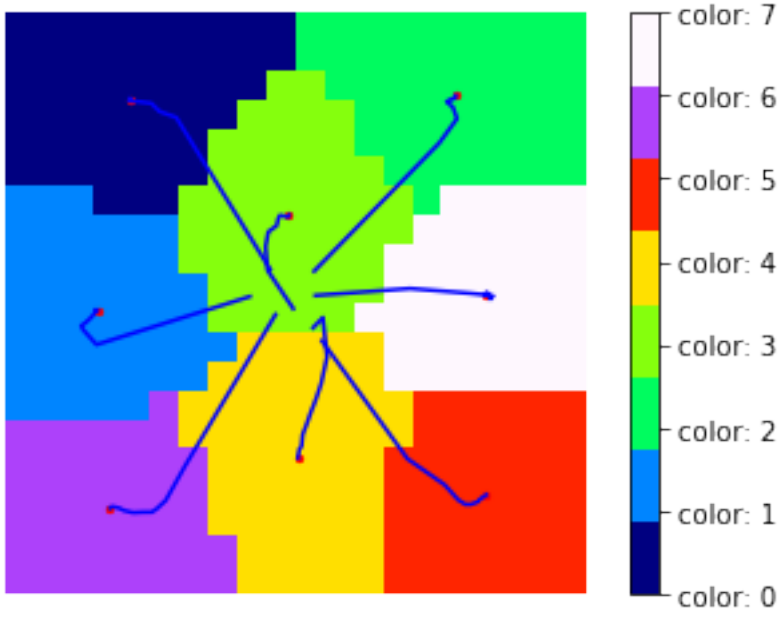
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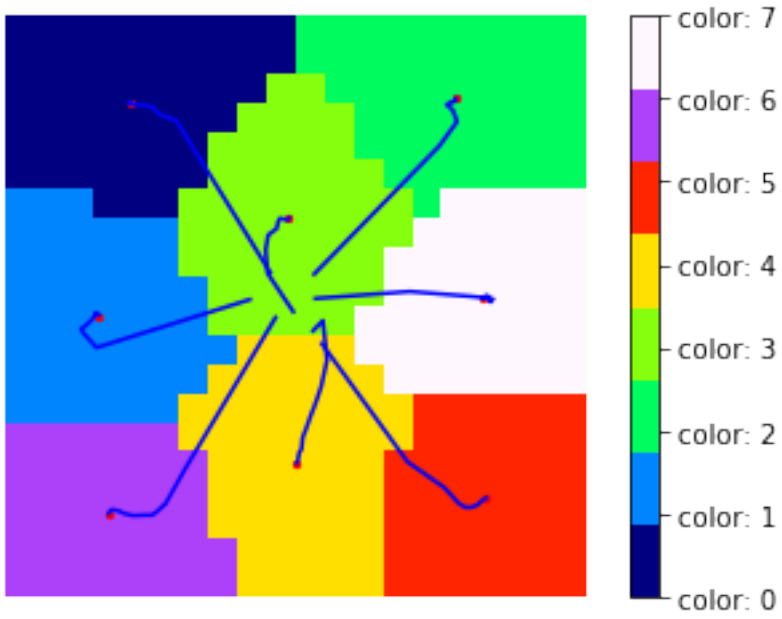
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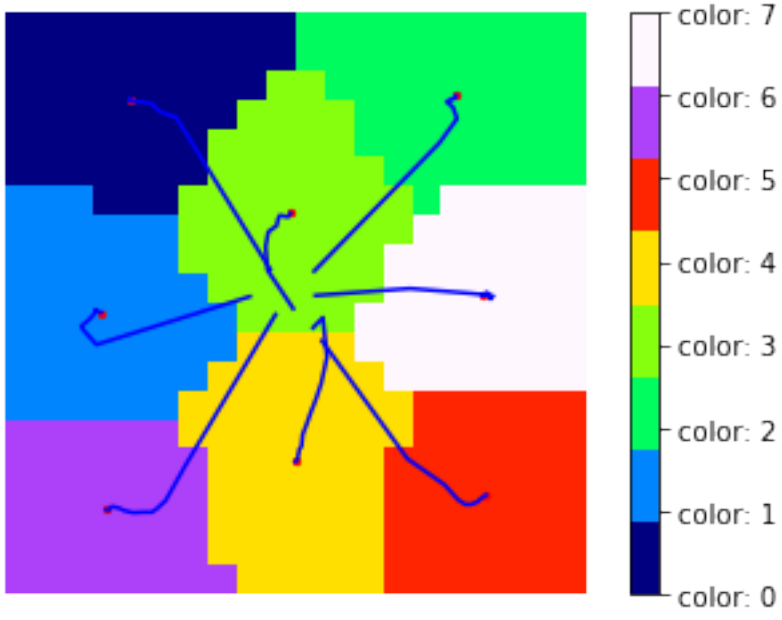
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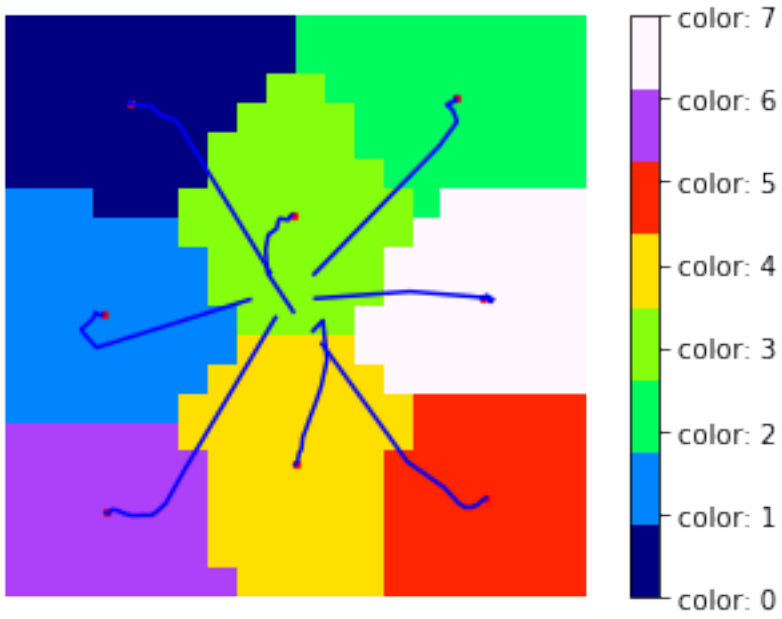
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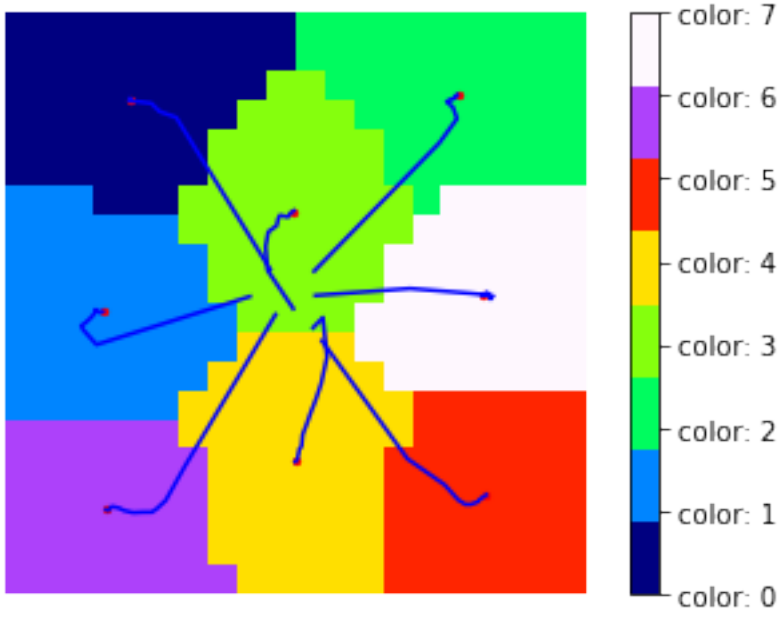
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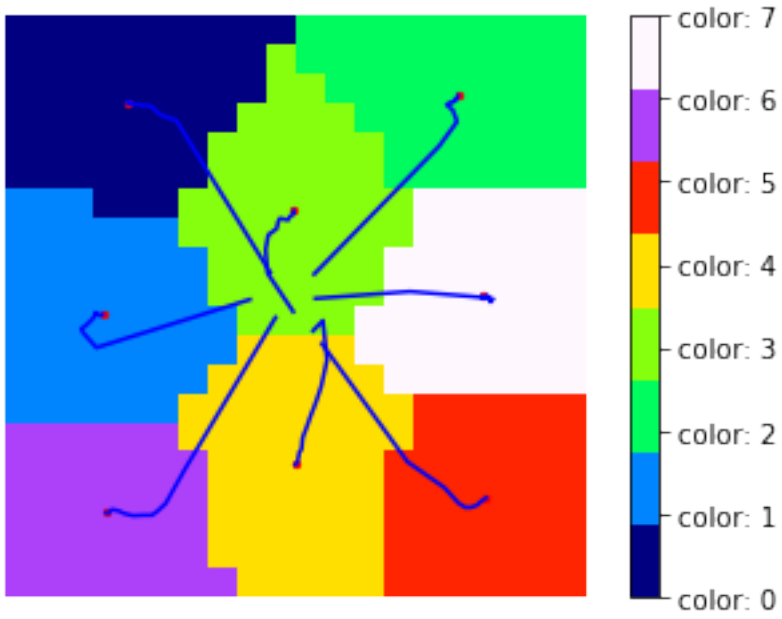
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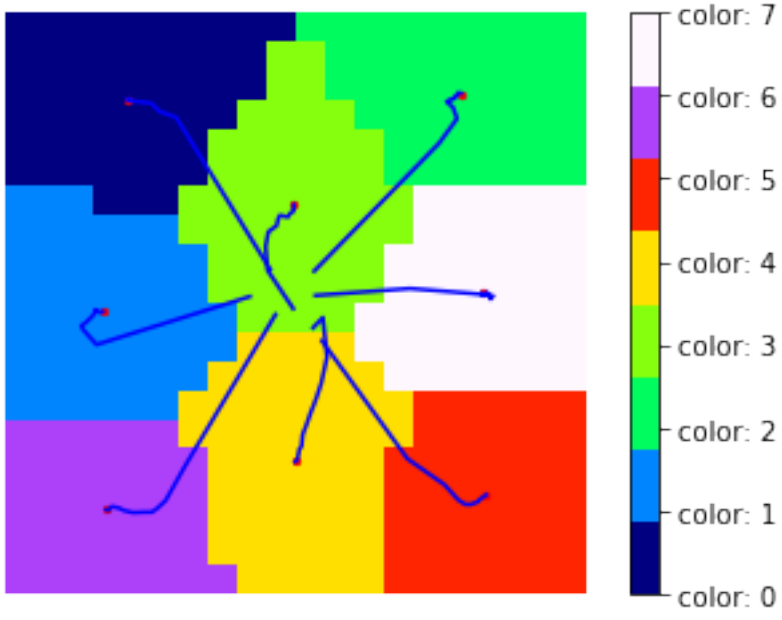
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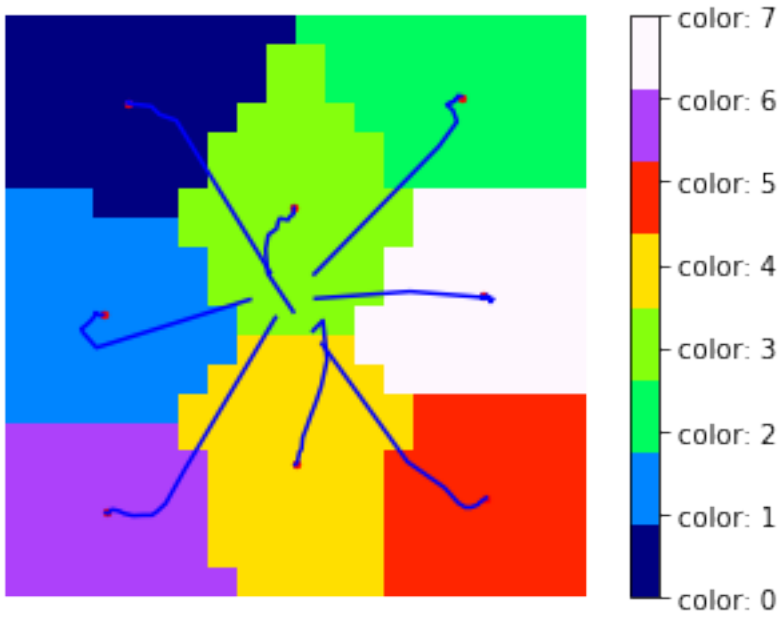
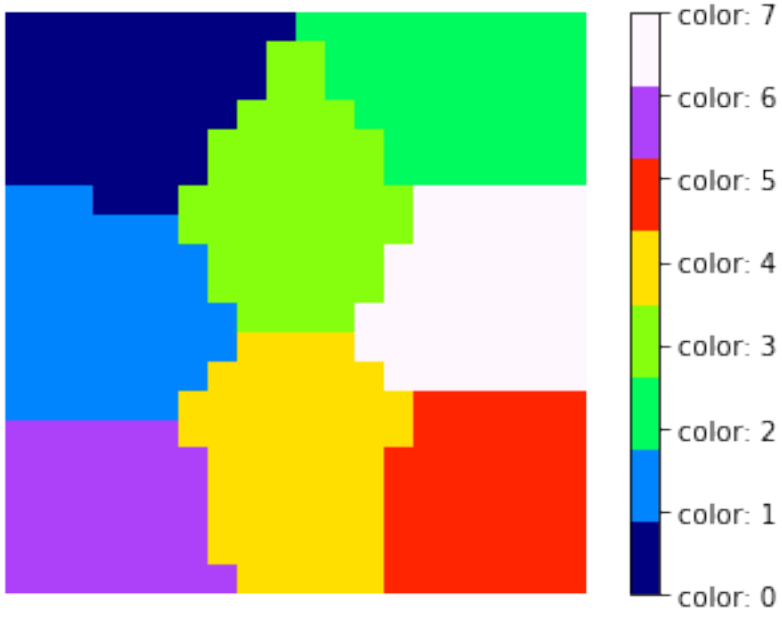


In [12]: `plot_image(k_num_label, k_num)`

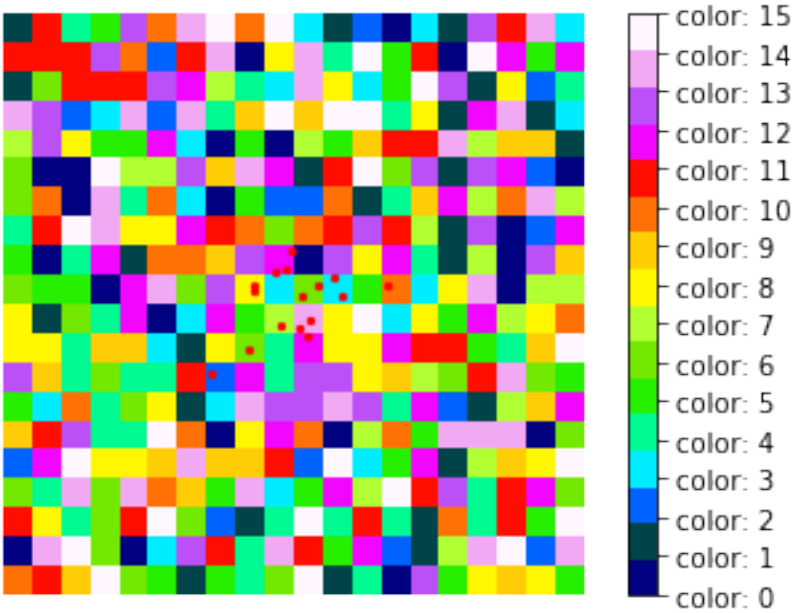


1.3 K = 16

1.3.1 L1 Norm

```
In [13]: k_num = 16
         k_means= KMeans(k_num)
         k_num_label = k_means.train(1)
```

0



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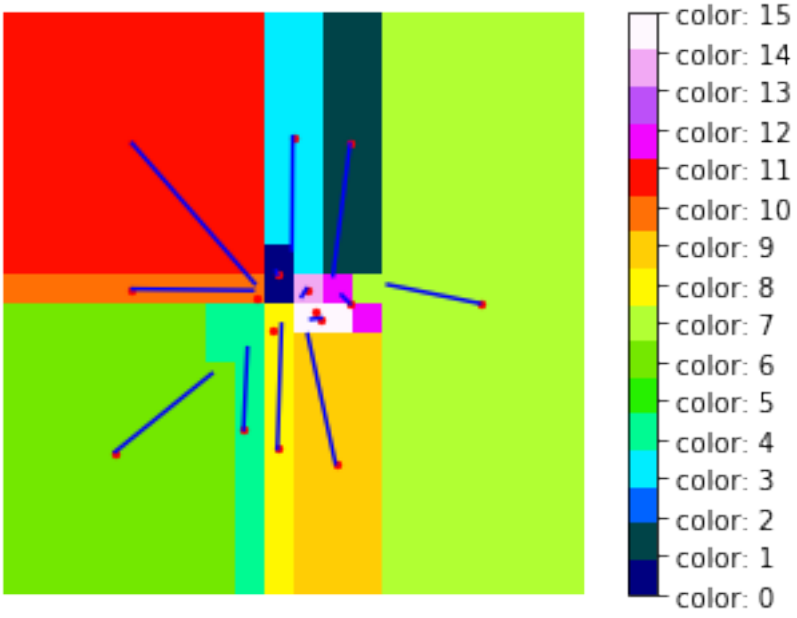
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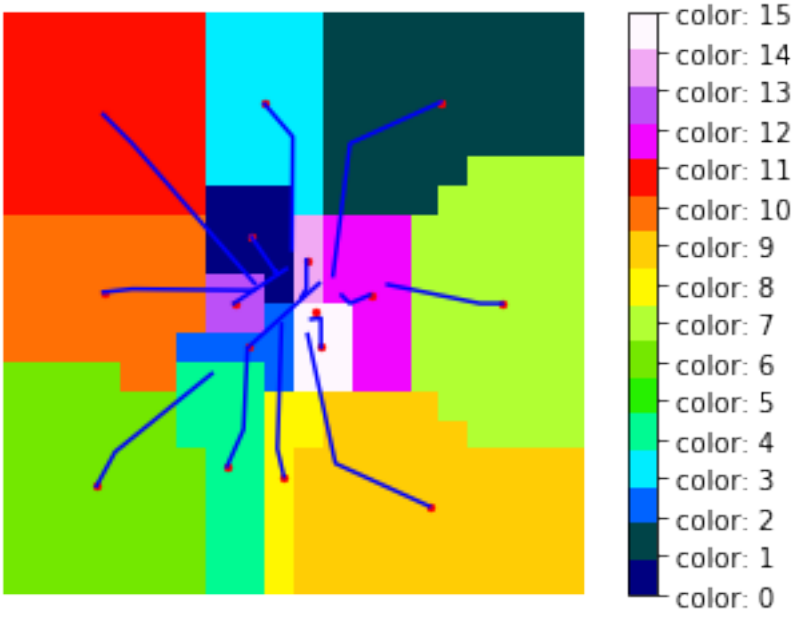
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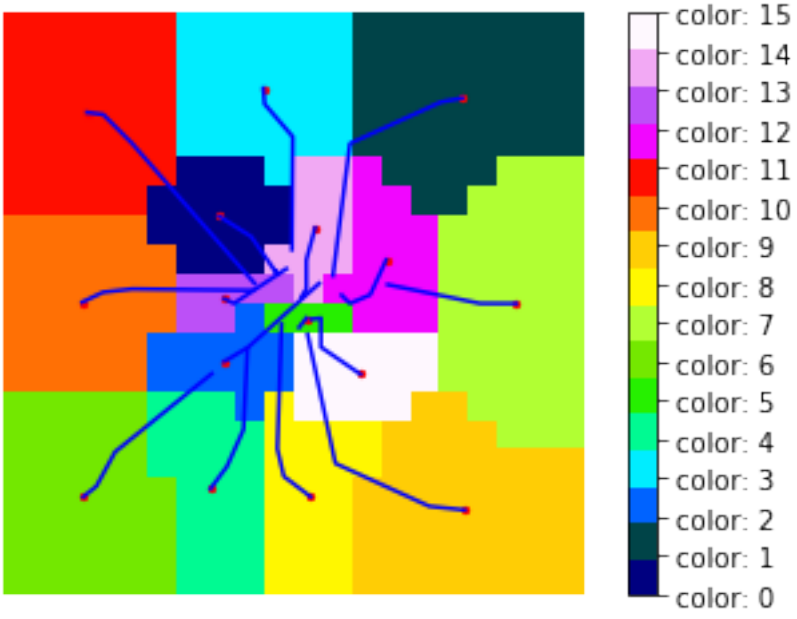
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color: 1
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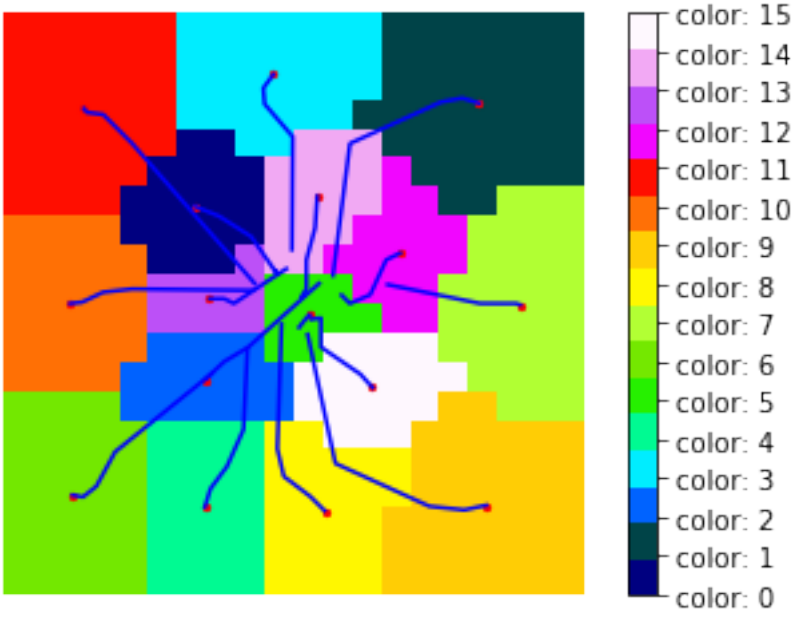
4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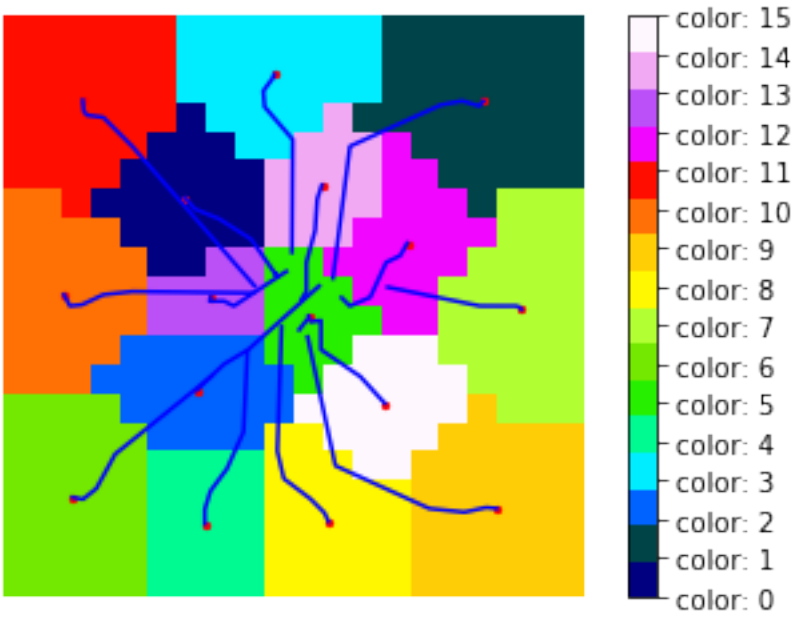
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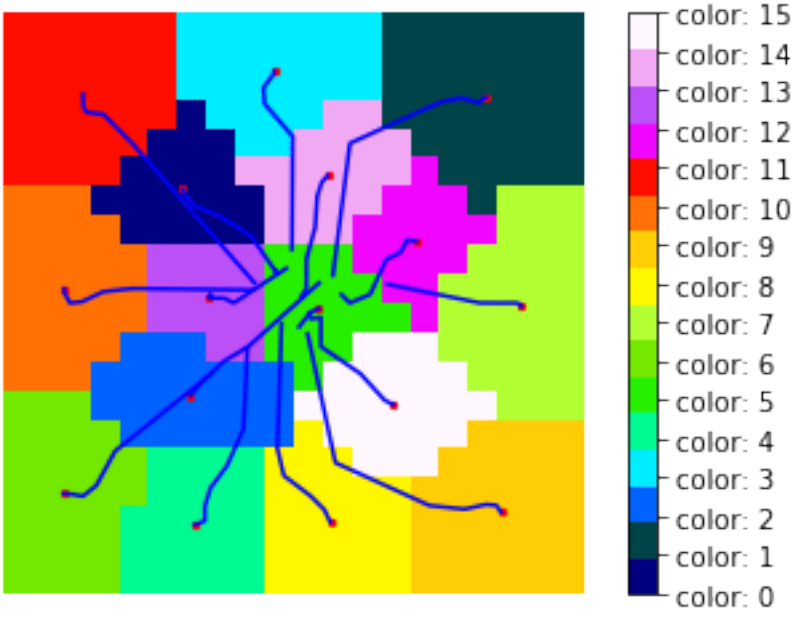
6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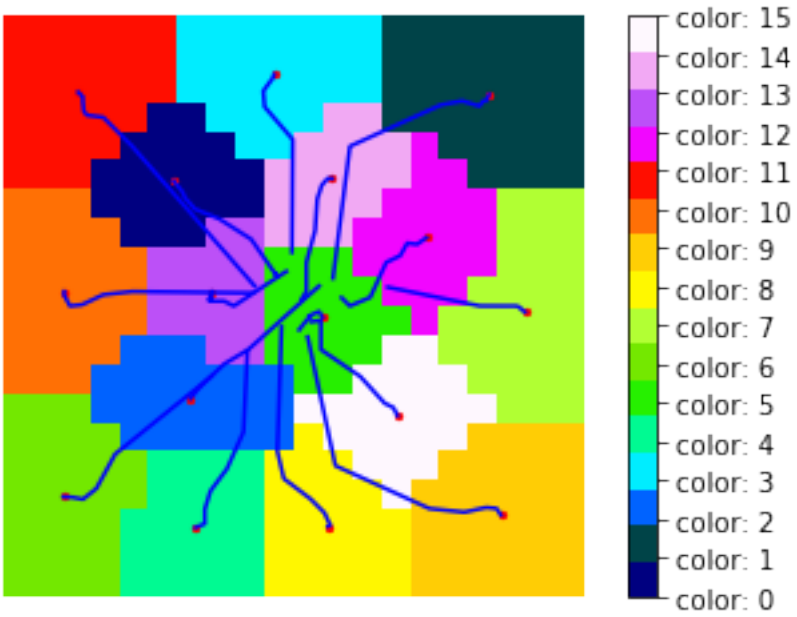
7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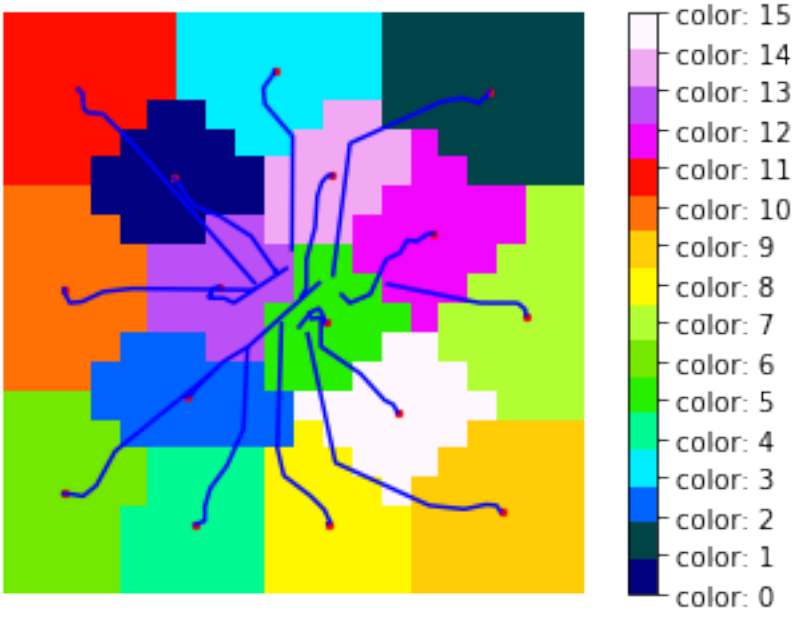
8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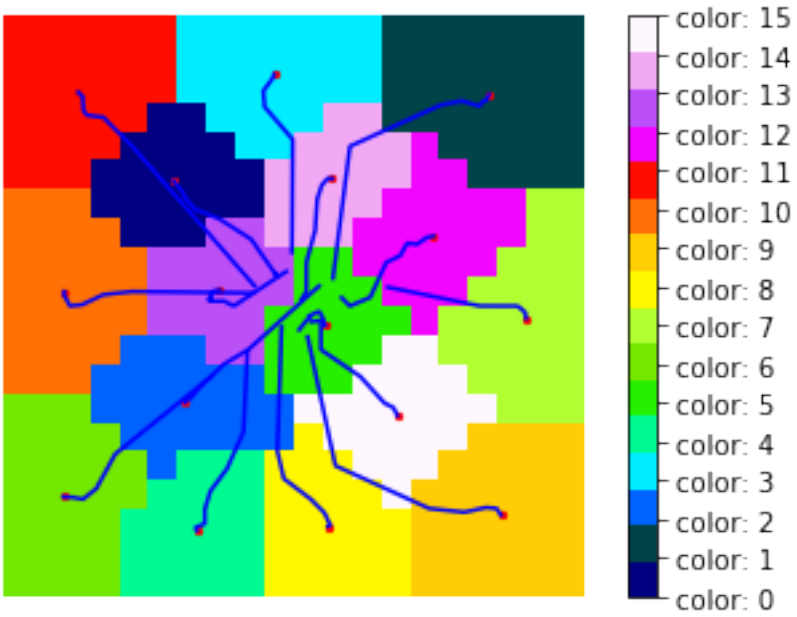
9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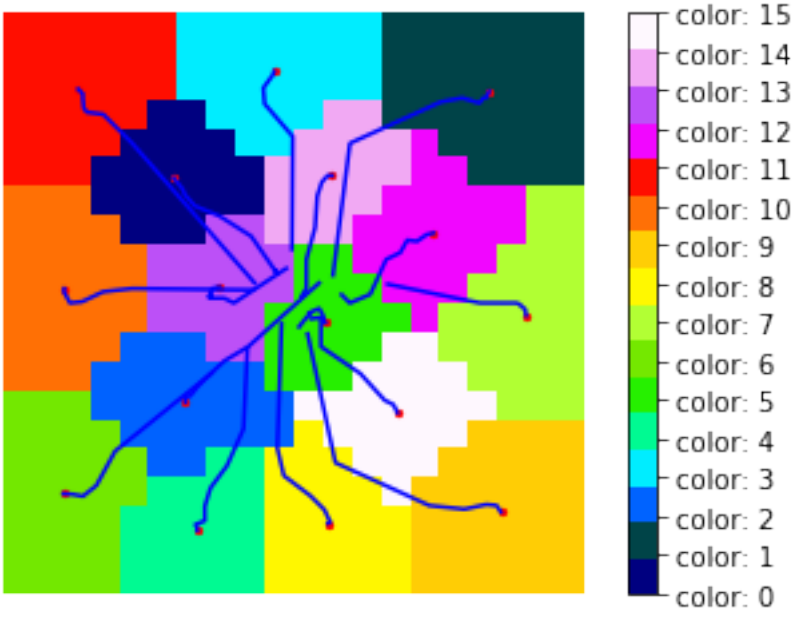
10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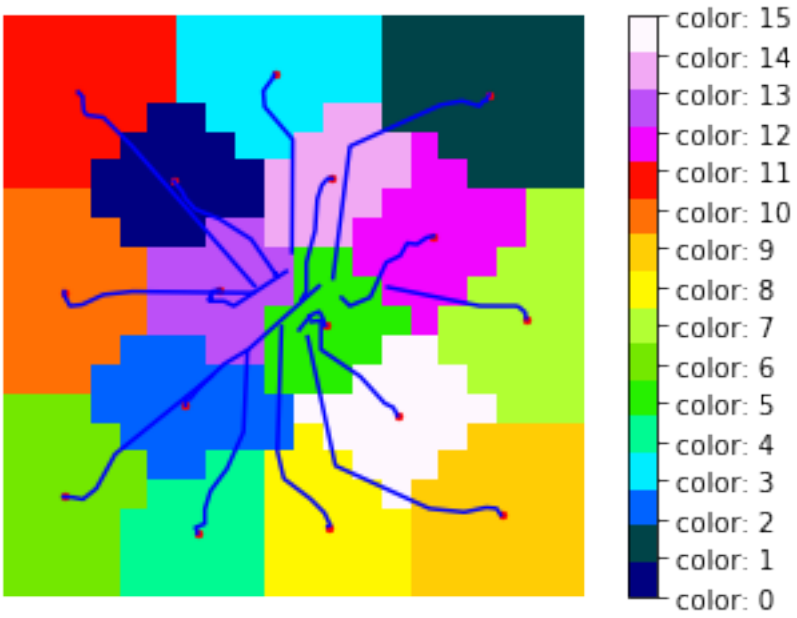
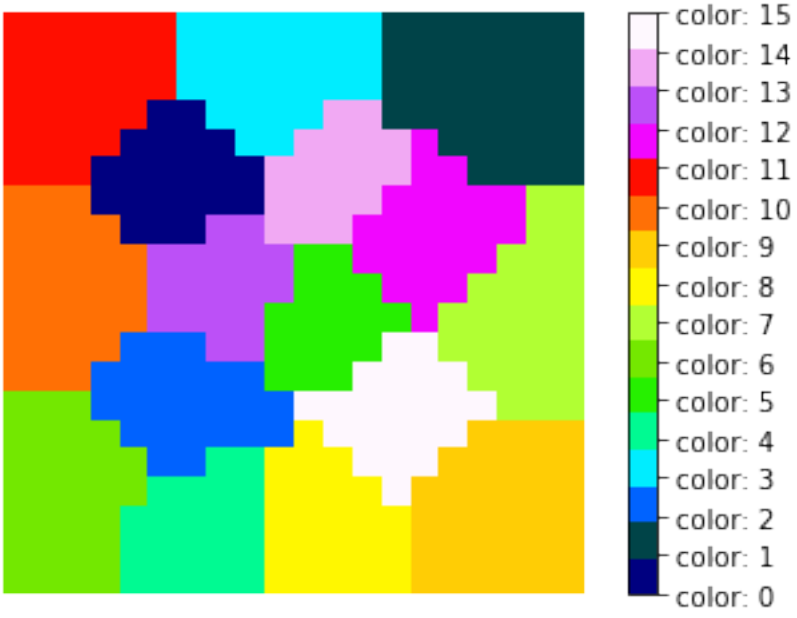
12



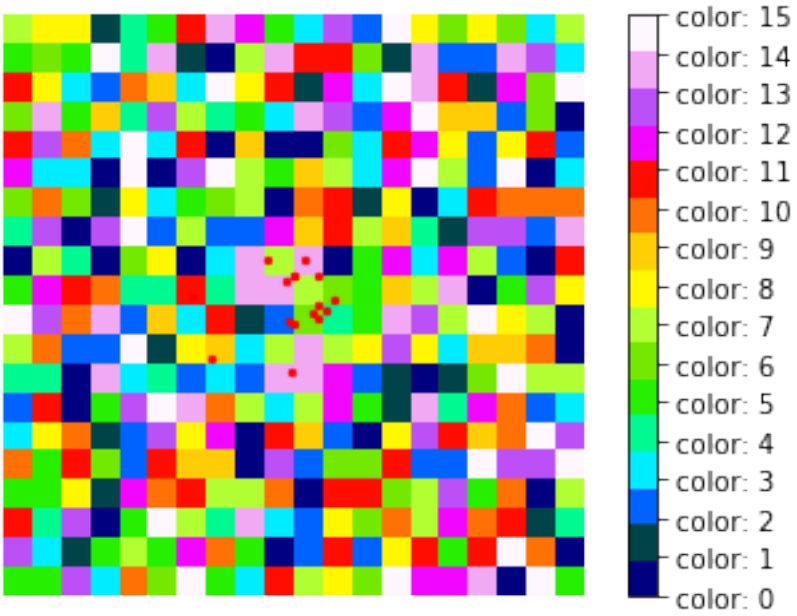
In [14]: plot_image(k_num_label, k_num)



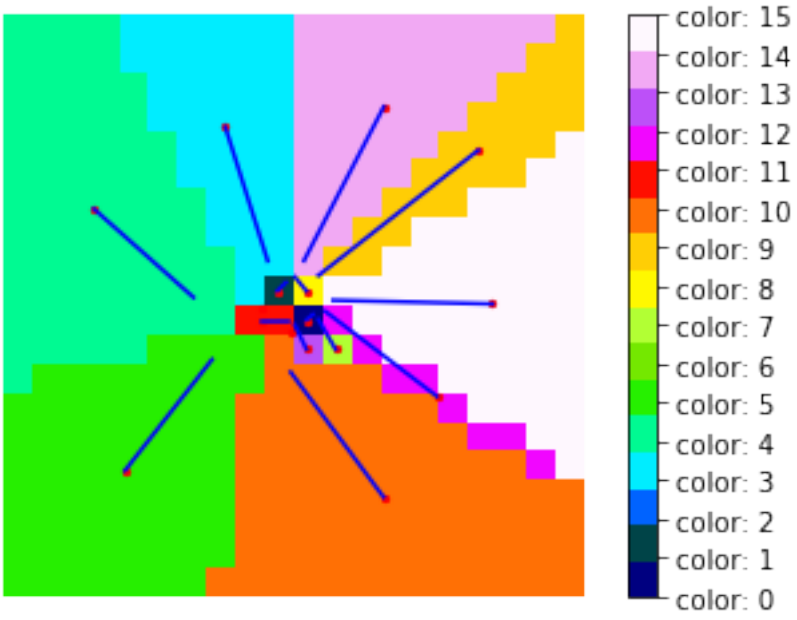
1.3.2 L2 Norm

```
In [15]: k_means= KMeans(k_num)
         k_num_label = k_means.train(2)
```

0



1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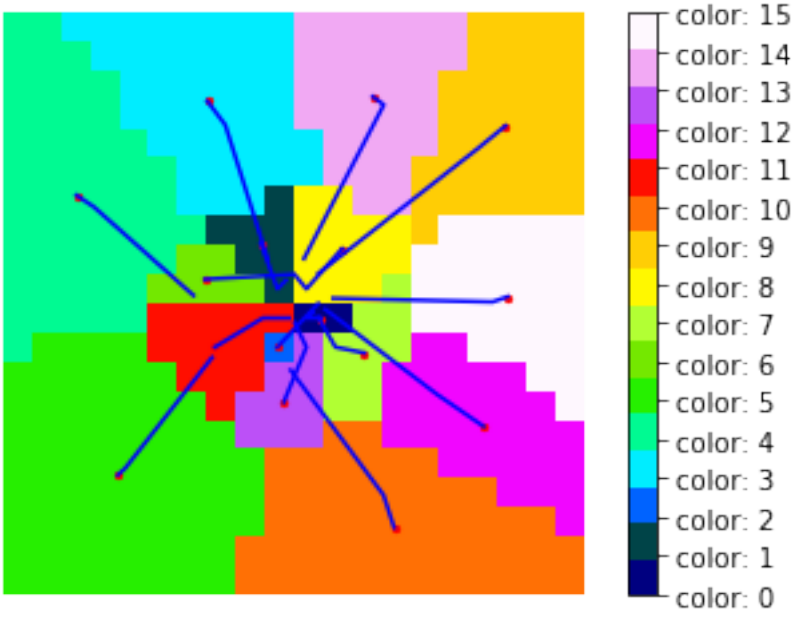
2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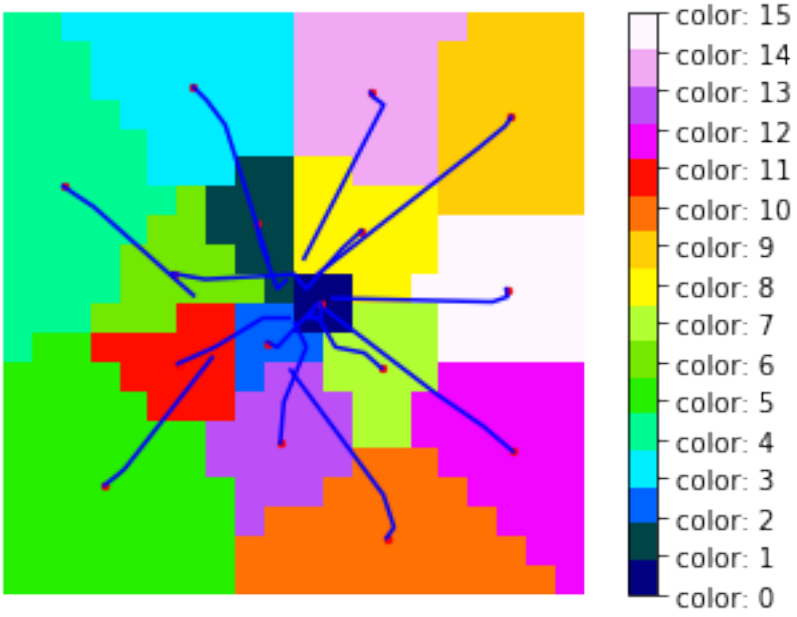
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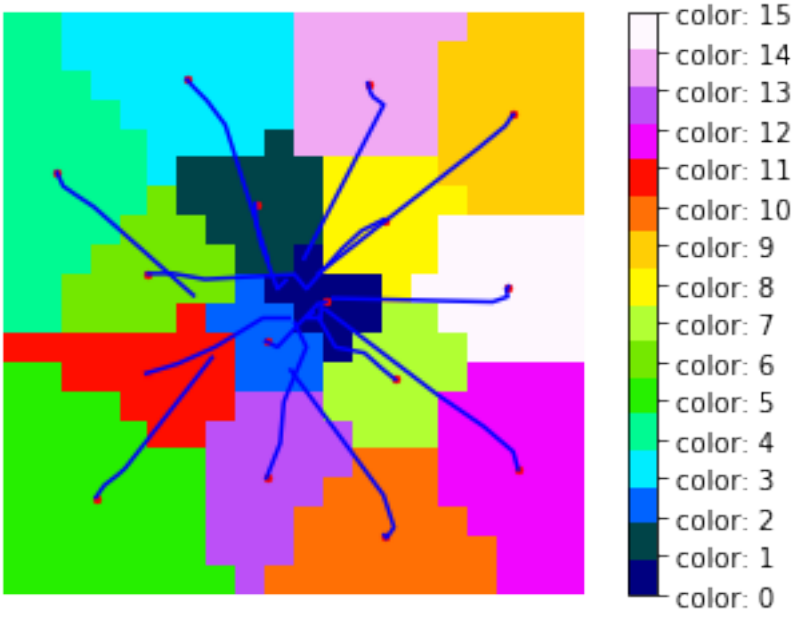
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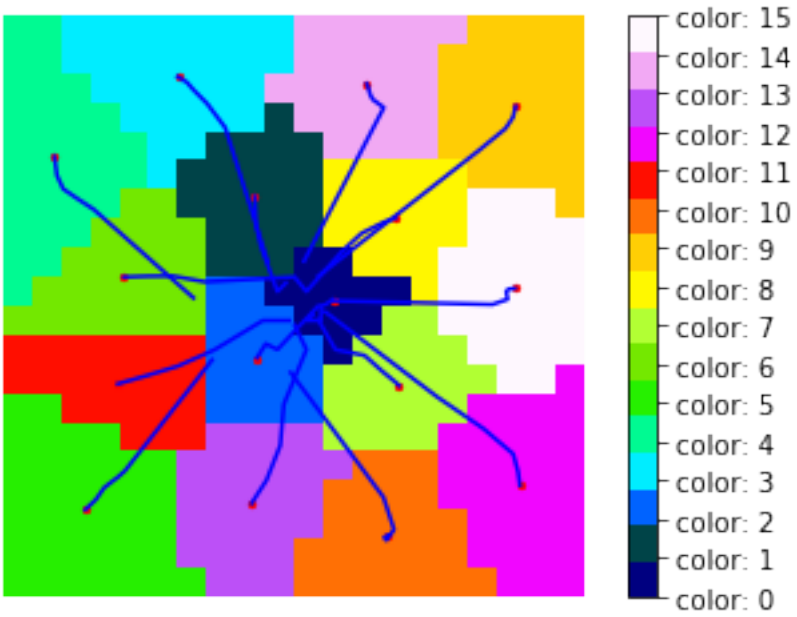
5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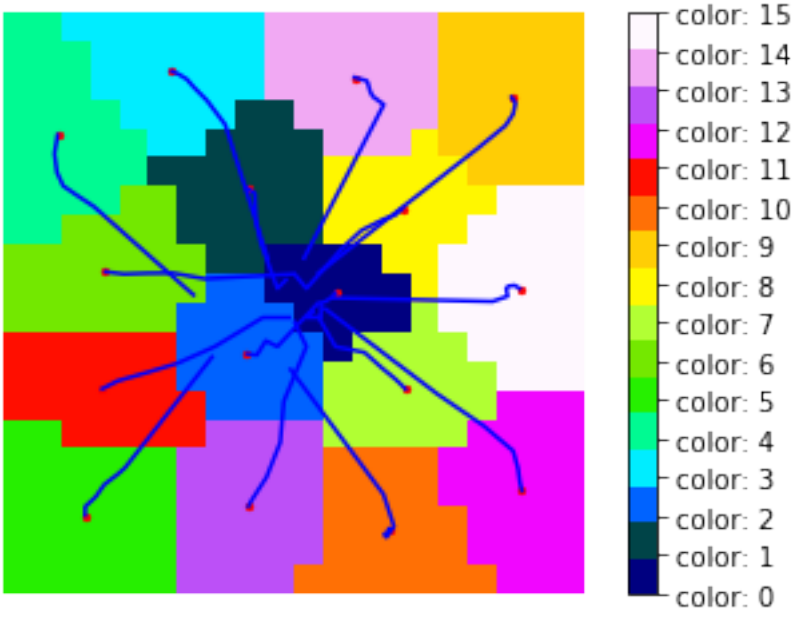
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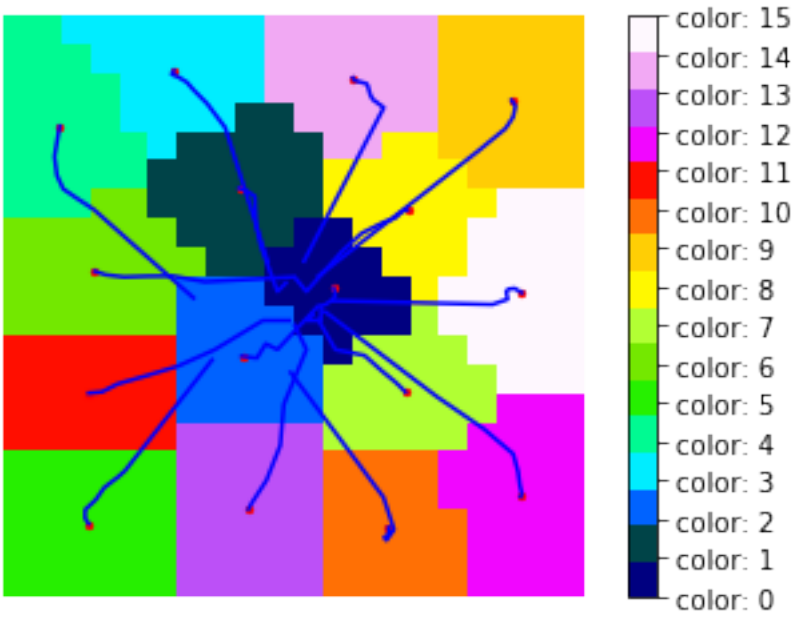
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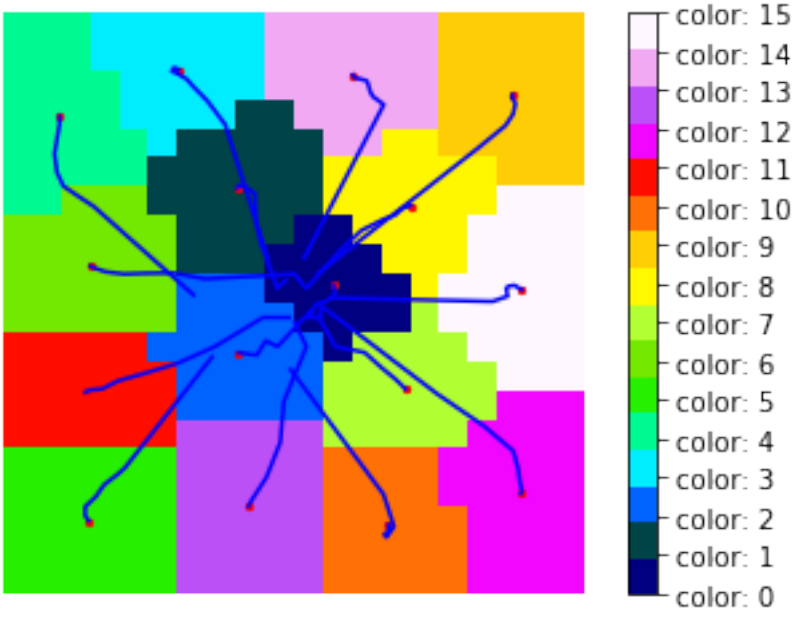
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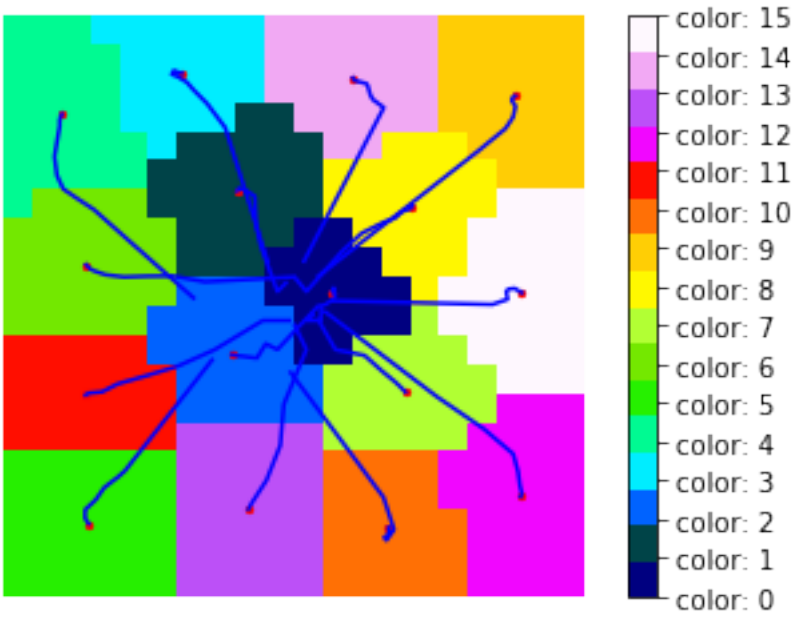
9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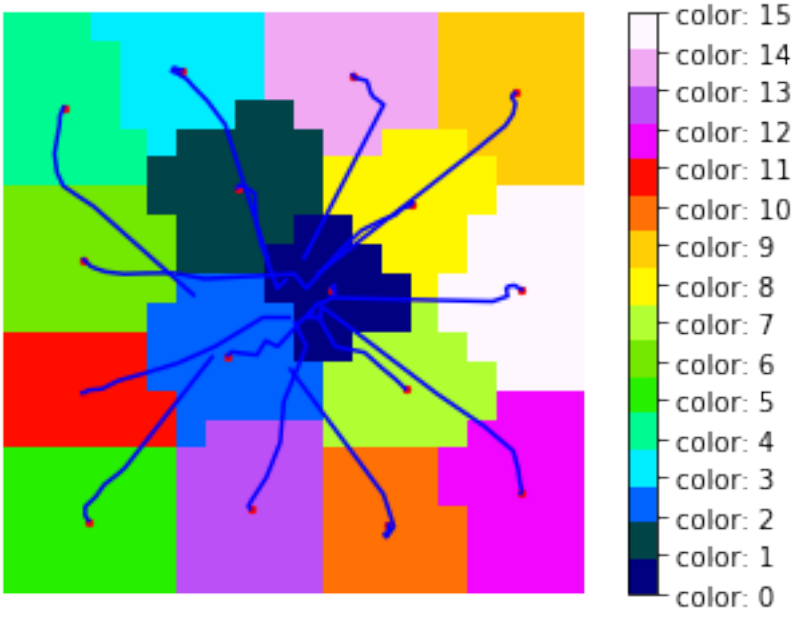
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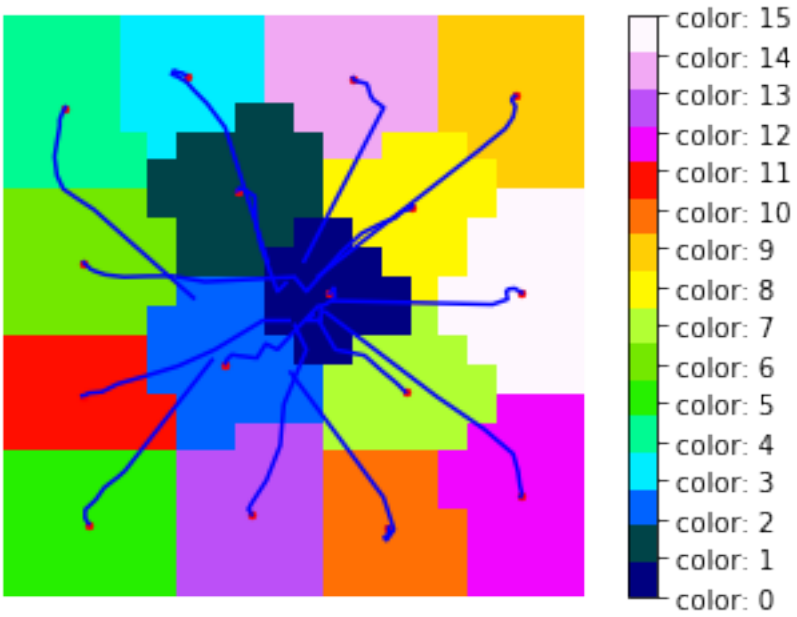
11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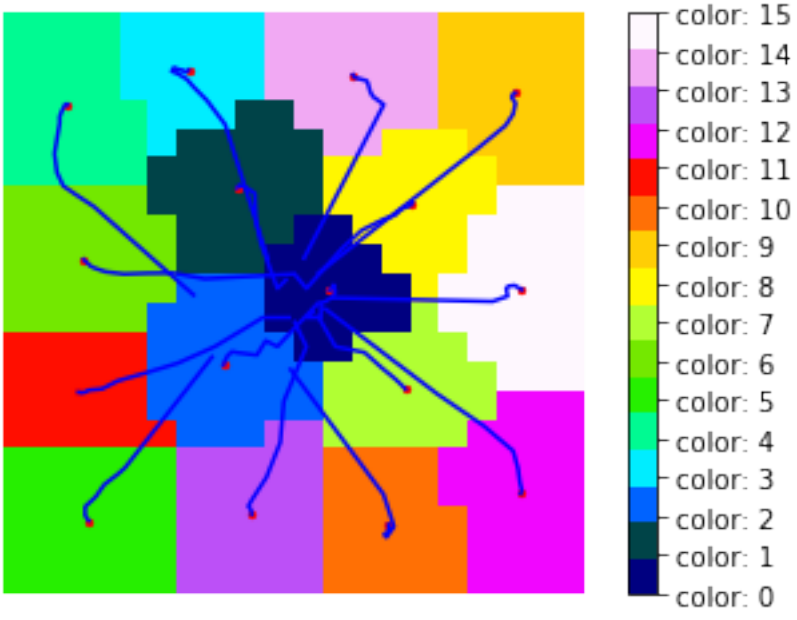
12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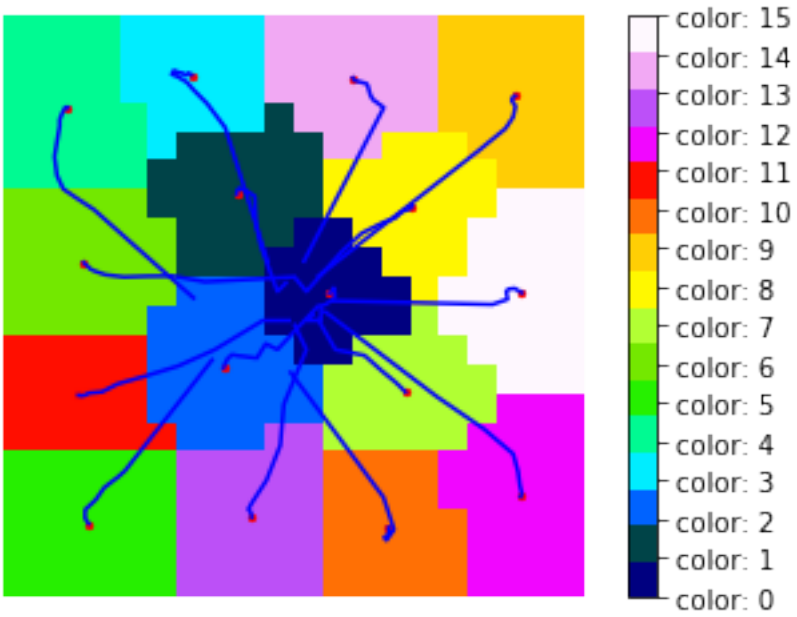
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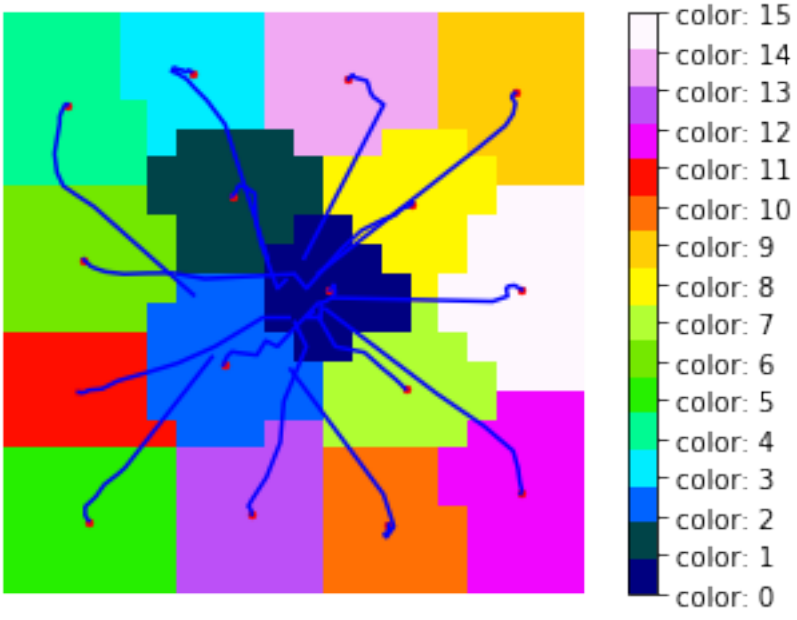
14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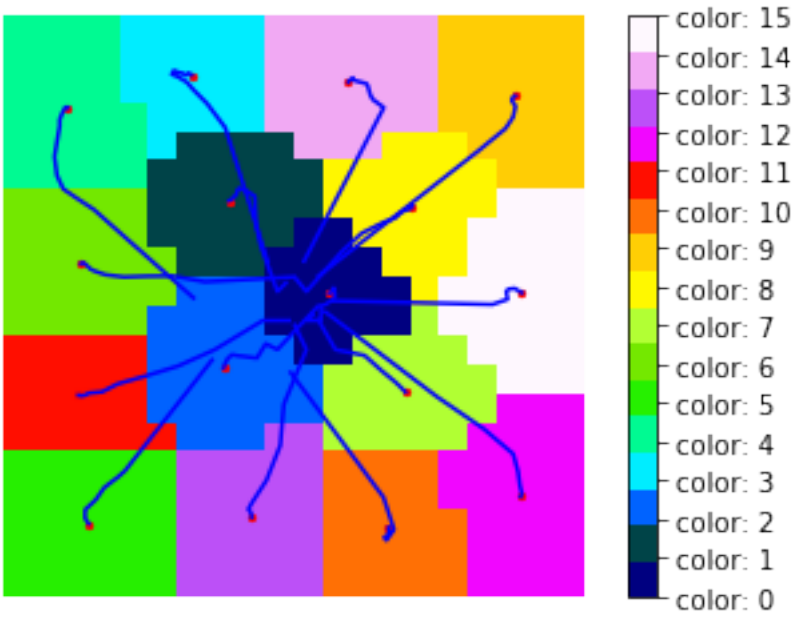
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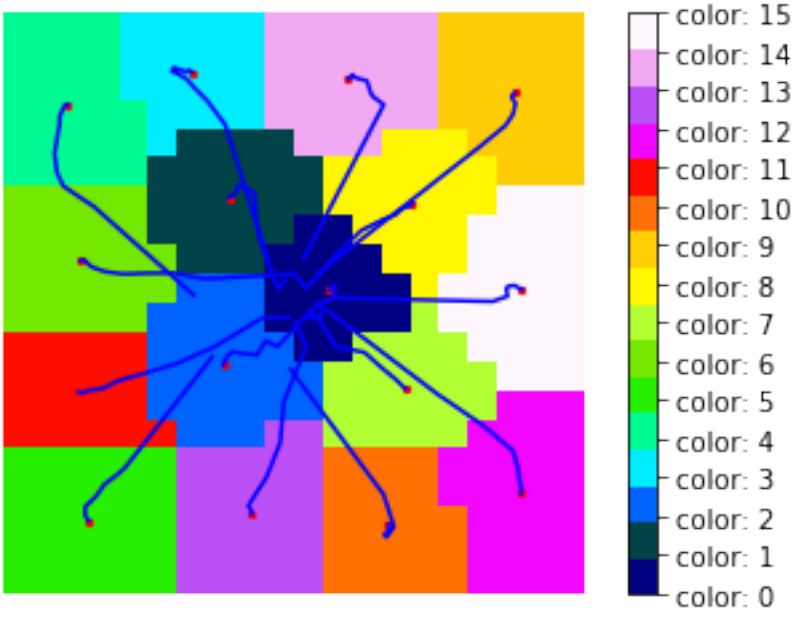
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color: 2
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color: 0

In [16]: plot_image(k_num_label, k_num)